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The Financial Drivers of European Monetary Union Optimality

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Abstract: Developments in optimum currency area theory as well as the experience of the European monetary union in the last decade mean the financial part of the economy cannot be disregarded when assessing currency area optimality. A set of well-established economic OCA criteria is used in conjunction with financial criteria suggested by the more recent developments (namely the synchronicity of financial cycles and the volatility of bilateral capital flows) in order to investigate the optimality of the European monetary union for a set of EU countries. This set of countries consists of a group of members of the European monetary union that are on the periphery of the EU, and a group of non-members of the currency area that belong to the EU. A descriptive analysis is used, which allows for comparing these countries and these two groups on both a cross-sectional basis, and on a time-varying basis. The period of analysis, whenever possible, corresponds to the time period between 1999 and 2020. The issue of endogeneity of these criteria is also approached on a criterion-level basis. Economic criteria generally favor the non-member countries as more optimal for the currency area, while the financial criteria produce mixed results. Specifically, business cycle synchronicity, and bilateral trade and openness appear to be lower for peripherical members of the European monetary union than non-members, and bilateral dissimilarity appears to be higher. On the other hand, financial cycle synchronicity appears to be higher for the former group than for the latter. Volatility for flows of FDI was found to be lower for peripherical European monetary union members than non-members, however the opposite is true for portfolio capital flows.

JEL codes: F31, F33, F36, F45

Keywords: Optimum Currency Areas; Financial Variables; Financial Cycle Synchronicity; Capital Flows Volatility

Resumo: Avanços recentes na teoria das zonas monetárias ótimas bem como a experiência da união monetária europeia implicam que a parte financeira das economias não pode ser descurada numa análise da otimização de zonas monetárias. Um conjunto de critérios OCA económicos bem estabelecidos é usado em conjunto com critérios financeiros sugeridos pelos avanços mais recentes (nomeadamente a sincronização dos ciclos financeiros e a volatilidade dos fluxos de capitais bilaterais) de maneira a aferir a adequação da união monetária europeia a um conjunto de países da UE. Este conjunto de países consiste num grupo de membros da união monetária europeia na periferia da UE, e um grupo de não-membros da área do euro que pertencem à UE. Uma análise descritiva é usada, que permite comparar estes países e estes dois grupos de maneira transversal bem como ao longo do tempo. O período em análise corresponde, sempre que possível, ao período entre 1999 e 2020. A questão de endogeneidade dos critérios é abordada ao nível do critério individual. Critérios económicos geralmente favorecem os países não-membros, enquanto que os critérios financeiros apresentam resultados mistos. Mais concretamente, a sincronização dos ciclos económicos e os índices de comércio e abertura bilaterais são inferiores para os países periféricos membros da união monetária europeia em relação aos não membros, e o índice de diferença na estrutura económica é maior. Por outro lado, a sincronização dos ciclos financeiros é maior para o grupo de países anterior é superior. A volatilidade de fluxos de IDE é inferior para os países periféricos membros da união monetária em relação aos não membros, no entanto, a volatilidade de fluxos de portefólio é superior.

Códigos JEL: F31, F33, F36, F45

Palavras-Chave: Zona Monetária Ótima; Variáveis Financeiras; Sincronização dos Ciclos Financeiros; Volatilidade dos Fluxos de Capital

Table of Contents

List of Figures

List of Tables

1. Introduction

The theory of optimum currency areas, or OCA, emerged from the debate regarding the ideal domain of a currency, with arguments that suggested that domain did not necessarily have to coincide with national borders. While at first the focus was on individual criteria that would allow policymakers to decide on this issue, the analysis eventually shifted to considering multiple criteria simultaneously that focused on economic aspects for this analysis. OCA theory grew in importance with the will for greater integration in Europe. The experiences of the European monetary union with the financial crisis, driven in no small part by the financial aspects of the economy, reveal the need to further the study of how the latter is influencing the former as an optimal currency area. A literature survey showing several recent results regarding the importance of the financial part of the economy on the functioning of the real part of the economy only serves to reinforce that need.

The objectives of this dissertation are to study a set of economic and financial OCA criteria that can be used to assess currency area optimality and to use these criteria to assess the optimality of the European monetary union for a set of periphery countries that are already members, as well as for a set of EU countries that are not members of the euro area. This analysis will assess the relative optimality for these sets of countries on both a cross-sectional basis for the entire period and over time.

The means by which this will be done is through a descriptive analysis that assesses a monetary union, which has the advantage of permitting comparisons for these sets of countries. Similar descriptive analyses can be found in Adámek and Kappel (2015), Quah (2016), Artis and Zhang (2002) and Loureiro, Martins, and Ribeiro (2012), among others. A methodological limitation of this descriptive analysis is that it does not calculate the statistical significance for each criterion. However, the theoretical part of this dissertation establishes the processes and channels by which all the analyzed indicators affect currency area optimality. The countries being analyzed are the peripherical members of the European monetary union, or EMU (Greece, Spain, Ireland, Italy and Portugal) and the non-member EU countries (Czech Republic, Sweden, Hungary, Poland, Denmark, Romania, Croatia and Bulgaria). The most significant methodological limitation encountered was the lack of data for Croatia, Bulgaria, and Romania, and required excluding these countries from the analysis. Denmark has an opt-out for the euro and was excluded too. The analysis runs from 1999 to

2020, which is the timeframe for the euro. However, that period was limited by data availability, especially in the case of capital flows from 2001 to 2018. This analysis was made in relation to a reference country, which is Germany. Proxying the entire European monetary union through Germany is recurrent throughout the literature. The results show, for each country and for each group of countries, from the perspective of each criterion, if they are relatively better or worse suited for EMU membership.

A set of established OCA criteria relating to the real part of the economy were analyzed, namely business cycle synchronicity, the dissimilarity of the economic structure, the intensity of trade and the openness of an economy. Some examples of analyses that estimate these criteria are Adámek and Kappel (2015), Frydrych and Burian (2017), Loureiro et al. (2012) and Quah (2016). In general, these criteria tend to disfavor the countries that are peripherical members of EMU relative to the non-members.

As for the financial OCA criteria, theoretical assessments as well as empirical results will be shown to justify their relevance for this analysis. The first financial OCA criterion being analyzed is the synchronicity of financial cycles between a country and a reference for the European monetary union. A survey of literature shows it must have an impact in the real part of the economy, and a notion of procyclicality is developed, linking it directly to asymmetries in the business cycle. Other channels that permit financial cycles to impact the real economy exist. Studies that analyze financial cycle synchronicity include Adarov (2019), which analyzes it on a cross-sectional basis for a different time period, Oman (2019) which estimates a different measure of synchronicity and Hessel (2019) which analyzes medium[1] term fluctuations in terms GDP, not financial variables.

The other financial OCA criterion that will be analyzed is the volatility of capital flows. A review of available literature suggests that flows of capital are capable of exciting business cycles, and that the flows themselves induce volatility in the exchange rate. Since a fundamental precondition for optimality of a currency area under a no arbitrage condition is the stability of bilateral exchange rates according to Frydrych and Burian (2017) (which underpins the analysis in Bayoumi and Eichengreen (1997), Horvath and Kučerová (2005),

[1] While according to the author these are strongly correlated to cyclical components of financial variables, they are not the same.

among others), there are several theoretical reasons and empirical results in literature that show the capability of capital flows to interfere with the assessment of a currency area. Forbes and Warnock (2012) analyzes it but not in terms of rolling window standard deviations, while Neumann, Penl, and Tanku (2009), Broto, Díaz-Cassou, and Erce (2011) and Pagliari and Hannan (2017) analyze it for a different sample (on a regional level, for different regions).

This dissertation is comprised by this introductory chapter, chapter 2 in which the literature regarding currency areas is reviewed, chapter 3 which establishes the methodology to use in the empirical analyses, chapter 4 in which said analyses are made, and a concluding chapter in which the work is summarized. The second chapter is divided into three sections that address OCA criteria and the experience of EMU. The second section establishes the financial OCA criteria. The third section then reviews empirical results regarding these criteria as pertaining to the European monetary union. The third chapter clearly outlines the methodology being used and the mathematical expressions for OCA criteria. The fourth chapter provides an in-depth analysis of the results, and the fifth chapter offers a brief conclusion and summarization of this dissertation.

2. Literature review

2.1 The Theory of Optimum Currency Areas

2.1.1 Theoretical Foundations and the Economic Optimum Currency Area Criteria

2.1.1.1 Early Research: the Factor Mobility, Openness of the Economy and Diversification or Dissimilarity Criteria

The theory of optimum currency areas, or OCA for short, is a framework used to analyze economic and monetary integration for countries and regions, helping to provide tools and criteria to help guide public policy (Masini, 2014). Mongelli (2008) defines an OCA as the ideal region for a single, shared currency or currencies with irrevocably fixed exchange rates.

The foundational approach to the issue of whether countries should have a single currency is usually regarded as Mundell (1961), which proposed certain countries could plausibly benefit from this, based on the mobility of productive factors such as labor and capital, the usefulness of a single shared currency and the functions that a floating exchange rate has in helping economies adjust to rapid changes in some macroeconomic variables.

Candidate regions or countries could want to share a currency, since doing so reduces the transaction costs for goods and services significantly. As argued by Mongelli (2002), this would come from greater price transparency, competition, and decreased market segmentation, increased price stability and access to financial markets that would promoted greater macroeconomic stability and growth. Additionally, according to Saxena (2005), if policymakers wish to pursue greater regional integration in political terms, a common currency is one way to signal their commitment.

However, according to Mundell (1961), if there were an economic shock[2] that had geographically distinct impacts, this would require the economies in each region to adjust their factor prices if a floating exchange rate is not available and there is immobility of economic factors. On the other hand, as the mobility of economic factors tends towards the theoretically perfect, this would reduce the need for other mechanisms of adjustment,

[2] More specifically, Mundell (1961) considers a shock in productivity in the automobile industry, causing excess demand for lumber and excess supply in automobiles.

including floating exchange rates and changes in real factor prices[3] if that exchange rate regime is not available, allowing regions to reap the previously stated benefits of a shared currency.

Note, however, that Kenen (1969) points out that in order to restore a balance to the regions, mobility of labor might not be sufficient, as the skillset of the laborers also matters, since there will be rigidities associated with reskilling the workers of different regions, which might specialize in different industries or, if that is not the case, might have different standards for how jobs are supposed to be worked. Essentially, as McKinnon (1963) points out, mobility between different industries is also important, not just mobility between geographic areas.

Besides the mobility of factors, OCA theory suggests looking at other criteria that allow to assess the optimality for a given or candidate currency area, such as economic openness as suggested by McKinnon (1963). McKinnon (1963) argues that economies that are more open to the exterior are quicker to translate changes in the prices of tradeable goods to the generalized standard of living for their citizens, thereby lessening the need for a system of floating exchange rates to produce those adjustments.

Horváth and Komárek (2003)[4], Horvath and Kučerová (2005)[5], and Frydrych and Burian (2017)[6] all concluded that the McKinnon (1963) openness criterion is a significant OCA criterion, with higher values of openness being better. Descriptive analyses that include this criterion are found in Adámek and Kappel (2015), Quah (2016), Loureiro et al. (2012) and Artis and Zhang (2002).

Another criterion that has become a standard in OCA theory was developed by Kenen (1969), on observing payment imbalances are caused by shocks in the demand at the microeconomic level and proposing that a diversified economy that produces many different

[3] Adjustments in the real price of labor (*i.e.,* real wages) are usually difficult and politically costly.
[4] The model includes Germany, Australia, Austria, Belgium, Canada, Denmark, Finland, France, the UK, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland and the USA. Time period is from 1960 to 1998 (yearly) and 1989 to 1998 monthly.
[5] The model includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, the UK, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, and the USA, from 1989 to 1998.
[6] The model includes Croatia, the Czech Republic, Hungary, Norway, Poland, Romania, Servia, Sweden, Switzerland, and the UK, from 2001 to 2013.

products is less vulnerable to shocks in the external demand for each individual product than an economy that produces a comparatively smaller or more concentrated set of products. This can be referred to as the diversification criterion or the specialization criterion. In the case of a negative shock in the demand for the products of an economy, the more diversified economy would see a lower rise in unemployment, and Kenen (1969) argues that these economies are better suited for fixed exchange rates, provided they possess the capability of dealing with the comparatively lower levels of unemployment that might arise from this regime.

Bayoumi and Eichengreen (1997) provides a similar perspective on this criterion, and suggests it can be seen in part as a proxy for the asymmetry of shocks to different countries in a currency area. In essence, as phrased by Mongelli (2005) and Saxena (2005), diversification in production and consumption is likely to be an OCA criterion since it helps dilute the impact of shocks specific to a sector over an entire economy.

This criterion can be approximated by the dissimilarity of composition in exports, according to Horváth and Komárek (2003) and Bayoumi and Eichengreen (1997), and the justification for including it as an OCA criterion alongside the asymmetry of output shocks for the entire real economy is that it should serve as a proxy for the proportion of shocks that are specific to a given industry, instead of the economy as a whole.

Bayoumi and Eichengreen (1997)[7], Horváth and Komárek (2003)[4], Horvath and Kučerová (2005)[5], and Frydrych and Burian (2017)[6] all concluded that the Kenen (1969) specialization criterion, as proxied by the dissimilarity approach, is a significant OCA criterion, with higher values for this specialization or dissimilarity being worse in terms of the assessment of optimality. Mongelli (2002) supports looking at specialization as a negative predictor of currency area optimality. Descriptive analysis that include this criterion are found in Adámek and Kappel (2015) and Quah (2016).

[7] The models include Germany, France, Italy, the UK, Austria, Belgium, Denmark, Finland, Greece, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden and Switzerland, between 1983 and 1992.

2.1.1.2 The Business Cycle Synchronicity Criterion

The business cycle is usually described in literature as a cyclical component of real GDP, which is obtained by detrending that time series[8]. However, it can also be estimated as the detrended component of industrial production time series as seen, for example, in Fidrmuc and Korhonen (2006).

As previously alluded to, the notion of a shock that affects different regions in different ways is central to OCA theory. Since the impacts of an asymmetric shock are different in a significant sense, this makes it harder, if not impossible, to have a response in terms of monetary policy that is the appropriate one for all regions if these regions share the same currency. Mongelli (2005) states that if the incidence of shocks in economic output, both in the demand and supply sides, is similar between two countries, the need for separate, opposing and potentially conflicting monetary policies is lower.

Bayoumi and Eichengreen (1997)[7], Horváth and Komárek (2003)[4], Horvath and Kučerová (2005)[5], and Frydrych and Burian (2017)[6] all concluded business cycle synchronicity is statistically significant OCA criterion on the basis that it helps drive fluctuations in the exchange rate. However, Horvath and Kučerová (2005) raises significant concerns with endogeneity in this criterion, which suggests the decision to join a currency area might affect its evolution. The former works all found that lower synchronicity is associated with a worse assessment in terms of OCA optimality in all time periods. Descriptive analyses that include this criterion are Adámek and Kappel (2015), Quah (2016), Loureiro et al. (2012) and Artis and Zhang (2002).

2.1.1.3 The Bilateral Trade Criterion

Bayoumi and Eichengreen (1997) consider that bilateral trade is important to measure since one of the benefits of a common currency, the reduction in transaction costs by expressing the price of goods in the same unit of currency, is greater for countries with stronger trade linkages. Saxena (2005) concurs, noting that a source of lowering of transaction costs comes from the elimination of exchange risks. Saxena (2005) also points out that before forming a

[8] For examples of this see Claessens, Kose, and Terrones (2012), Weyerstrass, van Aarle, Kappler, and Seymen (2011), and Beck (2021).

monetary union, a natural step is to form a customs union, and that such unions already have the potential to induce both trade creation and trade diversion effects.

Bayoumi and Eichengreen (1997)[7], Horváth and Komárek (2003)[4], Horvath and Kučerová (2005)[5], and Frydrych and Burian (2017)[6] all concluded bilateral trade intensity is a significant OCA, while noting there is a possibility of endogeneity with the dependent variable in all three cases. This could mean that the decision to join a currency area itself affects the evolution of this indicator. The three aforementioned works find that increased levels of bilateral trade are associated with better suitability in terms of an OCA assessment. Some descriptive analyses performed on this criterion are Adámek and Kappel (2015), Quah (2016), Loureiro et al. (2012) and Artis and Zhang (2002).

2.1.2 Cost-Benefit Analysis with Multiple Criteria

Ishiyama (1975) states that instead of considering each criterion individually, any analysis on the issue of determining currency area optimality is better made considering several distinct criteria simultaneously, arguing in favor of a framework that considers both the potential gains and losses of a currency union, in the form of a cost-benefit analysis. Mongelli (2005) concurs with the cost-benefit approach to OCA theory, and considers a distinct formulation of OCA theory that centers upon the benefits and costs of forming a currency union for each individual country, not for the general welfare of the area as whole. Besides the criteria that were previously discussed, additional criteria are a system of fiscal transfers, taking the form of, for example, automatic stabilizers according to Saxena (2005), economic rigidities and flexibility in prices according to Mongelli (2005), Zhang, Sato, and McAleer (2004) and Zerihun and Breitenbach (2018) and inflation differentials according to Ishiyama (1975) and Fleming (1971).

Jager and Hafner (2013) divide the OCA criteria discussed previously into two categories, the first one consisting of mechanisms that insulate members of currency union against asymmetric shocks, by way of an open economy that is similar to that of other countries in the union and not overly specialized. Therefore, business cycle synchronicity, differences in growth of labor productivity, openness, trade, and economic specialization are all criteria belonging to this category (Jager & Hafner, 2013). The second set of criteria, according to Jager and Hafner (2013) relate to mechanisms that contribute to less rigid adjustment to shocks, such as homogeneity in preferences for consumption, trade and similar political

systems which allow for less friction at the policymaking level when it comes to dealing with shocks. Other OCA criteria that improve the response time and capacity to shocks, according to Jager and Hafner (2013) are factor mobility, especially of labor and capital, and an existing and well-functioning system of fiscal transfers, that allows the economically depressed regions to quickly recover.

Some benefits have already been discussed previously (to restate them succinctly these are greater price transparency, competition, and decreased market segmentation, increased price stability and access to financial markets and signaling commitment to political projects). Mongelli (2005) also argues additional benefits are increased cross border flows of goods and capital. Ishiyama (1975) stresses the reduction of speculative flows of capital and costs of converting currency as potentially positive impacts, and these are corollaries of the increased price transparency.

The main cost of a currency area has been previously mentioned, but it can broadly be surmised as the loss of monetary policy as a macroeconomic policy instrument to respond to changing circumstances in any given economy according to Ishiyama (1975), which become especially relevant in the case of asymmetric shocks. More specifically, according to Frankel and Rose (1996), the impossibility for each region to soften the fluctuations of the business cycle with the appropriate monetary policy would impact the decision in the opposite direction, and that countries with more dissimilar cycles would be more negatively impacted, which is why any expected change in the synchronicity of the cycles coming from the decision should also figure in the analysis.

In addition, Mongelli (2002) points out additional costs such as choice of a sub-optimal nominal exchange rate parity when joining a currency area, loss of ability to respond to debt by raising inflation levels if required, and loss of ability to cope with frictional unemployment in the presence of significant price and wage rigidities.

2.1.3 The Endogeneity Hypothesis in Optimum Currency Area Theory

There is the possibility that the criteria which are used to decide whether any set of countries forms an OCA are endogenous, and if they are endogenous there is the possibility that implementing a shared currency either improves or worsens the OCA conditions. Therefore, looking at the history of the regions involved is not enough to decide the matter. Instead, if

the OCA criteria are endogenous, the decision to form a currency area can itself produce changes in those countries such that because of that decision, they will either converge or diverge on the assessment of the OCA criteria. Grauwe and Mongelli (2005) suggests that there are four distinct sources of endogeneity for OCA criteria, namely the effects of economic integration on prices and trade, of financial integration or risk-sharing provided by capital markets, the endogeneity of symmetry of economic shocks, and endogeneity in product and labor market flexibility.

Frankel and Rose (1996) advance two possible scenarios, an increase in the specialization of each region in any given industry that would result in more dissimilar business cycles, as the different industries are impacted by different shocks, or a scenario in which either shocks in the demand or shocks common to all economies dominate the analysis, business cycles would become more similar. If the decision to form an area has a significant impact on the analysis, then the criteria are endogenous, and it is imperative to consider its potential impact at a future time in our current analysis[9].

Frankel and Rose (1996) notes that the synchronization of business cycles in any two given economies has an impact on the volume of trade between those two countries, while Horvath and Kučerová (2005)[5] also raised similar concerns and in their assessment they encountered endogeneity. More specifically, Frankel and Rose (1996) argue that trade and business cycle correlation are endogenous since the expected reduction in transaction costs between two different regions with a single currency and subsequent increase in trade, should positively impact that decision. The impossibility for each region to soften the fluctuations of the business cycle with the appropriate monetary policy discussed previously should also figure in the analysis. Their results[10] seem to suggest the latter scenario and serve as an argument in favor of the endogeneity of the OCA criteria, in a broad sense, when assessing economic variables.

[9] There are theoretical reasons to believe that even if the OCA endogeneity hypothesis holds in general, the degree of convergence at the beginning stages of a currency union is important, and that insufficient convergence might preclude future convergence (Horváth & Komárek, 2003).
[10] The authors analyze Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Norway, Netherlands, New Zealand, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States between 1959 and 1993.

However, there is dissent from the endogeneity hypothesis by Baxter and Kouparitsas (2004)[11] which find the a inclusion of a qualitative variable that stands for inclusion in a monetary union is not significant in their model estimation, which also includes bilateral trade, total trade, sectoral structure, dissimilarity of exports and imports, factor endowments and gravity variables.

2.2 Financial Criteria for Optimal Currency Areas

2.2.1 The Role of Financial Integration; Risk-Sharing and Specialization

Ishiyama (1975) argues that the degree of financial integration between economies is necessarily relevant for OCA theory, since the author states capital flows can be destabilizing. Furthermore, according to Mongelli (2005), the integration of capital markets is suggested to be connected to baseline economic conditions and have the capability to increase foreign owned assets and to promote risk sharing across different economic regions, with the possibility of using capital flows to respond to shocks in real output. Horvath and Kučerová (2005)[5] find the level of financial development to be statistically significant, and to have a negative impact on suitability for any two countries to form a currency area, indicating the destabilizing power of the financial system on any two given economies.

In addition, Beck (2021) also finds that capital flows can induce specialization and increase dissimilarity of economies by way of risk sharing, a result supported by the work of Albuquerque (2003), furthermore Beck (2021) notes contagion effects transmitted by financial markets all have measurable impacts on business cycles.

2.2.2 The Financial Cycle Synchronicity Criterion

The financial cycle is increasingly relevant to the understanding of the real economy (Borio, 2014). Financial cycles require one to recognize the financial system is more than a simple system of allocation of purchasing power, but rather that it can create it as well, and that to understand it fully one must recognize the transnational nature of modern economies (Borio, 2014). Aldasoro, Avdjiev, Borio, and Disyatat (2020) assert not only that the financial cycle is a key driver of fluctuations in economic output, in a procyclical manner, but that the

[11] Sample consisted of over 100 countries, both developed and developing, between 1970 and 1995.

financial cycle can be broadly broken down into global and domestic financial cycles. According to Aldasoro et al. (2020), the global financial cycle is primarily described by the prices of financial assets like equity and bonds as well as capital flows, while the domestic financial cycle is driven by credit and property prices and has a closer connection to business cycles, having a longer duration relative to the previously mentioned global cycle.

2.2.2.1 The Domestic Financial Cycle

According to Borio (2014), when described as aggregates of credit and house prices, fluctuations in the financial aggregates (i.e. the domestic financial cycle) occur in the medium term rather than in the timespan of the business cycle.

Furthermore, according to Borio (2014), the domestic financial cycle is strongly procyclical when assessing its impact on economic output. Similarly, Ma and Zhang (2016) contend that the domestic financial cycle has become a key determinant of the business cycle, and its role is increased during times of financial instability. In their study, they conclude that the financial cycle is highly correlated with the business cycle, with shocks in the financial sector being responsible for real fluctuations in the output, and furthermore that it is a driver of these fluctuations. Yan and Huang (2020) also find that the domestic financial cycle has significant explanatory power over real output levels due to wealth effects being subject to practical restrictions, i.e. a change in the availability of credit can influence private actors such as households and corporations to change their consumption and investment decisions, providing a theoretical justification for the impact on the business cycle.

Borio, Drehmann, and Xia (2020) concur on this notion of procyclicality of the domestic financial cycle, with Borio (2014) and Borio et al. (2020) noting the high degree of predictive power for this cycle to predict recessions. Claessens et al. (2012) also supports a connection between the point a given country lies on the financial cycle and real economic output. Namely, the length and strength of recession and recovery are connected to the state of the financial cycle at the time, with rapid growth in credit facilitating recovery and depression of asset prices associated with a more severe recession (Claessens et al., 2012). Oman (2019) also noted the procyclicality of the financial cycle in relation to the business cycle.

Since the financial cycle is a key driver of fluctuations in the business cycle, and is strongly procyclical, asymmetries in the financial cycle between different countries will help drive

asymmetries in the corresponding countries' business cycles, reducing their synchronicity. As mentioned previously in section 2.1.1.2), business cycle synchronicity is an OCA criterion and asymmetries in the business cycles between two different countries imply that responses to macroeconomic conditions in terms of monetary policy that are simultaneously adequate to both become more difficult.

There are ways in which the financial cycle can impact currency area optimality that are not directly related to business cycle synchronicity, for example, Samarina, Zhang, and Bezemer (2017) note that the credit conditions in each country can have a decisive impact on the effectiveness of monetary policy, as well as a measurable impact on long-term economic growth and financial instability.

Lastly, Samarina et al. (2017) note that credit conditions will necessarily have an impact on the recovery of countries after a crisis. Another direct impact that financial conditions might have on the optimality of a currency area is described in Lobo, Paugam, Stolowy, and Astolfi (2017), which find that rating agencies' ratings are influenced not only by the business cycle, but also by where an economy lies on the financial cycle, and correlate positively with that. When combined with the fact that investors also tend to react more aggressively during the negative phase of the cycles, there is evidence for another destabilizing mode of interaction by the financial cycle with the real economy (Lobo et al., 2017).

2.2.2.2 The Global Financial Cycle

Passari and Rey (2015) describe an example of a financial cycle in terms of cross-border capital flows and financial asset prices (i.e. the global or supra-national financial cycle). Passari and Rey (2015) mention two main channels through which US monetary policy might impact monetary conditions in other countries, the first being a reluctance of a central bank to maintain a large interest differential with the Federal Reserve due to aversion to large movements of capital flows that would ensue, and the second being a direct impact of the US dollar on the domestic conditions of other countries by way of its status as an international currency. Miranda-Agrippino and Rey (2020) also find that US monetary policy is a key driver of the global financial cycle confirming US monetary contractions lead to deleveraging of financial institutions, increased risk aversion and a decline in global credit, which lead to reduced cross-border capital flows. According to Habib and Venditti (2018), the global financial cycle, as measured by capital flows and financial asset prices in the form

of stock prices, is driven to a significant extent by the global assessment of overall risk in asset prices. However, according to Habib and Venditti (2018), the authors were unable to identify a significant correlation between US monetary policy and capital flows.

2.2.2.3 A Combined or Aggregate Financial Cycle

Adarov (2019) constructs an aggregate financial cycle, comprising cycles for credit, housing, bond and equity aggregates, finding that the aggregate financial cycle is a driver for the domestic business cycle for European countries, with co-movement being especially high for Hungary, Italy and Germany, as well as measuring a significant influence of these cycles on debt-to-GDP ratios.

Claessens et al. (2012) also describes the financial cycle in terms of house prices, equity prices, and the levels of credit, and similarly notes the procyclicality in relation to the business cycle.

2.2.2.4 The Importance of the Financial Cycle for Optimum Currency Area Theory

As the financial cycle is an important driver of the business cycle and the real part of the economy, in a procyclical manner, it is expected to also be important to OCA theory. The financial cycle has an impact on real consumption and investment decisions, credit conditions have a direct impact on monetary policy, and on the ratings assigned to each country by credit agencies, which further influence investment and consumption decisions. The synchronicity of the financial cycle between two countries, in particular, should be important, since the procyclicality of the financial cycle implies that countries that lie on the same positions in the financial cycle will, all other factors equal, have those cycles impact their real cycles in the same manner. This impact on the real cycle is an established OCA criterion. Furthermore, credit conditions directly affect the effectiveness of monetary policy. If countries lie on the same position in the financial cycle, the impacts on monetary policy will occur in the same direction, which implies there is a benefit from having synchronized financial cycles from the perspective of OCA theory.

2.2.3 The Capital Flows Volatility Criterion

2.2.3.1 Different Types and Directions of Capital Flows

Determining role of flows of capital between countries in shaping macroeconomic conditions is not as straightforward as naively including the variable representing the net

position in flows of capital between any given pair of countries, as the type of flow (as supported by Bukovšak, Lukinić Čardić, and Pavić (2020) and Combes, Kinda, and Plane (2012)), the timing (as supported by Cavallo, Powell, Pedemonte, and Tavella (2015)) and direction (Combes et al. (2012) and Cavallo et al. (2015)) can be shown to be important to any analysis that involves these financial aspects. There is also an argument to be made that capital flows have a cyclical nature, and in Forbes and Warnock (2012) the authors point to the fact that they cannot be understood in isolation of one another when studying the larger pattern of flows that we observe over longer periods of time, of a wavelength of years and not months. According to Bukovšak et al. (2020), total capital flows can be broken down into Foreign Direct Investment (FDI), Portfolio Investment, and Other types of investment, and into their directional components. Both FDI and Portfolio investment, can be subdivided into Equity and Debt types of flow.

2.2.3.2 The Exchange Rate Volatility Approach to Optimum Currency Area Theory

OCA theory preoccupies itself with uncovering the ideal region for a single, shared currency. This question is raised due to tradeoffs between the gains from the single currency, and the loss of independent monetary policy as a mechanism for adjustment to shocks. Bayoumi and Eichengreen (1997) argue that one way of looking at optimum currency area theory, is that it is a framework that seeks to explain the variability in the bilateral exchange rate between two countries. According to the authors it should do this by establishing a set of criteria that are driving the volatility in the bilateral exchange rate.

Zerihun and Breitenbach (2018) state that exchange rate stability is a requirement for a group of countries to form an OCA. More specifically, Frydrych and Burian (2017) state that a low volatility in the exchange rate for two countries that have a floating rate is a precondition for an efficient monetary union. The assumption behind that statement is interest rate parity, which is a no arbitrage condition relating interest and exchange rates. Frydrych and Burian (2017) state that if two countries that would, under a floating exchange regime, have a very volatile bilateral exchange rate, by fixing this exchange rate these countries are instead exerting significant pressure on their interest rates that were determined at the moment of this fixing. Pressure which, according to the authors, would be translated to other parts of the economy.

Thus, non-volatile bilateral exchange rates are considered to be a fundamental precondition for OCAs by Bayoumi and Eichengreen (1997), Horváth and Komárek (2003), Horvath and Kučerová (2005), Frydrych and Burian (2017) and Zerihun and Breitenbach (2018) (among others) and these authors analyze OCA theory under the assumption that OCA criteria are precisely the variables that are driving the volatility in the bilateral exchange rates.

Bayoumi and Eichengreen (1997) consider the nominal exchange rates as their domain of analysis, Horvath and Kučerová (2005) ultimately decide on the real exchange rate as the fundamental precondition, since it can both be measured clearly and properly weigh the economic or real dynamics that produce them, and that it correctly conveys the notion of a low propensity for asymmetric shocks between any two countries when it is stable. Furthermore, there are discrepancies between official nominal exchange rates and de facto nominal exchange rates. Jager and Hafner (2013) and Zerihun and Breitenbach (2018) also support the usage of the real exchange rate.

2.2.3.3 The Impacts of Capital Flow Volatility on the Exchange Rate

Rashid and Husain (2013) use Granger causation tests to conclude that shifts in flows cause volatility in the nominal exchange rate in a time period of low amount of flows, but also in the real exchange rate in time periods of both low and high capital flows. Lastly, the authors find that capital flows do cause changes in domestic asset price levels. Furthermore, Desai and Hines (1997) find that inflation in an open economy with mobility of capital has a discouraging effect on domestic saving and encourages domestic investment, with the economic distortion being greater in regimes with higher levels of inflation and especially in economies where inflation exceeds the world average, and that this effect is mediated by capital flows in excess of the ideal from a societal welfare point of view.

Another way that capital flows might affect the optimality of a currency area comes from Gyntelberg, Loretan, and Subhanij (2018), which contend that the driving mechanism for that is the information content in the flows themselves. Gyntelberg et al. (2018) conclude that foreign investors who cause inflows to domestic stock markets have a significant and permanent impact on the exchange rate, while foreign investors who cause capital inflows to domestic public bond markets do not have a measurable impact on that variable. The reason being that the former are more likely to be driven by private information, while the latter are usually driven by public announcements or information that is at least already publicly

available and therefore more likely to already have been incorporated in the exchange rate itself by the markets (Gyntelberg et al., 2018).

Beck (2021) expands upon the ways that bilateral capital flows can impact the business cycles, noting that over the short-run capital flows can directly excite business cycles. In particular, Rothert (2020) finds that large fluctuations of the real exchange rates occur in the presence of sudden stops of capital inflows during crises, for example.

2.2.3.4 The Impacts of Capital Flow Volatility by Direction

As mentioned previously, the timing and direction of capital flows matter when it comes to assessing their impact on the real macroeconomic state, and Cavallo et al. (2015) approaches this subject by classifying different types of stoppages of capital flows, based on their inflow and outflow components. Their findings determine that the disruption of the normal functioning of an economy is not the same depending on the type of the sudden stop, with sudden stops in inflows and starts in outflows being the most disrupting and sudden stops of outflows the least disrupting (Cavallo et al., 2015). In general, the trend is that stoppages in inflows appear to be more detrimental to a given economy than starts in outflows (Cavallo et al., 2015).

García (2007) attempts to determine which policies should be implemented to cope with the increased fragility caused by the "overheating" of the economy. Essentially, an appreciation in real terms that leads to a deterioration of the current account. Since capital inflows, ceteris paribus, imply a surplus in the financial account, and in fixed exchange regimes there is the increase in the reserves of the domestic economy, this leads to a monetary expansion, and ultimately an increase in the aggregate demand caused by the inflows.

2.2.3.5 The Impacts of Capital Flow Volatility by Type

Bukovšak et al. (2020) determine that, for the case of Croatia, the type of capital flows matters when it comes to their impact on the exchange rate, with debt leading to appreciation and equity to depreciation. The authors were unable to find a statistically significant connection between flows directly to banks in the domestic country and the bilateral exchange rate, however, Croatia is not an EMU member, and as such does not experience the increased risk of capital flow volatility that results from EMU lowering risk premia and

borrowing costs for EMU members as pointed out in Kunovac and Pavić (2017), which could help explain that finding. Regarding capital inflows, Combes et al. (2012) find that while their type matters, in the sense that public and private flows impact the exchange rate, there are significant differences in their impact, with portfolio investments having a sevenfold impact relative to FDI and bank loans, in turn having a higher impact than private transfers. The implication of Combes et al. (2012) that a flexible exchange rate softens the impacts of these flows means they have a direct impact on the volatility of the real exchange rate. Bukovšak et al. (2020) note that this effect of capital flows was stronger in the real exchange rate relative to the nominal rate because domestic price levels grew faster than external price levels.

2.2.3.6 The Importance of Capital Flow Volatility for Optimum Currency Area Theory

The volatility of capital flows has a measurable and corresponding effect on the bilateral exchange rate between any two given economies. More specifically, there is evidence to suggest there is a causal impact of capital flow volatility on the bilateral exchange rate volatility. More volatile exchange rates indicate two countries are less suited to form a currency area, which as previously mentioned implies a shared currency or an irrevocable peg. In fact, bilateral exchange rate volatility is the dependent variable in model estimations such as the ones based on Bayoumi and Eichengreen (1997) or descriptive analyses such as Adámek and Kappel (2015). This suggests this criterion is of importance for OCA theory.

Furthermore, over the short run, it has been found to directly excite business cycles, against suggesting it must be analyzed when assessing currency area optimality. In addition, not all types and directions of flows have the same impact, with rapid stops in capital inflows being more detrimental, as such, a higher inflow volatility is expected to be more detrimental for the prospect of any two countries forming a currency area. As for the type of capital flows, volatility of banking flows is expected to be more detrimental than other types such as FDI. Lastly, there is at least a suggested mechanism through which countries joining EMU

experience a higher risk of volatility in capital flows due to lowered risk premia and borrowing costs (Kunovac & Pavić, 2017).

2.3 Applications of Optimum Currency Area Theory; The European Monetary Union as an Optimal Currency Area

2.3.1 The European Monetary Union; Members and Enlargement

The European Monetary Union (EMU) was formed by irrevocably fixing the exchange rates for eleven countries[12] in 1999, with Greece joining in 2001. It has currently enlarged to include Slovenia, Cyprus, Malta, Slovakia, Estonia, Latvia and Lithuania.

The European continent can broadly be divided into a set of core and periphery countries (Bartlett & Prica, 2016; Kinsella, 2012). While there is no unanimous agreement as to what constitutes the core and the periphery Bartlett and Prica (2016) suggests that Germany, the Netherlands, Austria, Belgium, France and Finland are core countries that are members of EMU. Furthermore, Bartlett and Prica (2016) suggest that the Denmark, Czech Republic, Poland and Sweden are core countries that are not members of EMU and that Cyprus, Greece, Ireland, Italy, Portugal and Spain are periphery countries that are members of EMU, while Hungary, Bulgaria and Romania are both periphery countries and non-members of EMU. Kinsella (2012) concurs that Ireland, Portugal, Spain, Greece and Hungary are periphery countries, with Italy on the edge of the core, while Germany, Austria, Belgium and France belong clearly to the core.

The enlargement of EMU from its founding members is a process expected to continue since countries that are in the European Union but do not have an op-out clause are required to join once certain conditions are met according to Deskar-Škrbić, Kotarac, and Kunovac (2020), such as participation in the Exchange Rate Mechanism II (Crespo-Cuaresma, Fidrmuc, & Silgoner, 2005). There are countries that appear to be willing to join but have not yet met the criteria, such as Romania, Bulgaria and Croatia, and countries that do not appear to be willing despite being obliged, such as the Czech Republic, Poland and Sweden

[12] These countries were Belgium, Germany, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal and Finland.

according to Deskar-Škrbić et al. (2020) and Deskar-Škrbić and Kunovac (2020). It is pertinent to investigate the optimality of the euro as a currency for these countries. Furthermore, according to Deskar-Škrbić et al. (2020) the previous authors, Denmark is not only not willing to join, it is not legally bound to do so.

2.3.2 Pre-European Debt Crisis Experience of the European Monetary Union

In order to gauge how suitable the candidate EMU countries were to forming a currency union, Bayoumi and Prasad (1997) compared the economic fluctuations in Europe (more specifically, shocks that led to real output growth) to those experienced by the United States, and concluded that they were largely similar, a favorable assessment of optimality. Despite this, Bayoumi and Prasad (1997) noted an important difference, in the form of reduced mobility of labor in Europe.

Lane (2006) asserts that a process of convergence, in the form of a significant reduction in inflation differentials between candidate countries, occurred from 1992 through 1998, before the fixing of exchange rates on January 1st, 1999. Kempa (2002) concurs and noted that a process of convergence had been occurring even before the formation of EMU. However, during the early years of EMU, a dispersion in inflation rates occurred, relative to the previous period before the fixing of the exchange rates, and while it is similar to that of the United States for the period, there is a significant persistence of inflation differentials seen in EMU not seen in the United States (Lane, 2006). According to Lane (2006), the European countries had different fundamentals and structural policies.

As for the effect of EMU on trade, in the periods leading up to the European debt crisis, Kunroo, Sofi, and Azad (2016) use a gravity model to determine that adoption of the single currency had a positive and significant impact for this variable on all of the countries studied, and furthermore, that EMU promoted a shift in the type of trade in European countries, shifting away from inter-industry trade to intra-industry flows, and suggest this is part of the convergence process. In an analogous line of inquiry, Berkel (2006) finds that EMU had a measurable and positive impact on cross border capital flows, especially portfolio flows, that cannot be accounted solely by increased integration in other aspects of the economy like financial markets and other real economic integration. Another work by De Santis (2010) confirms this effect, even after controlling for the elimination of exchange-rate risk. Therefore, the pre-crisis period is characterized by a convergence process in terms of the real economy, with EMU inducing increases of cross-border trade and capital flows, along with divergence in the inflation rates.

2.3.3 Post-European Debt Crisis Experience of the European Monetary Union

The European debt crisis began in 2009 and constituted a crisis in the balance of payments, with a sudden stop of flows of capital to countries with high deficits (Frieden, Copelovitch, & Walter, 2016). As for the cause of the financial crisis, Angelini and Farina (2012) conclude that capital outflows from the peripherical countries that sustain current account deficits pay for imports from the countries in the core. Krugman (2013) also states that, in the sense that it eliminated the risk premium associated with credit on the EMU periphery, the single currency provided a mechanism for creating a large, albeit gradual, asymmetric shock, with a noticeable economic boom and accompanying inflationary period in those countries. Post crisis, Stojkov and Warin (2018) conclude that there is a positive effect of being in the EMU for capital flows of FDI, and that the currency area has a clear impact on cross-border capital flows, confirming the results for Berkel (2006) and De Santis (2010). Furthermore, Beck (2021) finds that capital flows due to EMU have had an impact on business cycle synchronicity, with the negative impact of portfolio investment and the positive impact of FDI.

This still raises the question of concurrent interactions between trade and capital flows, if they exist, what is their nature. In Belke and Domnick (2018), the authors assert that if they are substitutes, as the original prevailing literature on this subject implied, they would appear to be negatively correlated, while the opposite sign would show up when assessing correlations if instead they are complementary to one another, and they favor this latter hypothesis. Hessel (2019)[13] also finds that for EMU there is some support for a convergence in the fluctuation of business cycles when looking at the entire pre and post crisis period, similarly to Bayoumi and Eichengreen (1997). However, long term fluctuations which are usually associated with the financial cycle have significantly worsened with time according to Hessel (2019) and Oman (2019). Similarly, the financial cycle synchronicity is lower between high and low cycle amplitude countries, namely Germany (Oman, 2019).

One may also enquire in which way, if any, has EMU itself impacted the financial cycle synchronicity in the euro area countries, and Samarina et al. (2017) find that through the

[13] The author compares the countries that are members of the European Monetary Union to US regions, between 1978 and 2019 for this specific assessment.

channels of currency risk, capital flows and interests, EMU has decreased the coherence of some variables used to construct the financial cycle, namely the total credit and housing, corresponding to the domestic financial cycle. Furthermore, according to Schoenmaker and Wierts (2016), confirm different regions within the euro area have different financial cycles, for example Germany and the Netherlands have cycles that are different than Ireland and Spain, and that these differences might have been accentuated by the single currency.

From the perspective of the cyclical financial side of the economy, there is further dissent from the positive endogeneity hypothesis from Bayoumi and Eichengreen (2017)[14] which find evidence that EMU countries, interactions between OCA variables act to reduce the real economic output levels of these countries, which is an endogenous effect that worsens the OCA assessment. Bayoumi and Eichengreen (2017) posit several ways in which this could happen, as the effect of negative shocks in aggregate demand, through a form of hysteresis, inducing the erosion of human capital during phases of temporarily high unemployment or reduced investment levels reducing output at a later point in time, but mostly believe this effect to be caused by the financial side of the economy. From empirical observations, Aizenman (2018)[15] also raises the possibility of a reduction in synchronicity in the business cycles of countries in the European Monetary Union, leading to a reduction and possible reversal in the sign of the net gains of membership for countries.

[14] The authors compare Germany, France, Italy, Spain, the Netherlands, Belgium, Austria, Ireland, Portugal, Greece, and Finland, as well as the Euro area to 8 US regions, namely the Mideast, New England, Southeast, Southwest, Great Lakes, Plains, Rocky Mountains, and the Far West. Additionally, they include the United States, Japan, the United Kingdom, Canada, Sweden, Switzerland, Australia, New Zealand, Denmark, and Norway in the analysis, from 1990 to 2014.

[15] The author uses a survey of relevant literature to state this.

3. Empirical Analysis – Data and Methodology

In order to empirically analyze the convergence process of EMU, a set of currency area optimality criteria will be used. This approach is established following the multiple criterion suggestion of Ishiyama (1975). As for the methodology used to assess optimality, some studies use a descriptive analysis, such as Artis and Zhang (2002), Loureiro et al. (2012), Adámek and Kappel (2015), Quah (2016) and Lima (2017), while some studies follow the methodology in Bayoumi and Eichengreen (1997), such as Horvath and Kučerová (2005), Frydrych and Burian (2017) and Horváth and Komárek (2003) where an OCA index is directly assessed using a statistical model consisting of a linear regression. Other studies follow a vector autoregressive or VAR analysis, such as Stock and Watson (2003), Zhang et al. (2004), Espinoza, Fornari, and Lombardi (2012) and Ma and Zhang (2016).

In this dissertation, a descriptive analysis is used, which will permit an assessment of how well suited each country is for EMU, for both current members and non-members, given the criteria which determine its optimality. The downside of this descriptive analysis is that it does not permit the assessment of whether the optimality criteria would all be statistically significant, as would be the case with a model estimation. Therefore, care needs to be taken with the results, especially since there are concerns about the endogeneity of these criteria.

Since Bayoumi and Eichengreen (1997) performed their analysis of OCA optimality with respect to Germany, so too will this descriptive analysis be made with respect to that country, which will also be referred to as the reference country. Not only do the authors still regard Germany as the most important country in the EU core as seen in Bayoumi and Eichengreen (2017), but if on a future occasion an equation derivable from (and implied by) this work is ever estimated, the results will be more directly comparable. Adámek and Kappel (2015) also use Germany as a proxy for the EMU average, citing concerns over data availability for other methodological approaches, which this work also encounters.

The countries being assessed form a representative sample of both periphery EMU countries, and candidates that are obliged to join EMU at some point in time but have still not joined. Financial data such as credit levels for Croatia, Bulgaria and Romania are scarce, and problems existed when trying to find data on GDP, GDP deflators, and bilateral exports broken down by sector for these same countries at a frequency higher than one year.

Furthermore, Denmark has a an opt-out clause and is not willing to join EMU. Thus, data was compiled for ten countries, which are Germany (the reference country throughout this analysis), Greece, Ireland, Spain, Portugal, Italy, Czech Republic, Poland, Hungary and Sweden. Data was compiled at quarterly frequency when available, and annual when not. Data was compiled for the time period ranging from 1999 to 2020 when available in order to properly assess the results for the entire history of the euro area.

3.1 Business Cycle Synchronicity Criterion

The business cycle synchronicity criterion, as discussed in section 2.1.1.2) is important for OCA theory as asymmetric shocks are harder to respond to than shocks with a high degree of symmetry. Data was available with quarterly frequency between Q1-1999 and Q4-2020 from the OECD[16] databases. This criterion is also referred to as the output disturbances symmetry criterion, the output fluctuations symmetry criterion or the output gap coherence criterion and is assessed in two different forms, as a correlation coefficient (for the entire period of analysis and for periods of eight consecutive years). It is calculated in the form of a correlation[17]:

$$\rho_{BC_i} = \frac{Cov(g_i,g_r)}{\sigma(g_i)\sigma(g_r)} = \frac{\sum(g_{it}-\overline{g_i})(g_{rt}-\overline{g_r})}{(\sum(g_{it}-\overline{g_i})^2(g_{rt}-\overline{g_r})^2)^{\frac{1}{2}}} \qquad 3.1^{18}$$

and

$$\rho_{BC_i}(t) = \frac{Cov(g_i,g_r)}{\sigma(g_i)\sigma(g_r)} = \frac{\sum(g_{ik}-\overline{g_i})(g_{rk}-\overline{g_r})}{(\sum(g_{ik}-\overline{g_i})^2(g_{rk}-\overline{g_r})^2)^{\frac{1}{2}}} \qquad 3.2^{18}$$

where ρ_{BC_i} is the business cycle correlation between country i and the reference country r calculated over the entire time period, g_{it} is the average output gap[21] for country i at time t

[16] The database used was https://www.oecd.org/sdd/na/quarterlynationalaccountsoecd.htm
[17] It is assessed as a correlation coefficient for the entire period, as well as a moving window or rolling window of a length comparable to one period if at all possible, since Weyerstrass et al. (2011) points out the results are sensitive to the window length, which should be wide enough to allow sufficient samples for a meaningful estimation, but short enough to allow the dynamics to be observed. As an example, Weyerstrass et al. (2011) chooses a window length of six years for assessing business cycle correlations. Since the financial cycle, on the other hand, has a much longer period than the business cycle, data was not available that would permit to compute moving window analysis for this criterion.
[18] Higher values in these indicators imply more synchronized business cycles and a better assessment in terms of OCA.

and $\overline{g_i}$ is the average output gap for a country. As for $\rho_{BC_i}(t)$, it is the business cycle correlation starting at time t and ending at a time that is 8 years later (i.e. an 8 year moving window, following the principle in Weyerstrass et al. (2011) of choosing a window as close to the cycle length as possible). g_{ik} is the average output gap[21] for country i at time k and $\overline{g_k}$ is the average output gap for a country during that 8 year time period. The business cycle synchronicity criterion is also assessed in a different form, as the cycle similarity[19] measure which is calculated as:

$$\gamma_{BC_i}(t) = 1 - \frac{|g_{it} - g_{rt}|}{\sum_i^n \frac{|g_{it}|}{n}} \qquad 3.3^{20}$$

where $\gamma_{BC_i}(t)$ is the business cycle similarity between country i and the reference country r, which is Germany, for time t. Furthermore, g_{it} is the output gap[21] for a country i at time t. The summation is therefore for the n countries at time t. Note that similarity ranges from minimum of 1 – n to a maximum of 1.

3.2 Dissimilarity Criterion

The dissimilarity criterion or economic structure dissimilarity criterion as discussed in section 2.1.1.1) is important for OCA since is a proxy for industry-specific asymmetric shocks. Higher values imply worse suitability for OCA. Data was obtained from the OECD BTDIxE[22] database, on an annual basis, between 1999 and 2020. It was assessed[23] as the sum of the absolute differences in the shares exports broken down by sector in the total bilateral exports between a country and the reference country. Or, in mathematical notation:

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[19] An alternative to calculating correlations is computing a measure of symmetry called cycle similarity, as suggested by Mink, Jacobs, and de Haan (2012) and implemented by Oman (2019) and Hessel (2019), which is desirable since it allows for a more fine-grained analysis than the correlation coefficient, as well as preventing some problems with correlation coefficient, since as Oman (2019) points out, there can be differences in the positions of cycles that would otherwise appear to be correlated to a significant extent.

[20] Higher values in this indicator imply more synchronized business cycles and a better assessment in terms of OCA.

[21] Output gaps were calculated following Weyerstrass et al. (2011) by detrending the real GDP or $RGDP$ time series for these countries using a Hodrick-Prescott[21] (HP) filter with $\lambda = 1600$.

[22] https://stats.oecd.org/Index.aspx?DataSetCode=BTDIXE_I4

[23] It was constructed following the works of Bayoumi and Eichengreen (1997), Adámek and Kappel (2015) and Frydrych and Burian (2017). It will also be assessed in the form of the mean dissimilarity for the entire period, which is simply $Dissim_i$.

$$Dissim_i(t) = \sum_{Sector1}^{SectorN} \left| \frac{XSector_{irt}}{X_{irt}} - \frac{XSector_{rit}}{X_{rit}} \right| \quad 3.4$$

where $Dissim_i(t)$ is the economic dissimilarity index between country i and the reference country which is Germany, $XSector_{irt}$ is the exports from a given sector from country i to r at time t and X_{irt} is total exports from country i to r at time t, with the reference country r being Germany. The summation occurs over the number of sectors[24] available in the dataset.

3.3 Bilateral Trade Criterion

The bilateral trade criterion, or trade intensity criterion, is important due to the reasons discussed in section 2.1.1.3) and is related to OCA since it correlates to how much a common currency lowers transaction costs between economies, with higher values reflecting better suitability for a currency. Data on trade was sourced from the OECD BTDIxE[25] database, and data for the nominal GDP was obtained from the IMF[26] World Economic Outlook database. Data was obtained at an annual frequency, between 1999 and 2020. It is represented by the mean of a ratio of bilateral exports to nominal GDP was assessed[27] as:

$$Trade_i(\mathrm{t}) = Mean\left[\frac{X_{irt}}{GDP_{it}}; \frac{X_{rit}}{GDP_{rt}}\right] \quad 3.5$$

where $Trade_i(t)$ is the bilateral trade criterion, X_{irt} is the exports between country i and r at time t and the reference country r is Germany, and GDP_{jt} is the nominal GDP of country j at time t

3.4 Openness Criterion

The openness criterion or economic openness criterion is important for OCA theory since as discussed in section 2.1.1.1) more open economies will have an easier time adjusting to

[24] The sectors considered were intermediate goods, basic household consumption goods, capital goods, mixed end use goods, personal computers, passenger cars, personal phones, precious goods and packed medicines.
[25] https://stats.oecd.org/Index.aspx?DataSetCode=BTDIXE_I4
[26] https://www.imf.org/external/datamapper/NGDPD@WEO/OEMDC/ADVEC/WEOWORLD
[27] It was constructed following the works of Bayoumi and Eichengreen (1997), Adámek and Kappel (2015) and Frydrych and Burian (2017). It will also be presented in the form of the mean trade intensity for the entire period, which is $Trade_i$.

shifts[28] in international prices via a higher proportion of foreign goods in the economy. Higher values therefore imply better suitability to join a currency area. Data on trade was sourced from the OECD.Stat Data Warehouse[29] database, and data for the nominal GDP was obtained from the IMF[26]. Data was obtained at an annual frequency, between 1999 and 2020. The mean openness[30] of two economies, on an unweighted basis is expressed by:

$$Openness_i(\mathrm{t}) = Mean[\frac{X_{it}+M_{it}}{GDP_{it}}; \frac{X_{rt}+M_{rt}}{GDP_{rt}}] \qquad 3.6$$

where $Openness_i(\mathrm{t})$ is the mean openness criterion at time t, $X_{it} + M_{it}$ represents the sum of exports and imports for country i at time t and the reference country r. GDP_{it} is the nominal GDP for country i at time t.

3.5 Financial Cycle Synchronicity Criterion

The financial cycle synchronicity criterion, as discussed in section 2.2.2) should be important for OCA theory since it has a procyclical effect on the business cycle, and countries lying on the same position in this cycle should have less of a potential conflict for responses to shocks in terms of monetary policy. Data was available with quarterly frequency between Q1-1999 and Q4-2020 from the OECD for the deflator[31] and GDP[16] for credit from BIS[32]. Higher values imply better suitability for a currency area.

The cycle fluctuations symmetry criterion or financial cycle disturbance symmetry criterion, required constructing a synthetic financial cycle, following the insights and methodology of Ma and Zhang (2016) and Yan and Huang (2020). The synthetic financial cycle FC was constructed using time series consisting of financial asset prices[33], credit[34], and credit[34]-to-GDP ratio. All the series were deflated using a GDP deflator[35], and were then normalized

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[28] And translating those shifts into changes in the standard of living of the domestic economy.
[29] OECD (2021), Trade in goods and services (indicator). doi: 10.1787/0fe445d9-en)
[30] It was constructed following the works of Adámek and Kappel (2015) and Frydrych and Burian (2017). It will also be presented in the form of the mean openness for the entire period, $Openness_i$.
[31] https://stats.oecd.org/index.aspx?queryid=220
[32] https://www.bis.org/statistics/totcredit.htm
[33] Obtained from https://stats.oecd.org/index.aspx?queryid=84
[34] Credit refers to total credit to the non financial sector of the economy, as indicated in Yan and Huang (2020).
[35] Obtained https://www.oecd.org/sdd/na/quarterlynationalaccountsoecd.htm on a quarterly basis.

using min-max[36] feature scaling. Principal component analysis[37] was then performed on the time series. The first principal component, or PC1, explained over 80% of the variance for all time-series, therefore PC1 was taken to represent the financial cycle FC, in a manner consistent with the reasoning in Yan and Huang (2020). The financial cycle synchronicity criterion is assessed in two different forms, as a correlation[17] coefficient:

$$\rho_{FC_i} = \frac{Cov(gf_i, gf_r)}{\sigma(gf_i)\sigma(gf_r)} = \frac{\Sigma(gf_{it} - \overline{gf_i})(gf_{rt} - \overline{gf_r})}{(\Sigma(gf_{it} - \overline{gf_i})^2 (gf_{rt} - \overline{gf_r})^2)^{\frac{1}{2}}} \quad 3.7$$

where ρ_{FC_i} is the financial cycle synchronicity between country i and the reference country r, gf_{it} is the average financial level gap[38] for country i at time t and $\overline{gf_i}$ is the average financial level gap[38] for the entire period. The financial cycle synchronicity criterion is also assessed in a different form, as the cycle similarity[19] measure which is calculated as:

$$\gamma_{FC_i}(t) = 1 - \frac{|gf_{it} - gf_{rt}|}{\sum_i^n \frac{|gf_{it}|}{n}} \quad 3.8$$

where $\gamma_{FC_i}(t)$ is the financial cycle similarity between country i and the reference country r, which is Germany, for time t. Furthermore, gf_{it} is the financial cycle gap[38] for a country i at time t, and the summation occurs for the n countries at time t. Note that similarity ranges from minimum of 1 – n to a maximum of 1.

3.6 Capital Flows Volatility Criterion

The capital flows volatility criterion[39] is important from the point of view of OCA theory since, as discussed in section 2.2.3) it directly contributes to exchange rate instability, as well

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[36] As done in Ma and Zhang (2016) and Yan and Huang (2020), this is a method of normalizing time series.
[37] See Ma and Zhang (2016) and Yan and Huang (2020) for the procedure, this is a method of dimensionality reduction for data.
[38] Financial cycle gaps were calculated following Ma and Zhang (2016) and Yan and Huang (2020) by detrending the FC time series for these countries using a Hodrick-Prescott (HP) filter with $\lambda = 400000$.
[39] This dissertation requires estimating measurements of capital flow volatility, which according to Broto et al. (2011) is not a straightforward task. Neumann et al. (2009) point out that analyzing capital flow volatility over a single, long time period and over short time periods has the possibility to make prominent different dynamics, operating at different time scales. For analyses of capital flow volatility over shorter time periods, Pagliari and Hannan (2017) suggest that a GARCH(1,1) model from Engle and Rangel (2008) as well as an ARIMA(1,1,0) model are possible methodologies, but all the former concur that standard deviations over a rolling window is a reasonable methodology. Furthermore, Forbes and Warnock (2012) also calculate moving standard deviations of capital flows when assessing volatility. In addition Beck (2021) suggests looking at the

as has the potential to directly excite business cycles. Therefore, higher values of volatility will be understood as detrimental towards the assessment of currency area optimality for the country being considered. Data regarding capital flows broken down by type and direction was available from the EU Finflows[40] JRC-ECFIN database and data on GDP from the IMF[26] World Economic Outlook database, on an annual basis, between 2001 and 2018.

It was assessed for both inflows and outflows from and to the reference country and for both FDI and portfolio flows. It was assessed in two forms, first as a standard deviation over a rolling window, broken down by flow type, on both an inflow and outflow basis:

$$\sigma_{type,dir,i}(t) = \left(\frac{1}{n}\sum_{k=t-(n-1)}^{t}\left(\frac{Flow_{type,dir,ik}}{GDP_{ik}} - \sum_{k=t-(n-1)}^{t}\frac{Flow_{type,dir,ik}}{n \times GDP_{ik}}\right)^2\right)^{\frac{1}{2}} \quad 3.9$$

where $\sigma_{type,dir,i}(t)$ is the rolling window volatility on a bilateral basis between Germany and country i, broken down by flow type and the flow direction for a time period ending at t. $Flow_{type,dir,ik}$ is simply the flow for country i at time k broken down by type and direction and GDP_{ik} the GDP of country i at time k. In this equation, n represents the number of time periods. When k appears, it represents a time instant, not a country. In these calculations n was taken to be 5[41] years. In addition, the volatility for the entire period of analysis was calculated, which consists of:

$$\sigma_{type,dir,i} = \left(\frac{1}{n}\sum_{t}\left(\frac{Flow_{type,dir,it}}{GDP_{it}} - \sum_{t}\frac{Flow_{type,dir,it}}{n \times GDP_{it}}\right)^2\right)^{\frac{1}{2}} \quad 3.10$$

where $\sigma_{type,dir,i}$ is the volatility on a bilateral basis between Germany and country i, broken down by flow type and the flow direction, for the entire time period being considered. $Flow_{type,dir,it}$ represents flows in a given time between Germany and i and GDP_{it} represents the GDP of country i in a given time. In this equation, n represents the number of countries.

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dynamics of capital flows over shorter timescales relative to the business cycle. Nevertheless, capital flow volatility over the entire period of available data will be calculated, with care to consider that different dynamics might be exhibited at the longer timescales. Capital flows are assessed on a ratio of flows to a country's GDP, as pointed out in Pagliari and Hannan (2017) and Neumann et al. (2009).

[40] https://data.jrc.ec.europa.eu/dataset/807d5d4f-2d73-4f17-81db-7ba2171bab83

[41] In a manner consistent with Neumann et al. (2009) and Forbes and Warnock (2012).

4. Descriptive Analysis of Optimum Currency Area Criteria and Optimality for the European Monetary Union

4.1 Results and Analysis for Economic Optimum Currency Area Criteria

4.1.1 Business Cycle Synchronicity Criterion

As mentioned in section 3.1) business cycle synchronicity was assessed for the time period ranging from 1999 to 2020 for nine different countries, five countries representative of the EMU periphery (Portugal, Spain, Italy, Ireland and Greece), and four non-EMU EU countries (Poland, Sweden, Hungary and the Czech Republic) and data was available on a quarterly basis. This criterion refers to comovement of real economic output gaps (gaps in real GDP), as such, greater comovement implies greater suitability for a country or group of countries to form a currency area with EMU.

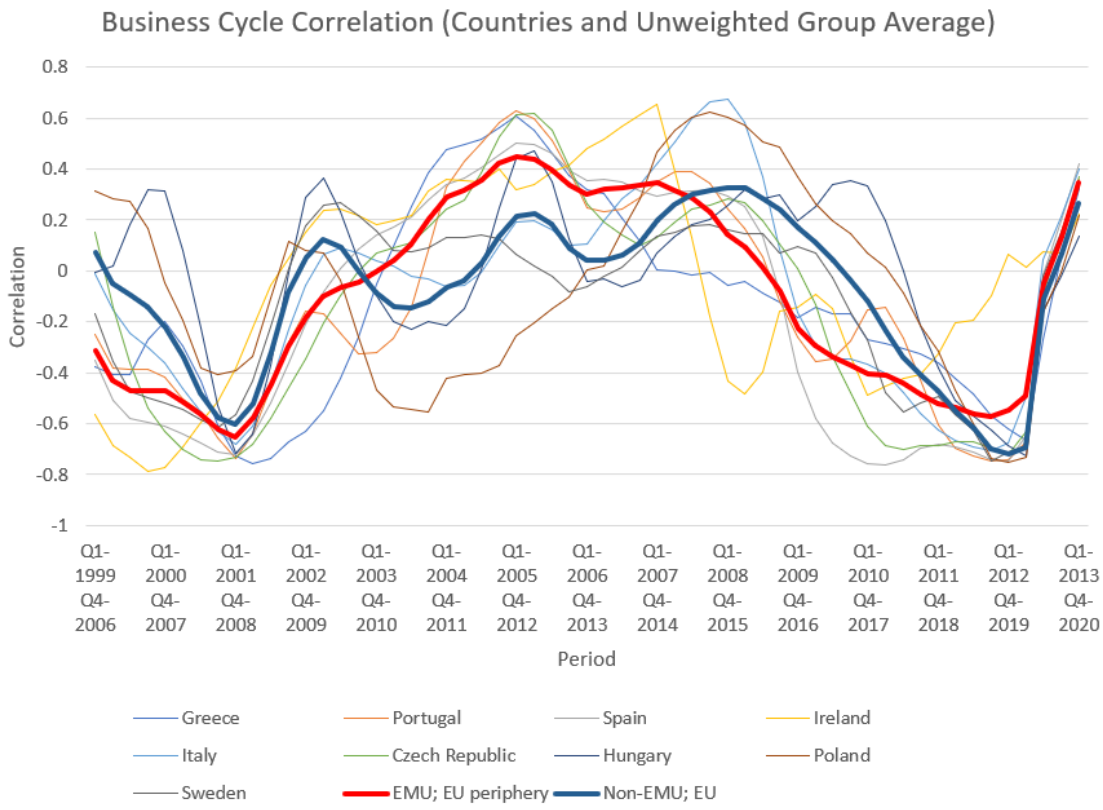
Table 1 – Business Cycle Correlation; EMU and Non-EMU EU countries; Q1-1999 Q4-2020

Business Cycle Correlation Q1-1999 to Q4-2020	
Countries	
Greece	0.446098
Portugal	0.781695
Spain	0.865609
Ireland	0.35919
Italy	0.913368
Czech Republic	0.835955
Hungary	0.734795
Poland	0.764264
Sweden	0.840544
Groups	
EMU; EU periphery	0.673192
Non-EMU; EU	0.79389

Note i – Business cycle synchronicity as assessed by the correlation index for the entire period between Q1-1999 and Q4-2020. Values for groups are an unweighted average, source is author's own calculations from data from the OECD data.oecd.org domain database. Refers to equation 3.1).

Regarding the business cycle synchronicity for the period between the Q1-1999 and Q4-2020 as assessed by the correlation indicator ρ_{BC_i}18, in Table 1, as seen in chapter 3, higher values imply more synchronized business cycles and a better assessment in terms of OCA. It appears that non-EMU EU countries exhibit a higher business cycle synchronicity as measured by correlation for the entire period of analysis than the EMU periphery countries, meaning they would be more suitable for EMU membership than the latter according to this criterion.

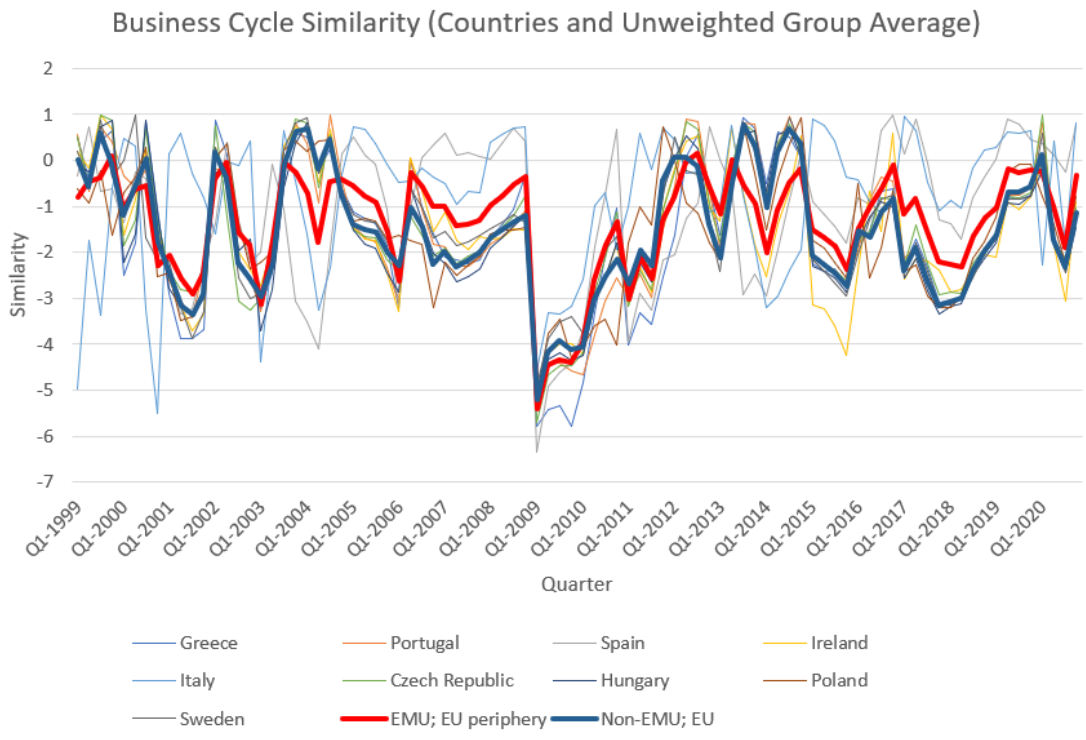
Figure 1 – Business Cycle Correlation; EMU and Non-EMU EU countries; 8 year periods



Note ii – Business cycle synchronicity as assessed by the correlation index over 8 year periods. Values for groups are an unweighted average, source is author's own calculations from data from the OECD data.oecd.org domain database. Refers to equation 3.2).

Regarding the business cycle synchronicity for 8 year periods between 1999 and 2020 as assessed by the correlation indicator $\rho_{BC_i}(t)$ as seen in Figure 1, as seen in chapter 3, higher values imply more synchronized business cycles and a better assessment in terms of OCA. We can observe that in general it tends to decrease from above 0.6 at the start for most countries to -0.7 until the period Q1-2002 Q4-2009 indicating OCA optimality decreased, to increase again until the period Q1-2005 Q4-2012 indicating OCA optimality increased, to decrease again until Q1-2012 Q4-2019 indicating OCA optimality decreased and finally we notice an increase for Q1-2013 Q4-2020 indicating OCA optimality increased. The decreased correlation for Portugal, Spain, Italy, Ireland and Greece between Q1-1999 and Q4-2009 is in agreement with Weyerstrass et al. (2011).

Figure 2 – Business Cycle Similarity; EMU and Non-EMU EU countries; Quarterly



Note iii – Business cycle synchronicity as assessed by the similarity index on a quarterly basis. Values for groups are an unweighted average, source is author's own calculations from data from the OECD data.oecd.org domain database. Refers to equation 3.3).

Regarding the business cycle similarity on a quarterly basis between 1999 and 2020 as assessed by the indicator $\gamma_{BC_i}(t)$ seen in Figure 2 for EMU EU periphery countries, as seen in chapter 3, higher values imply more synchronized business cycles and a better assessment in terms of OCA. Similarity appears to fluctuate around -1, hitting a minimum during Q1-2009. It is higher than non-EMU EU countries between Q1-2007 and Q1-2009, and between Q1-2017 and Q1-2020, meaning during these periods EMU EU periphery countries were better suited for EMU membership according to this criterion, however in other periods they would not have been better suited. In fact, in some periods of time such as from Q1-2014 Q1-2015, EMU EU periphery countries were less well suited for EMU than non-EMU EU countries. The large decline in similarity for Q1-2009, while not directly comparable with Hessel (2019), is congruent with the results of the author. The main disagreement of these results with literature is with the case of Greece, as Oman (2019) reports a sustained increase in similarity until Q1-2007 which cannot be observed in this analysis.

According to different measures of the business cycle synchronicity criterion, it cannot be said that EMU EU periphery countries are better suited for EMU membership than the other non-EMU countries being analyzed. During several periods of time, they appear to have economic outputs that are less synchronized with those of Germany. The correlation and similarity metrics produce opposite assessments for the financial crisis period. It is not clear exactly why without further inquiry, but as stated in the literature this suggests that while the business cycles themselves are correlated, there are differences in the positions in the cycle in terms of amplitude for example.

4.1.2 Economic Structure Dissimilarity Criterion

The dissimilarity of economic structure was assessed for the time period ranging from 1999 to 2020 for nine countries, Portugal, Spain, Italy, Ireland and Greece (EMU EU) and Poland, Sweden, Hungary and the Czech Republic (non-EMU EU). Data was available on an annual basis. This criterion ascertains how dissimilar economies are in terms of the goods that they produce, as such, greater dissimilarity implies lower suitability for a country or group of countries to form a currency area with EMU as mentioned in section 3.2).

Table 2 – Dissimilarity Index; EMU and Non-EMU EU countries; 1999 to 2020

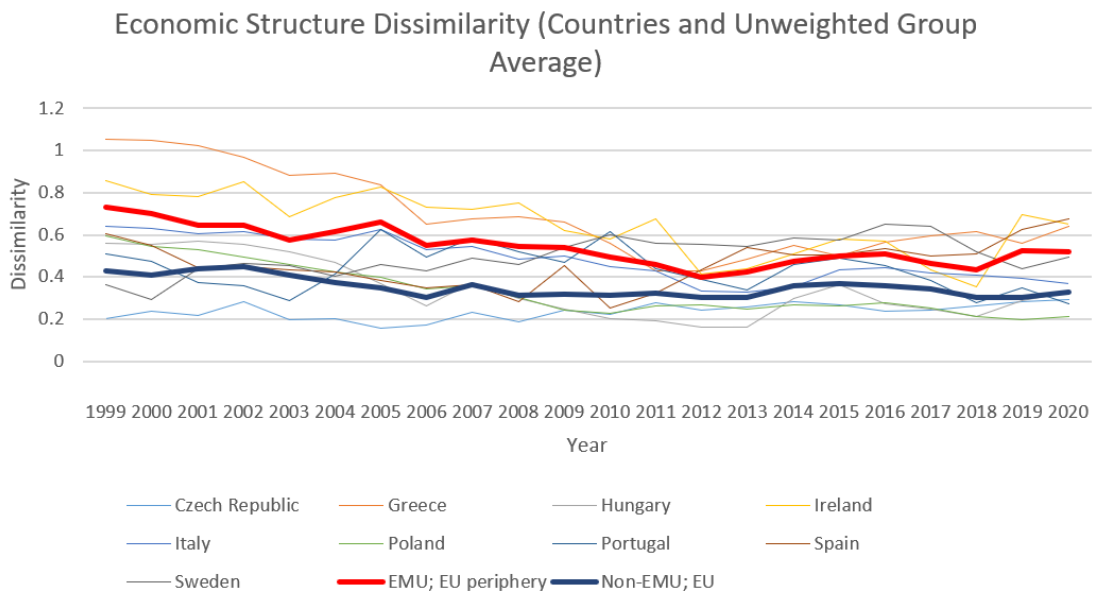
Dissimilarity Index 1999 to 2020	
Countries	
Czech Republic	0.23594
Greece	0.695232
Hungary	0.34121
Ireland	0.649758
Italy	0.485788
Poland	0.335692
Portugal	0.434836
Spain	0.461105
Sweden	0.497996
Groups	
EMU; EU periphery	0.545344
Non-EMU; EU	0.35271

Note iv – Economic structure dissimilarity as assessed by the dissimilarity index for the entire period between 1999 and 2020. Values for groups are an unweighted average, source is author's own calculations from data from the OECD BTDIxE database. Temporal mean for equation 3.4).

Regarding the economic structure dissimilarity for the period ranging from 1999 to 2020 as assessed by the dissimilarity index $Dissim_i$ as seen in Table 2, higher values imply stronger

asymmetric shocks at the sector level and a worse assessment in terms of OCA. We can observe that the economies of Greece and Ireland are the most dissimilar from the German economy, with values above 0.5. This implies they are less suited for EMU than the other countries in this set, as more dissimilar economies are likelier to exhibit shocks that are asymmetric. The Czech, Hungarian and Polish economies are more similar to the reference country than all of the EMU EU periphery countries, implying they are in fact more suitable to form a currency area with EMU than these countries which are already members. These results differ from Adámek and Kappel (2015) for the case of Portugal and Italy, but otherwise agree, and agree with Frydrych and Burian (2017) except for Sweden.

Figure 3 – Dissimilarity Index; EMU and Non-EMU EU countries; Annual



Note v – Economic structure dissimilarity as assessed by the dissimilarity index on an annual basis 1999 and 2020. Values for groups are an unweighted average, source is author's own calculations from data from the OECD BTDIxE database. Refers to equation 3.4).

Regarding the economic structure dissimilarity for the period ranging from 1999 to 2020 as assessed by the dissimilarity index $Dissim_i(t)$, higher values imply stronger asymmetric shocks at the sector level and a worse assessment in terms of OCA. We can verify that over time, in general, it has decreased for both groups of countries, which implies that as of 2020, these on average are better suited to form a currency area with the reference country than they were in 1999, as their economies are less dissimilar than those of Germany. In particular, the economy of Greece which was very dissimilar relative to Germany's at the start of this

period, more than those of other countries, is now converging with the others when assessed by this index.

During the entire period, the mean dissimilarity for non-EMU EU economies remains lower than the mean dissimilarity for the EMU EU periphery, which implies the former group as a whole is better suited for EMU than the latter according to this indicator. However, it should be noted that the dissimilarity for both these groups is decreasing with time. Economic dissimilarity relative to Germany, is lower as of 2020 than it was in 1999 in general, and this effect is stronger for EMU EU periphery countries, therefore these results show some support for the endogeneity hypothesis for EMU, and do not support the increasing specialization hypothesis. However, it is possible that a different data set with more fine-grained data would show different results, since the dissimilarity indices were calculated based on sectorial exports that contained a large consumer goods category, it could be the case breaking this category down into several types of goods would produce different outcomes.

4.1.3 Bilateral Trade Intensity Criterion

The intensity of trade linkages on a bilateral basis was assessed for the time period ranging from 1999 to 2020 for nine countries, Portugal, Spain, Italy, Ireland and Greece (EMU EU) and Poland, Sweden, Hungary and the Czech Republic (non-EMU EU). Data was available on an annual basis. This criterion ascertains how closely tied are countries in terms of trade, therefore, higher values imply a greater usefulness for the single currency in both microeconomic (reductions in transaction costs) and macroeconomic (there is less scope for a different currency if bilateral trade relations are stronger) terms.

Table 3 – Trade Index; EMU and Non-EMU EU countries; 1999 to 2020

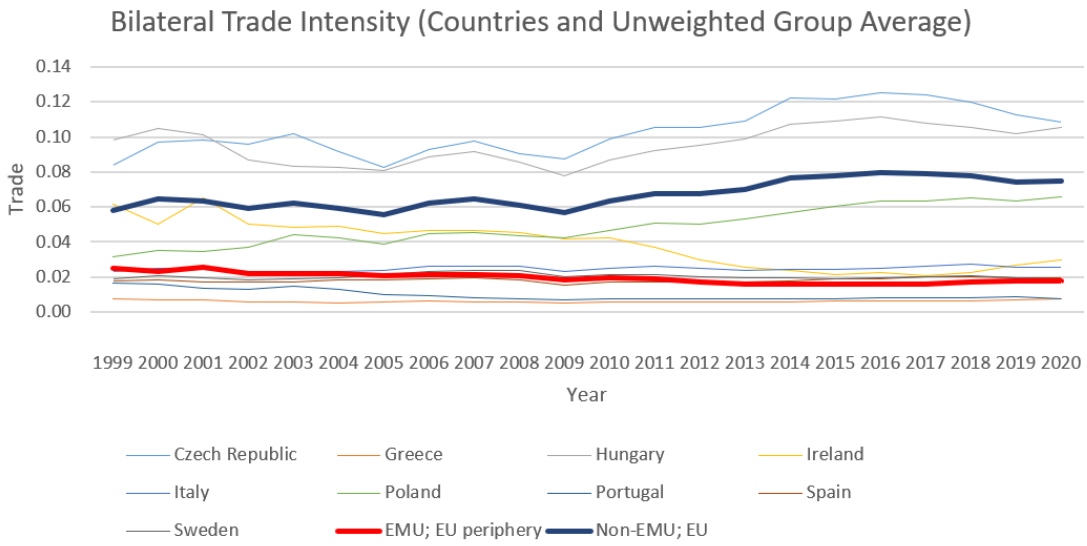
Bilateral Trade Index 1999 to 2020	
Countries	
Czech Republic	0.103297
Greece	0.006070
Hungary	0.095498
Ireland	0.038741
Italy	0.024676
Poland	0.049018
Portugal	0.009684
Spain	0.018116

Sweden	0.020382
Groups	
EMU; EU periphery	0.019458
Non-EMU; EU	0.067049

Note vi – Trade intensity as assessed by the bilateral trade index for the entire period between 1999 and 2020. Values for groups are an unweighted average, source is author's own calculations from data from the OECD BTDIxE database as well as the IMF World Economic Outlook database. Temporal mean for equation 3.5).

Regarding the bilateral trade intensity criterion for the period ranging from 1999 to 2020 as assessed by the trade index $Trade_i$ as seen in Table 3, higher values imply stronger trade links and a better assessment in terms of OCA. We can observe that as a whole, non-EMU EU countries appear to be more strongly tied to the reference country than EMU periphery, nearly three times as much in fact, driven by the high values achieved by Hungary and the Czech Republic, which implies as a group these economies are better suited for EMU than EMU periphery members according to the trade criterion. In relative terms, these results disagree with Adámek and Kappel (2015) for the case of Portugal and with Frydrych and Burian (2017) for the case of Sweden and Poland.

Figure 4 – Trade Index; EMU and Non-EMU EU countries; Annual



Note vii – Trade intensity as assessed by the bilateral trade index on an annual basis between 1999 and 2020. Values for groups are an unweighted average, source is author's own calculations from data from the OECD BTDIxE database as well as the IMF World Economic Outlook database. Refers to equation 3.5).

Regarding the time-dependent economic structure dissimilarity for the period ranging from 1999 to 2020 as assessed by the dissimilarity index $Trade_i(t)$, it can be verified that over time some countries deepened their trade ties with Germany, while some did not. In fact, the EMU EU periphery countries as of 2020 are on average maintaining the same level of trade integration with Germany than they did in 1999. On the other hand, non-EMU EU countries have increased their bilateral trade levels. This implies the latter grew more suitable for EMU membership over time, and are more suitable than EU periphery countries. Portugal in 1999 had the same level of trade integration with Germany than the EMU EU periphery average, however, over time, it diverged, decreasing its integration specifically with Germany. It is possible, however, that Portugal increased its trade integration with other countries in the EMU EU core. Ireland also markedly decreased its trade ties with German between 1999 and 2020, after the financial crisis, though again, it is possible it is now trading more with other countries in the EMU EU core. The results do not lend their support to the endogeneity hypothesis for this criterion.

4.1.4 Economic Openness Criterion

The mean openness of the economy between a reference country for EMU and another EU country basis was assessed for the time period ranging from 1999 to 2020 for nine countries, Portugal, Spain, Italy, Ireland and Greece (EMU EU) and Poland, Sweden, Hungary and the Czech Republic (non-EMU EU). Data was available on an annual basis. This criterion ascertains how open economies are on average, which *ceteris paribus* means a single currency has more benefits for these economies, therefore higher values are better.

Table 4 – Openness Index; EMU and Non-EMU EU countries; 1999 to 2020

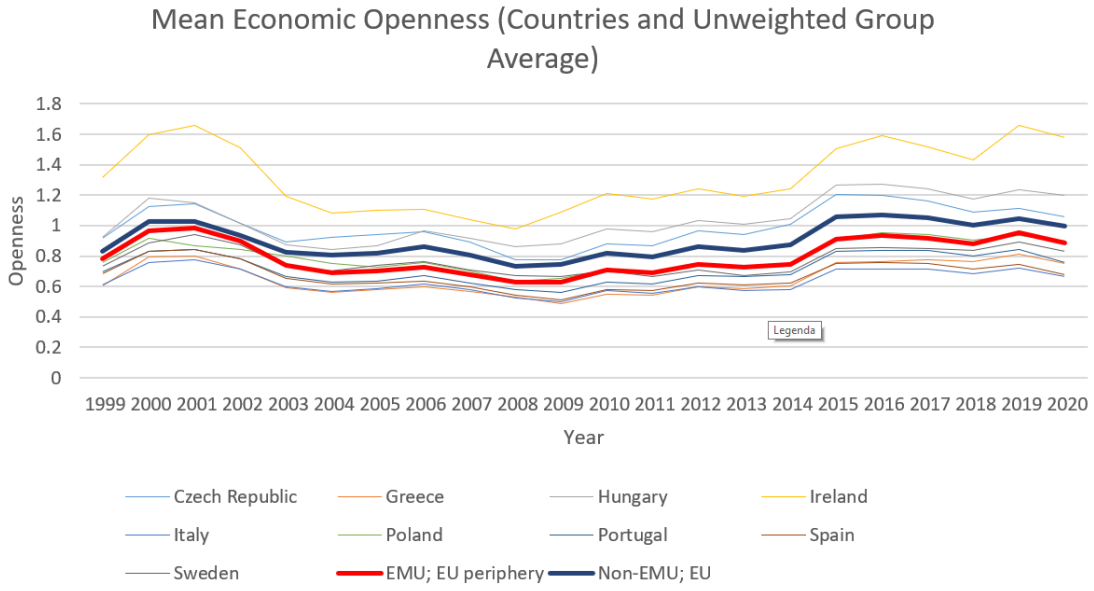
Mean Openness Index 1999 to 2020	
Countries	
Czech Republic	0.993527
Greece	0.651632
Hungary	1.040595
Ireland	1.3197
Italy	0.632802
Poland	0.798796
Portugal	0.713109
Spain	0.669368
Sweden	0.772263
Groups	

EMU; EU periphery	0.797323
Non-EMU; EU	0.901295

Note viii – Economic openness on a bilateral basis as assessed by the mean openness index from the period between 1999 to 2020. Values for groups are an unweighted average, source is author's own calculations from data from the OECD.Stat Data Warehouse database as well as the IMF World Economic Outlook database. Temporal mean for equation 3.6).

As for the economic openness criterion for the period ranging from 1999 to 2020 as assessed by the mean openness index $Openness_i$ as seen in Table 4, higher values imply more open economies and a better assessment in terms of OCA. We observe the mean openness of non-EMU EU countries is higher than EMU EU periphery countries, which means as a group they are more suitable for EMU membership than the latter group of countries. These results are congruent with Adámek and Kappel (2015).

Figure 5 – Mean Openness Index; EMU and Non-EMU EU countries; Annual



Note ix – Economic openness on a bilateral basis as assessed by the mean openness index on an annual basis between 1999 and 2020. Values for groups are an unweighted average, source is author's own calculations from data from the OECD.Stat Data Warehouse database as well as the IMF World Economic Outlook database. Refers to equation 3.6).

Regarding the time-dependent economic structure dissimilarity for the period ranging from 1999 to 2020 as assessed by the dissimilarity index $Openness_i(t)$, it is immediately apparent they have a high degree of comovement and that the dynamics driving the comoving evolution of this index are likely to be more relevant for this criterion than dynamics at the individual country level. The mean economic openness evolves positively in general for both

EMU EU periphery and non-EMU EU countries from 1999 until 2000 indicating they become better suited as members of EMU, decreasing until the year 2008 indicating EMU becomes a less optimal choice for them. After that point it increases until 2015, at which point it remains relatively unchanged, which indicates that in general, for both sets of countries and for this criterion, there has not been an improvement of EMU membership optimality since that time.

On an individual country level, the mean openness for Ireland is markedly above that of other countries across this series, while Spain and Italy have the lowest openness as of 2020, with Greece improving on this indicator since the start of the period in 1999.

The values of mean openness for 2020 are slightly higher than for 1999, however that is true for both groups of countries and a strong comovement is evident in these series, which indicates very limited support, if any, for the endogeneity hypothesis for EMU regarding this specific criterion.

4.2 Results and Analysis for Financial Optimum Currency Area Criteria

4.2.1 Financial Cycle Synchronicity Criterion

Financial cycle synchronicity was assessed for the time period ranging from 1999 to 2019 for nine countries, Portugal, Spain, Italy, Ireland and Greece (EMU EU) and Poland, Sweden, Hungary and the Czech Republic (non-EMU EU). Data was available on a quarterly basis. Higher values for the comovement financial cycles, *ceteris paribus*, imply better suitability for a country to be a member of EMU, for several important reasons. First, countries that lie on similar positions in the financial cycle are more likely to have less incompatibility in terms of the response of a monetary authority to evolving macroeconomic circumstances, since they would share similar financial conditions. Second, the financial cycle has been established as significantly procyclical, driving fluctuations in the business cycle, so dissimilar financial cycles are more likely to drive real economic output fluctuations in different directions or at least with different amplitudes.

Table 5 – Financial Cycle Synchronicity; EMU and Non-EMU EU countries; Q1-1999 Q4-2019

Financial Cycle Correlation; EMU and Non-EMU EU countries; Q1-1999 to Q4-2019	
Countries	
Czech Republic	0.446112

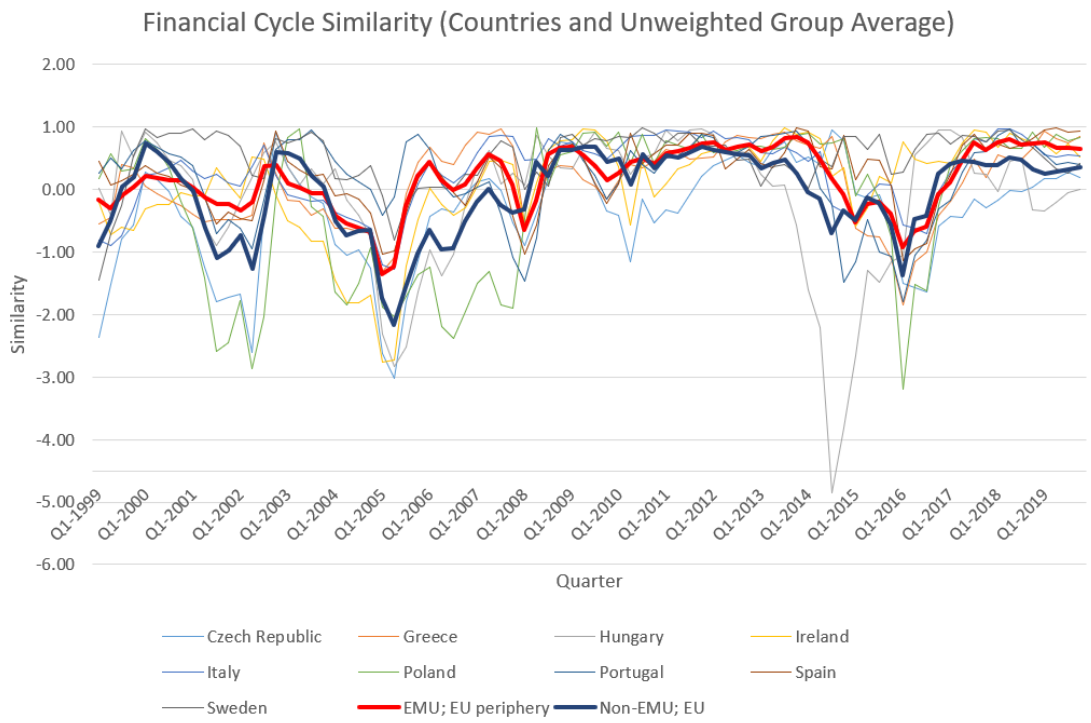
Greece	0.874523
Hungary	0.731183
Ireland	0.696303
Italy	0.886941
Poland	0.586803
Portugal	0.843927
Spain	0.867405
Sweden	0.943578
Groups	
EMU; EU periphery	0.83382
Non-EMU; EU	0.676919

Note x – Financial cycle synchronicity as assessed by the correlation index for the period between Q1-1999 and Q4-2019. The value for 2020 is missing due to lack of data availability. Values for groups are an unweighted average, Group averages are unweighted by GDP, source is author's own calculations from data from the OECD and from BIS. Refers to equation 3.7).

Regarding the financial cycle synchronicity for the period between the Q1-1999 and Q4-2019 as assessed by the correlation indicator ρ_{FC_i}, higher values imply more synchronized financial cycles and a better assessment in terms of OCA. As seen in Table 5, it can be observed that the Czech Republic and Poland exhibit the lowest synchronicities with the reference country Germany, which would make them less suitable for EMU membership according to this criterion. Hungary and Ireland exhibit similar levels of financial cycle synchronicity, thereby benefitting similarly from this criterion when assessing their optimality with EMU, with Ireland already being a member and Hungary not. Sweden has the highest synchronicity with the reference country for the period and benefits the most from this criterion, which would make it the most suitable for EMU membership. The other countries have synchronicity levels that are similar to that of their group. On average, EMU periphery countries have higher synchronicities than non-EMU countries, therefore they are better suited to form a currency area with the reference country. The period for this data makes any direct comparison with Adarov (2019) difficult, although both Sweden and Italy appear as relatively more correlated cycles in that analysis too. Furthermore, when assessing the cycle synchronicity via a concordance index, Adarov (2019) notes the cycles exhibit a high degree of comovement. While the results are not directly comparable to Oman (2019) which uses a concordance index and not a correlation, the main disagreement in relative terms seem is with the fact that in that Oman (2019) Portugal and Greece appear to have a notably lower cycle synchronicity than other countries. The difference in results could be the result of differences in constructing the financial cycle (Oman (2019) averages the three components,

while this dissertation uses principal component analysis to extract the first principal component) and the choice of filter.

Figure 6 – Financial Cycle Synchronicity; EMU and Non-EMU EU countries; Quarterly



Note xi – Financial cycle synchronicity as assessed by the similarity index on a quarterly basis between Q1-1999 and Q4-2019. The values for 2020 are missing due to lack of data availability. Values for groups are an unweighted average, source is author's own calculations from data from the OECD and from BIS. Refers to equation 3.8).

Regarding the business cycle similarity on a quarterly basis between 1999 and 2020 as assessed by the indicator $\gamma_{FC_i}(t)$ higher values imply more synchronized financial cycles and a better assessment in terms of OCA. As seen in Figure 6, we can observe that in general, synchronicity as assessed by this indicator oscillates more for non-EMU EU countries than EMU EU periphery countries. Important local minima in this indicator occur for Q2-2005 and Q1-2016, when the financial cycles from these countries was most dissimilar from that of the reference country.

On an individual country level, until Q2-2005, the synchronicity of both the Czech Republic and Poland oscillates and is lower than that of other countries, which is a negative assessment of their optimality for EMU membership. The synchronicity of Ireland is always markedly lower than that of other countries until Q2-2005, converging with the mean of its group

afterwards. During the period of time between Q2-2005 and Q1-2008, Poland has a lower synchronicity than other countries and the financial cycle for Hungary is very dissimilar than that of the reference country between Q3-2013 and Q2-2015, in fact reaching the absolute minimum for these time series in Q3-2014, which produce a negative assessment of optimality from the perspective of this criterion. In general, synchronicity is higher in 2019 than it was in 1999 for both groups of countries, indicating it improved over time, and this even more true for EMU EU periphery countries, lending some support to the hypothesis this criterion is endogenous for EMU. These results are different than those of Hessel (2019), which calculates medium term fluctuations in a methodologically very different way.

4.2.2 Capital Flows Volatility Criterion

Capital flow volatility was assessed for the time period ranging from 2001 to 2018 for nine countries, Portugal, Spain, Italy, Ireland and Greece (EMU EU) and Poland, Sweden, Hungary and the Czech Republic (non-EMU EU). Data was available on an annual basis, broken down by the type of flow (FDI and portfolio flows) and the direction of flow (inflows from the reference country, and outflows to the reference country). The database[40] used does not have data for other time periods and no other database was available. Higher volatility is associated causally with bilateral exchange rate volatility and has been found to directly excite business cycles, therefore from the perspective of OCA theory a higher value in each indicator implies a lower suitability for EMU membership.

Table 6 – Capital Flow Volatility; Inward and Outward flows from the reference country; EMU and Non-EMU EU countries; 2001 to 2018

Volatility of Capital Flows; Direction (inflows from and outflows to the reference country) and Type (FDI and portfolio); 2001 to 2018				
	FDI Inflows	**Portfolio Inflows**	**FDI Outflows**	**Portfolio Outflows**
Countries				
Greece	0.001979	0.020393	0.000486	0.005248
Portugal	0.002111	0.014511	0.001313	0.009912
Spain	0.00263	0.01327	0.002238	0.009035
Ireland	0.013219	0.032717	0.011789	0.052227
Italy	0.003506	0.008819	0.003695	0.009425
Czech Republic	0.004465	0.003115	0.005735	0.002075
Hungary	0.010579	0.009358	0.008844	0.001678
Poland	0.002479	0.002835	0.000594	0.000895
Sweden	0.007795	0.003555	0.003931	0.007182
Groups				

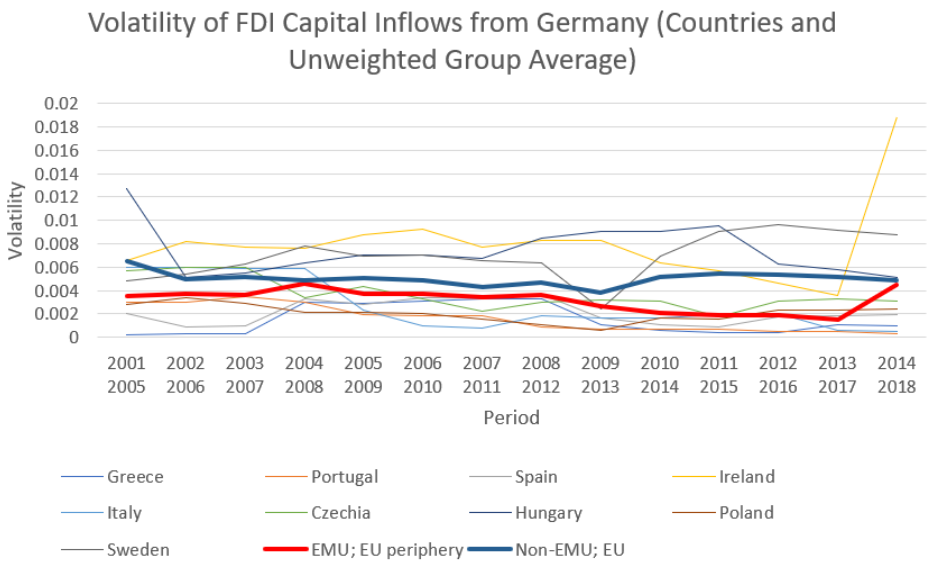
EMU; EU periphery	0.004689	0.017942	0.003904	0.017169
Non-EMU; EU	0.006329	0.004715	0.004776	0.002957

Note xii – Capital flow volatility as assessed by the standard deviation for the period between 2001 and 2018. Values for 1999, 2000, 2019 and 2020 are missing due to lack of data. Values for groups are an unweighted average, source is author's own calculations from data from the EU Finflows JRC-ECFIN database. Refers to equation 3.10).

Regarding the volatility of capital flows as assessed by the indicator $\sigma_{type,dir,i}$ as seen in Table 6, higher values imply more volatile flows and a worse assessment in terms of OCA. The results show that, broadly speaking, for EMU EU periphery countries the volatility of FDI is slightly lower than the volatility of portfolio flows relative to non-EMU EU members (and regarding FDI outflows, the difference does not appear to be very significant), while for portfolio capital flows EMU EU periphery countries exhibit higher volatility over this period of time. Furthermore, the maximum volatility occurs for portfolio flows from and to the reference country in EMU EU periphery countries.

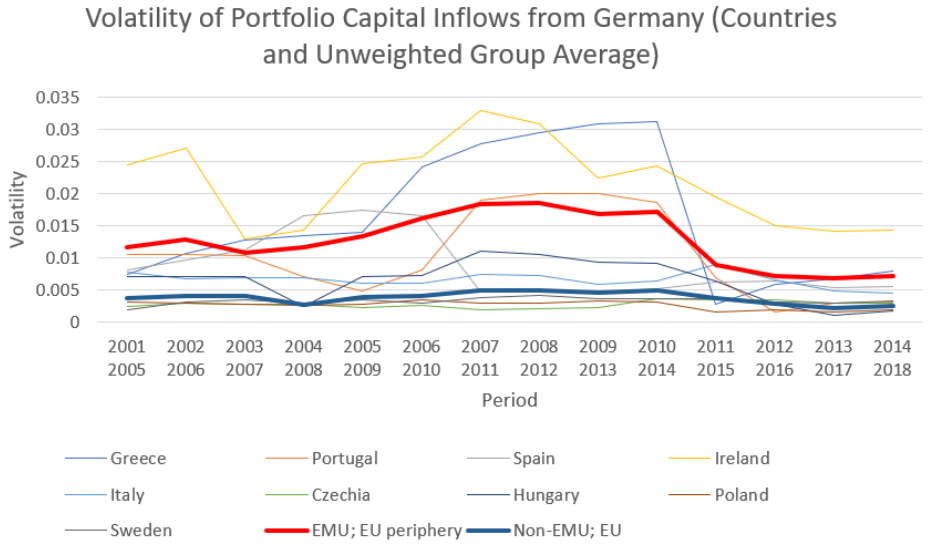
As for FDI inflows, Ireland and Hungary exhibit higher levels of volatility than other countries, while it is lower for Poland, Greece and Portugal. This suggests the former countries are less suited for EMU membership from this perspective relative to the latter. Other countries exhibit volatilities that seem to cluster together. Regarding portfolio inflows, Greece and Ireland exhibit higher levels of volatility than other countries, while it is lower for the Czech Republic, Poland and Sweden. This suggests the former countries are less suited for EMU membership from this perspective, while the latter are more suited. Other countries have volatilities that seem to cluster together. Considering FDI outflows, Ireland appears to be an outlier with higher volatility, while Poland and Greece have lower levels of volatility. This suggests Ireland is less suited for EMU membership from this perspective, while the latter are more suited, despite Ireland being a member already and Poland not. The other countries have comparable volatilities. Lastly, considering portfolio outflows for the entire period, the volatility of Ireland is a clear outlier in that it is very higher than that of other countries, while the volatility of Poland is clearly lower. This suggests Ireland is less suited for EMU membership from this perspective, while Poland is more suited, despite Ireland being a member already and Poland not.

Figure 7 – Capital Flows Volatility (Inward from Germany; FDI); EMU and Non-EMU EU countries; 5 year rolling window



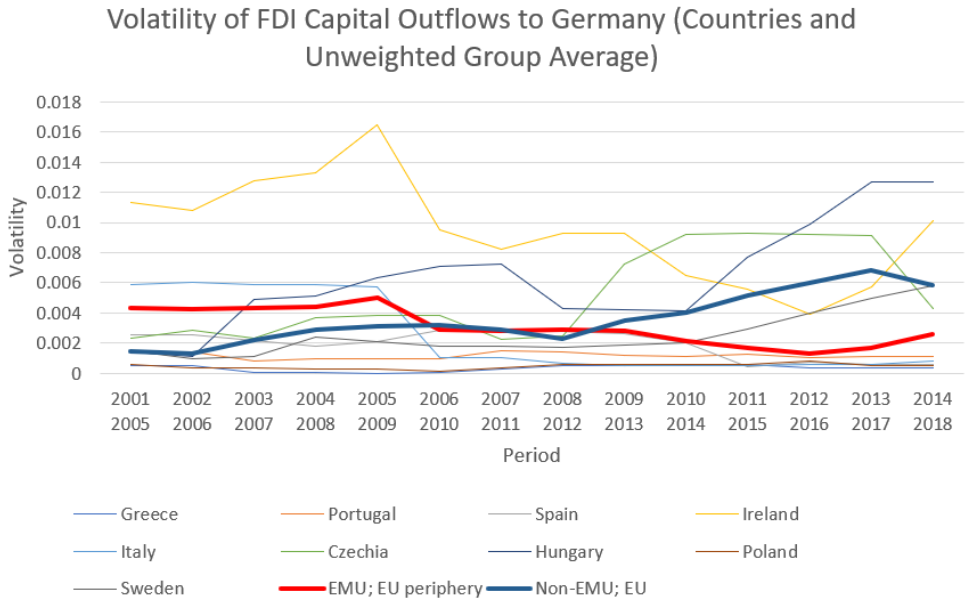
Note xiii – Capital flows volatility as assessed by rolling 5 year standard deviations for the period between 2001 and 2018. Values for 1999, 2000, 2019 and 2020 are missing due to lack of data. Values for groups are an unweighted average, source is author's own calculations from data from the EU Finflows JRC-ECFIN database. Refers to equation 3.9).

Figure 8 – Capital Flows Volatility (Inward from Germany; Portfolio); EMU and Non-EMU EU countries; 5 year rolling window



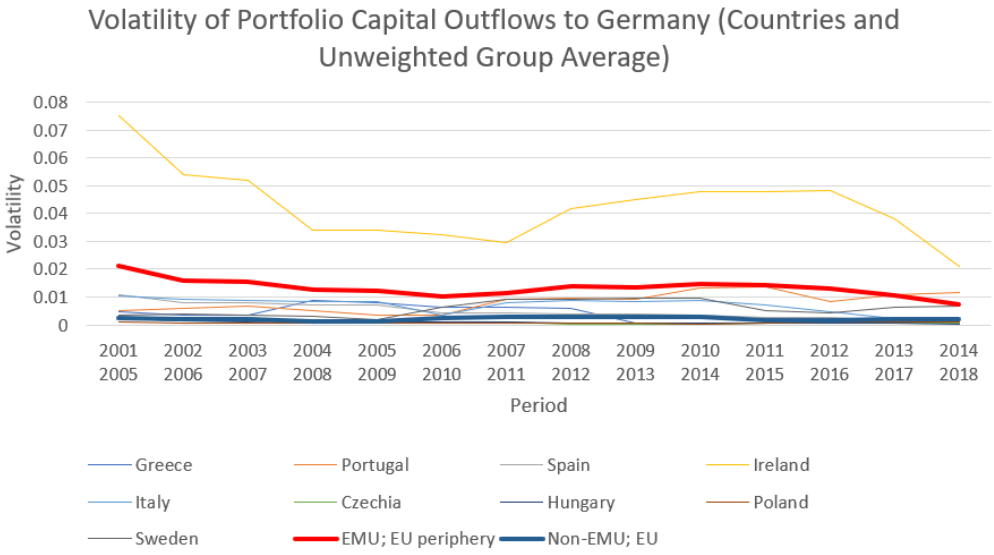
Note xiv – Capital flows volatility as assessed by rolling 5 year standard deviations for the period between 2001 and 2018. Values for 1999, 2000, 2019 and 2020 are missing due to lack of data. Values for groups are an unweighted average, source is author's own calculations from data from the EU Finflows JRC-ECFIN database. Refers to equation 3.9).

Figure 9 – Capital Flows Volatility (Outward to Germany; FDI); EMU and Non-EMU EU countries; 5 year rolling window



Note xv – Capital flows volatility as assessed by rolling 5 year standard deviations for the period between 2001 and 2018. Values for 1999, 2000, 2019 and 2020 are missing due to lack of data. Values for groups are an unweighted average, source is author's own calculations from data from the EU Finflows JRC-ECFIN database. Refers to equation 3.9).

Figure 10 – Capital Flows Volatility (Outward to Germany; Portfolio); EMU and Non-EMU EU countries; 5 year rolling window



Note xvi – Capital flows volatility as assessed by rolling 5 year standard deviations for the period between 2001 and 2018. Values for 1999, 2000, 2019 and 2020 are missing due to lack of data. Values for groups are an unweighted average, source is author's own calculations from data from the EU Finflows JRC-ECFIN database. Refers to equation 3.9).

In general, a direct comparison with Pagliari and Hannan (2017)[42] is difficult, however the main difference between the two results is that a noticeable peak of volatility between 2005 and 2015 (therefore, centered around 2010) occurs only for portfolio inflows from Germany.

Regarding the volatility of capital flows as assessed by the indicator $\sigma_{FDI,Inward,i}(t)$ as seen in Figure 7, it falls notably over time for EMU EU periphery countries, however it increased markedly in the period between 2014 and 2018, driven by a large increase in volatility for Ireland. Excluding this outlier shows a consistent decrease in volatility over time for this group of countries. Since this effect is stronger for EMU EU periphery countries than for non-EMU EU countries (in fact, volatility for this group appears to be largely unchanged) if Ireland is excluded so as not to allow a specific large shock to dominate the analysis, these results show some support for the endogeneity hypothesis for EMU.

As for the volatility of capital flows as assessed by the indicator $\sigma_{Portfolio,Inward,i}(t)$ as seen in Figure 8, this indicator rises notably at first beginning in 2001 to 2005 for EMU EU periphery countries, with a peak in a period between 2007 and 2012, but afterwards it declines to levels lower in the 2014 to 2018 than they were in the beginning. For non-EMU EU countries, the volatility remains consistently low, lower than the previous group. Depending on the cyclicity of the dynamics of capital flows, since for EMU EU periphery countries the period between 2014 and 2018 exhibits lower volatility than the period between 2001 and 2008, with the period corresponding to the financial crisis having high volatility, while the non-EMU EU countries do not improve their volatility assessments, the results could be interpreted as showing some support for the endogeneity of OCA for this criterion. However, if the high volatility episode is recurrent in this time series, which will require observing its evolution in the future, the previous interpretation might not hold.

Regarding the volatility of capital flows as assessed by the indicator $\sigma_{FDI,Outward,i}(t)$ as seen in Figure 9, there can be broadly said to exist a reversal of the relative volatility for these groups of countries between 2001 and 2018. In 2001 to 2005, EMU EU periphery countries had a higher volatility than non-EMU EU countries, while by 2007 to 2011 they had the same volatility, and by the 2014 to 2018 rolling window the volatility of non-EMU EU

[42] The authors calculate their results for a group of 33 countries, not on a bilateral basis relative to Germany.

countries was higher than that of the former group. Therefore, over time, according to this indicator, EMU EU periphery countries improved their suitability for EMU, and there is some evidence to support the endogeneity for this OCA criterion. In terms of individual countries, Italy and Ireland in the 2001 to 2005 period have higher volatilities than the other countries, while by the 2014 to 2018 period, Hungary, Ireland, Sweden and the Czech Republic exhibited higher volatility, making them less suitable to join EMU than Italy, an EMU member. The volatility for Ireland peaked in the 2005 to 2009 rolling window, but it still remains elevated as of the 2014 to 2018 period, meaning it is less suitable for EMU membership, despite being a member.

As for the volatility of capital flows as assessed by the correlation indicator $\sigma_{Portfolio,Outward,i}(t)$ as seen in Figure 10 (portfolio outflows toward the reference country), the analysis of these dynamics is clearly dominated for the outlier, which is Ireland. The volatility for Ireland for this indicator hits the maximum for all indicators of volatility in the 2001 to 2005 period, decreases until 2007 to 2011, rises again and decreases yet again for the 2014 to 2018 period, in which it remains still twice as high as the next country, which is Portugal. The suitability of EMU for Ireland from the perspective of this indicator is questionable, however, over time, it converges with the mean for the EMU EU periphery, meaning it is not as much of a mismatch for EMU, and this is despite Ireland already being a member. As for Portugal, the volatility increases between 2001 to 2018 until it hits the second highest value from 2014 to 2018, although it is not clear if this is significant in light of the large volatility of Ireland, but it does imply a less optimal assessment of the decision to join EMU in the posterior period. On the other hand, the volatility for Italy is as high as Portugal in the first period of analysis, 2001 to 2005, however Italy converged with the main cluster of countries as of 2014 to 2018. For this main cluster of countries, volatility remains more or less constant over time.

4.3 Summary of Results

It is important to consider that this analysis[43] is limited by the absence of empirically verifiable statistical significance for these criteria and the availability of the data for more

[43] Being descriptive in nature, no calculations were made that would allow to establish whether the results are statistically significant for the indicators.

countries (in particular, data for Romania, Croatia, and Bulgaria could not be found for several important financial variables).

As for the economic OCA criteria, these tend to produce more positive assessments for the non-EMU countries. Business cycle synchronicity is lower and dissimilarity is higher for EMU countries, implying higher levels of asymmetric shocks and a lower assessment in terms of OCA optimality. A result for business cycle synchronicity is that when assessed on a rolling window basis, the correlation and similarity between business cycles during the financial crisis tend to show different results; as pointed out by Hessel (2019) this can imply the cycles are not significantly out of phase, but have very different amplitudes.

The bilateral trade criterion shows non-EMU EU countries to be more strongly linked to the reference country than EMU periphery, and regarding the economic openness criterion, it is not clear that EMU periphery countries fare worse in this criterion if Greece is removed from the analysis. There is a clear comovement between all series, suggesting the time-evolution of this criterion is being driven by common factors.

As for the financial OCA criteria, these tend to produce more mixed results, as opposed to the economic criteria. More specifically, for the case of financial cycle synchronicity the EMU periphery countries achieve better performance than non-EMU countries. Given the procyclical nature of these cycles, they are deemed to be better suited for EMU membership from the perspective of this criterion. The time-varying analysis shows two events of desynchronicity, one during the financial crisis and another in 2017.

Regarding the capital flow volatility criterion, the EMU periphery countries exhibit a higher volatility of portfolio flows, while non-EMU countries exhibit a slightly higher volatility of FDI flows, regardless of the directional basis, which implies that, from the perspective of portfolio flows, EMU periphery countries are less well suited for EMU in terms of this criterion. As for the dynamics of these flows, there is an episode of large volatility in portfolio inflows for EMU periphery countries from the reference country consistent with the financial crisis. Furthermore, regarding outward flows of FDI, the mean volatility for EMU periphery and non-EMU countries reversed itself over the period from 2001 to 2018, with EMU periphery countries faring better at the end of the period in analysis.

5. Conclusion

This dissertation sought to establish the theoretical justifications for meaningful real and financial criteria of currency area optimality, and to analyze in a descriptive manner the optimality of two sets of countries for the European Monetary Union since the inception of the euro area. In particular, the optimality of EU periphery members of the European Monetary Union was assessed (Portugal, Spain, Greece, Italy and Ireland), as well as the optimality of a set of non-members (Poland, Sweden, Hungary and the Czech Republic; Denmark, Croatia, Bulgaria and Romania were excluded from the analysis).

Optimum currency area theory literature has a set of well established criteria based on the real part of the economy. However, the financial part of the economy cannot be disregarded in the study of currency areas. In particular, the financial cycle and capital flows are shown in literature to play an important role in impacting real macroeconomic variables, as well as the bilateral exchange rate between two countries.

As for the well established OCA criteria, dealing with the real part of the economy, results show that EMU EU periphery members are less suited for membership in the currency union than the non EMU members, for all indicators analyzed. In particular, for the two indicators that are related to asymmetry of shocks[44], Ireland and Greece appear to fare worse than other countries. A pertinent result for the business cycle synchronicity criterion is that two synchronicity metrics produce opposing results during the financial crisis period. Further investigation would be required to tell why, however, it is suggested in the literature this could be because of a divergence in the amplitude and not necessarily the phase of the business cycles during this period. The other OCA criteria dealing with the real part of the economy show that Greece tends to fare worse than other countries, with non EMU members in general faring better. The performance of EU EMU members in the bilateral trade indicator appears to not have improved significantly with time, however, note that this indicator only refers to trade with Germany. Another pertinent result is that the time series for the openness criterion appear to exhibit a high degree of comovement, suggesting a common factor is driving their evolution over time.

[44] To recall, these are business cycle synchronicity and economic structure dissimilarity.

Regarding the financial cycle synchronicity, it required constructing synthetic cycles that are representative of the financial part of the economy. They were described[45] in terms of credit levels in the economy, as well as asset prices for all of the countries in this analysis. In general the EU EMU member countries appear to have their cycles more synchronized with those of the reference country for the euro area. This is desirable due to the procyclical nature of the financial cycle relative to the business cycle, as well as for reasons of lessening conflicts in monetary policy. In general, financial cycles became desynchronized in two moments, one coinciding with the financial crisis and another one in 2017. Hungary reached the minimum synchronicity as assessed by similarity in 2015 for all time series.

As for capital flow volatility, it was described using the standard deviation in flows. The literature suggests[46] that disruptions in the economy are not the same depending on direction and type of flows. An important result is that volatility for FDI appears to be higher for non-EMU member countries, while EMU countries experienced higher volatility in terms of portfolio flows. There also appears to be a difference between the volatility of portfolio inflows and outflows for non-EMU countries, with the former being higher. Another result is that the volatility of portfolio inflows to EMU member countries appears to be higher between 2007 and 2014.

In general, economic OCA indicators tend to disfavor the periphery EMU members, with the financial indicators producing mixed results.

This dissertation consisted of a descriptive analysis; therefore, care must be taken not to use these results conclude things on a statistically significant level. Other limitations encountered were the lack of availability of data for both Croatia, Romania and Bulgaria required for calculating many of the indicators, the lack of data at frequencies higher than one year for most indicators, and missing data for some time periods for the capital flows calculations. Future avenues of research include constructing better datasets in order to allow the aforementioned countries to be included, as well as estimating the statistical significance of each criteria in a joint estimation and broadening the analysis to regions other than Europe.

[45] Ideally, housing prices would have been included but these were not available neither for all countries nor at a quarterly frequency.
[46] Rapid shifts in inflows and in portfolio flows impact the normal functioning of an economy the most.

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Annex 1 – Table with the real output gaps

	OUTPUT GAP									
Time	Germany	Greece	Portugal	Spain	Ireland	Italy	Czechia	Hungary	Poland	Sweden
Q1-1998	-20458.2	-7560.14	1612.58	-17226.7	-1875.87	-4799.13	-5276.26	-4150.77	-5542.11	1606.91
Q2-1998	995.729	-5879.62	1202.15	-15879.6	-1934.98	-9375.07	-4260.63	-3304.39	-814.486	1491.92
Q3-1998	-1449.46	-3897.37	938.415	-11976.8	-3127.21	-5887.32	-2759.31	-2437.91	-676.203	2440.53
Q4-1998	17086.2	-1964.19	1277.01	-6303.58	2196.01	11791	-796.722	-558.683	2265.22	2257.1
Q1-1999	-1153.21	346.34	157.297	2907.33	1287.22	16864.7	333.305	2091.88	3713.87	1285.97
Q2-1999	9635.49	1944.2	477.025	8108.7	3295.98	24608.6	1039.86	2748.12	-883.766	1626.56
Q3-1999	1428.81	4320.93	54.2543	9806.51	1389.66	23268.9	1526.71	2717.45	-4687.63	752.893
Q4-1999	2161.14	3542.36	-192.256	8557.41	836.051	8475.97	1614.3	2721.48	-8181.92	-3223.52
Q1-2000	-8968.42	4587.03	-3745.98	135.892	1228.99	-6968.56	2099.07	3514.13	-2381.48	-5131.53
Q2-2000	-10362.6	4659.54	-1816.87	-3600.18	-441.228	-14075	1873.71	3555.79	-3065.76	-10211.8
Q3-2000	2231.78	2932.86	-3352.54	-4376.95	-1462.35	-17698.7	695.054	2892.98	-1105.73	-10416.2
Q4-2000	17878.2	2191.72	-2966.57	-3184.49	-755.263	-32095	372.485	1648.39	-9309.12	-6344.72
Q1-2001	-26923.1	1497.02	-589.936	-1386.55	-1185.54	-33166.7	-2248.95	784.199	-1733.48	-3541.66
Q2-2001	-25635.2	3678.5	-1241.97	452.722	-714.677	-23194.6	-2708.15	-514.838	1212.46	-627.4
Q3-2001	-19263.5	1564.16	-419.731	-1170.37	783.569	-13790.7	-2787.78	-725.563	-562.456	1568.2
Q4-2001	-14336.6	2110.2	-2609.7	-3168.28	964.086	-7965.2	-2094.45	-236.493	-941.329	772.862
Q1-2002	384.904	768.139	-2852.2	-6010.87	-1577.53	-6585.59	1066.41	-3081.29	-2155.52	2330.32
Q2-2002	-6320.39	-2853.01	-1762.42	-8664.19	-315.468	-10279.3	2286.85	-2223.58	-3875.48	-124.757
Q3-2002	-18033.5	-1456.93	-823.466	-5819.14	-2299.06	-12151	3372.27	-2452.43	-5497.14	704.525
Q4-2002	-14344.4	540.683	609.157	-786.514	-89.5167	-16776.2	3582.32	-2827.87	-126.003	2543.75
Q1-2003	26361.2	842.155	579.058	8340.54	3939.67	-6023.15	2278.18	-1989.95	7015.48	2862.76
Q2-2003	30792.2	1436.06	3696.57	21521.8	6066.79	5010.83	1908.06	-1537.27	5381.63	7587.79
Q3-2003	12013.4	3360.06	3346.15	29372.3	6217.74	14952.1	2148.55	-1427.19	5601.77	5604.52
Q4-2003	3354.55	417.999	4691.86	32828.7	1381.44	13811.1	2520.96	-1214.91	7596.47	4636.46
Q1-2004	515.156	-3265.56	5439.86	35630.8	3552.82	20741.2	1934.65	-875.333	-5694.89	-81.2673
Q2-2004	-12267.4	-928.926	5967.79	35577.7	1650.47	27654.9	2579.79	-164.098	-6819.71	-343.655
Q3-2004	7502.29	-662.46	7402.99	39323.2	3822.91	43939.6	2793.47	1163.89	1367.71	1367.97
Q4-2004	32233.5	5502.25	8536.94	46331.1	3669.88	53759.7	2519.34	2951.25	3369.41	4907.29
Q1-2005	63766.9	13176.6	6627.83	51834.7	4968.8	69882.1	4107.73	3854.65	8310.16	11567.4
Q2-2005	76037.3	16409.2	5236.8	52548.3	4619.61	67286.5	5952.17	2088.72	16833.4	15276.6
Q3-2005	67194.9	13723.8	4910.35	42674.7	5514.83	53096	6570.74	1952.98	15119.3	14368
Q4-2005	61534.3	11138.1	2808.3	25120.2	652.306	42212	5627.89	880.665	13703.3	12711.4
Q1-2006	37048.5	-2267.27	-1363.69	-2172.19	-3045.07	23304.2	5214.67	745.061	12375	6281.64
Q2-2006	-11292.2	-5053.51	-5216.73	-24501.5	-5229.4	-1893.74	2991.62	-1352.48	6494.55	-850.137
Q3-2006	-28468.3	-5486.96	-4731.45	-39375.4	-9516.2	-14923.8	1624.4	-1709.48	3972.14	-5203.22
Q4-2006	-56056	-8732.29	-4249.65	-44158.3	-9451.92	-31031.5	435.81	-1014.31	20646.2	-6907.33
Q1-2007	-58434.2	-1259.83	-5068.85	-50793.1	-19180	-30859.7	-4561.06	1610.83	940.118	-11735.1
Q2-2007	-75762.3	-7142.46	-4456.23	-56588.6	-16335.4	-33474	-5656.29	2826.66	228.563	-13790.6
Q3-2007	-82465.5	-4695.96	-3931.79	-62756.9	-12058.2	-42177.8	-8889.43	1553.02	-4078.42	-16081.8
Q4-2007	-93357.4	-5448.46	-6677.16	-68274.2	-19186.8	-45940.7	-10824.3	73.7415	-7652.57	-20367.1
Q1-2008	-104760	-12858.3	-7474.99	-71457.4	-11493.3	-83643.2	-11601.6	-4566.97	-15800	-19246.1
Q2-2008	-99232.7	-16240.7	-7426.98	-76923.7	-6895.44	-84085.7	-14247.2	-7069.89	-12897.4	-18693
Q3-2008	-93055.3	-21930.1	-9276.43	-82909.4	-7390.11	-82293.3	-17032.4	-8551.81	-5908.71	-17478.5
Q4-2008	-47954.9	-21283.9	-6451.74	-59194	1930.78	-42375.8	-12464.7	-4411.63	603.705	-1365.07
Q1-2009	98346.8	-7527.72	646.725	-16313.2	4252.69	11285.2	-6071.7	2875.12	2574.07	6172.92
Q2-2009	107150	-19003.8	923.119	-9155.17	5326.56	22685.2	-4070.65	2539.94	13941.7	11310.8
Q3-2009	105097	-19854.5	-1735.21	-5843.06	6711.57	19587.2	-3057.04	2457.86	17006.1	16117.8
Q4-2009	98670.8	-24432.4	-2559.59	749.318	8391.48	22773.8	-483.123	1758.4	2476.95	18969.1
Q1-2010	100418	-8464.78	-5328.85	12861.7	3045.27	33575.6	3566.97	2581.66	6028.13	11093.5
Q2-2010	47977.1	-1892.66	-7336.75	14606.4	1483.63	25071.9	3459.1	892.631	-4894.19	7663.51
Q3-2010	38446.9	4532.81	-6605.7	19047.7	-950.708	19480.3	3802.99	-929.3	-10869.5	5865.01
Q4-2010	16418.8	4077.87	-5215.52	14481	-762.06	-1532.46	3479.83	-639.613	-14064.2	204.738

Annex 2 – Table with the real output gaps

Q1-2011	-49370.5	10945.4	-1655.61	10091.1	-87.1454	-25224.6	809.208	-3315.9	-15657.3	-2808.68	
Q2-2011	-50753.4	12615.8	161.592	6444.01	-2256.51	-44593.3	-962.359	-3502.07	-21073.5	-4226.06	
Q3-2011	-71287.6	13535.8	2391.18	7700.85	562.671	-48886.3	-556.054	-3986.62	-26801.4	-9481.37	
Q4-2011	-26657.4	21498.4	7323.36	16535.3	1620.61	-30694.8	1479.14	-4405.41	-23015.5	-2713.63	
Q1-2012	-8761.8	18946.4	7673.91	23322.9	3447.08	-14580.6	4527.08	1300.32	-19244.4	-3620.73	
Q2-2012	9064.45	18651.7	10002.5	32710.7	2897.33	-4225.09	7532.82	4293.19	-10916.2	-3742.17	
Q3-2012	12193.8	16926.2	10539.2	32728.1	7262.38	-1253.1	8716.75	4359.9	-10605.2	-1593.08	
Q4-2012	31727.2	12718.4	11489.7	35081	7279.12	6287.68	8237.19	4203.05	-1867.69	1627.04	
Q1-2013	47426	9621.25	6100.41	33570	14145.8	18669.6	7589.28	2977.65	1954.74	-1446.21	
Q2-2013	16957.6	4734.11	1483.83	32694.5	14068.4	19310.9	5431.73	1202.94	-269.531	2217.25	
Q3-2013	2172.62	1550.06	740.563	32090.8	15155.7	15637.6	3510.4	-1060.77	741.124	3371.21	
Q4-2013	-4798.66	-1854.27	-2644.84	29944.3	23402.7	23883.3	-917.832	-1265.62	8136.49	3102.77	
Q1-2014	-23866.1	-2600.69	1556.94	32154.2	25974.1	35743.8	2597.3	-223.808	11824.1	5003.32	
Q2-2014	-6546.97	-1476.28	2238.86	32239.7	24864.1	45522	1428.23	-637.23	11587.7	4846.62	
Q3-2014	4635.3	-3009.27	4136.59	32415.5	29699.2	56091.8	1586.7	-197.639	14099.4	5801.3	
Q4-2014	20663.2	1068.52	4453.04	37739.3	30362.8	81172.4	3789.24	1573.8	19427.5	6585.85	
Q1-2015	105400	2025.56	6302.99	45440.8	-26443.6	102272	6155.48	518.967	18512.1	4842.04	
Q2-2015	100234	1931.72	6055.16	37938.6	-21112.4	93422	6041.3	1845.53	16350.6	2259.14	
Q3-2015	95978.1	6635.26	6092.73	31560.3	-25858	80488.1	5638.11	1780.25	10515.9	-1229.03	
Q4-2015	82658.2	3491.57	4843.2	23561.7	-28278.4	53593.7	5897.37	899.335	7336.79	-1299.64	
Q1-2016	36473.3	4343.66	2931.76	15786.1	-1982.32	20362.5	5404.7	4947.27	19422.3	1766.08	
Q2-2016	-9035.42	3608.19	333.445	743.672	-733.234	-18529.6	3733.84	2111.29	8743.66	2362.63	
Q3-2016	-17722	1222.65	-2198.9	-13862.3	11027.7	-41959.1	2776.96	3767.03	15200.5	3255.62	
Q4-2016	-22147.4	-846.827	-2895.46	-22436.7	-27494.8	-48251.1	2258.76	4356.9	44.0304	1214.05	
Q1-2017	-46885.7	-395.197	-2670.65	-34780.3	3837.74	-46399.5	-359.941	3476.18	1353.76	1345.21	
Q2-2017	-43619.9	-2499.67	-156.46	-45027.5	4022.35	-38107.1	-6964.28	3905.39	6271.33	-1240.56	
Q3-2017	-65890.4	-4538	130.276	-46478.1	-7258.63	-38866.8	-6263.44	4812.72	6949.76	-3041	
Q4-2017	-102283	-3572.51	-1615.67	-47118.1	-20969.7	-52046.7	-7768.98	2289.77	-858.332	-2385.74	
Q1-2018	-96327.6	-5164.85	-3510.32	-42306	-8905.56	-54250.7	-9021.42	-2229.61	-1557.2	-2817.42	
Q2-2018	-130677	-6834.07	-7410.56	-47688.8	-13853.9	-67795.3	-11397.5	-4379.36	-9170.23	-7544.39	
Q3-2018	-104211	-6970.76	-8863.92	-52209.9	-7321.16	-70717.5	-11785.4	-4564.59	-14935.3	-2916.54	
Q4-2018	-107924	-8965.46	-10921.5	-63004.4	-7914.95	-82640.6	-12738.2	-5997.07	-17405	-8992.84	
Q1-2019	-112745	-12613.9	-13680.7	-76387.2	1942.33	-86402.7	-14149.4	-9284.55	-30312.9	-11957.7	
Q2-2019	-89133.3	-15841.5	-17481.3	-93514.1	-11565.4	-105311	-15858.4	-10297.4	-37997.3	-13332.4	
Q3-2019	-94411.7	-14268.6	-18573	-104118	-4134.61	-112541	-16075.2	-9430.89	-46969	-14020.9	
Q4-2019	-90521.9	-13524.2	-20462.8	-114192	-11612.3	-106024	-16036.8	-13115	-42826	-12026.8	
Q1-2020	-897.804	-14949.7	-3462.65	-9526.98	12622.2	42934.9	-559.032	-17226.8	-24807	-6506.24	
Q2-2020	486646	32295.9	53284.3	346525	34232.8	396066	43854.1	36102.4	106597	43488.3	
Q3-2020	101341	21705.2	9240.6	67341.4	-9927.35	22580.2	15358.8	7570.23	12159.2	6870.14	
Q4-2020	70578.2	12597.4	9036.99	63442.4	17375.3	65206.7	13572.3	1312.73	20502.9	6798.18	

Annex 3 – Table with the Dissimilarity Index

Dissimilarity Index																						
Location	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Czech Rep	0.18862	0.20041	0.23729	0.21863	0.28247	0.19804	0.20211	0.15876	0.17052	0.23034	0.18626	0.2409	0.22015	0.27994	0.24173	0.25656	0.2816	0.2692	0.2369	0.2416	0.2626	0.28392	0.2907
Greece	1.11133	1.05339	1.04911	1.02121	0.96771	0.8827	0.89422	0.83491	0.64828	0.67385	0.6851	0.66035	0.56163	0.42743	0.42726	0.48295	0.552	0.49966	0.56515	0.59679	0.61317	0.5587	0.6395
Hungary	0.49728	0.55844	0.55359	0.57063	0.55253	0.51846	0.46751	0.3699	0.26408	0.37147	0.29852	0.24998	0.20476	0.19042	0.16043	0.16387	0.30015	0.36517	0.27357	0.24845	0.21072	0.28802	0.3259
Ireland	0.75483	0.85616	0.7936	0.77912	0.84987	0.68427	0.77423	0.82894	0.73123	0.72	0.75205	0.61901	0.58142	0.67676	0.41436	0.43967	0.51011	0.58105	0.56831	0.43332	0.35154	0.69735	0.6523
Italy	0.66045	0.64195	0.62927	0.60301	0.61346	0.57901	0.57424	0.62681	0.53186	0.5465	0.48682	0.49908	0.44783	0.43015	0.33274	0.32769	0.35351	0.43173	0.44161	0.41734	0.40747	0.39535	0.369
Poland	0.6384	0.59745	0.54264	0.53181	0.497	0.45931	0.42446	0.40108	0.34414	0.35717	0.30421	0.24265	0.22842	0.26076	0.26678	0.24624	0.26636	0.26168	0.27777	0.2505	0.21483	0.19906	0.2109
Portugal	0.6514	0.50973	0.4742	0.37375	0.35607	0.28613	0.41294	0.62582	0.49449	0.58515	0.52074	0.46908	0.6151	0.43733	0.38835	0.33943	0.45867	0.48769	0.45203	0.38265	0.2789	0.34698	0.2711
Spain	0.65669	0.6068	0.5474	0.44617	0.44869	0.43429	0.42321	0.38323	0.35068	0.36182	0.28074	0.45627	0.25519	0.32265	0.43346	0.54184	0.50207	0.50397	0.53269	0.50141	0.51099	0.62691	0.6738
Sweden	0.41305	0.36344	0.29413	0.43855	0.46304	0.45395	0.40335	0.45863	0.42703	0.49014	0.45938	0.53781	0.60207	0.55958	0.55286	0.54603	0.58352	0.57486	0.65288	0.64166	0.52021	0.43964	0.4931
EMU; EU p	0.76694	0.7336	0.69872	0.64465	0.64716	0.57328	0.61577	0.65994	0.55131	0.57746	0.54509	0.54076	0.49223	0.45886	0.39924	0.42632	0.47527	0.50082	0.51196	0.4663	0.43241	0.52506	0.5213
Non-EMU;	0.43434	0.42993	0.40692	0.43991	0.44876	0.40744	0.37436	0.34709	0.30144	0.36228	0.31209	0.31783	0.31385	0.32267	0.30545	0.30318	0.35791	0.36773	0.36028	0.34555	0.30209	0.30266	0.3301

Annex 4 – Table with the Trade Index

Trade Index																						
Location	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	A
Czech Rep	0.074236	0.084063	0.097158	0.098155	0.095770	0.101545	0.091506	0.082728	0.092638	0.097517	0.090650	0.087452	0.099055	0.105669	0.105410	0.108974	0.122318	0.121544	0.125060	0.124109	0.119849	0.112765	0.108608	
Greece	0.007162	0.007225	0.006835	0.006750	0.005919	0.005394	0.005095	0.005812	0.006213	0.005797	0.005531	0.005298	0.005513	0.005756	0.005674	0.005812	0.005751	0.005996	0.006277	0.006234	0.006353	0.006673	0.007635	
Hungary	0.085975	0.097944	0.104838	0.101515	0.086633	0.082964	0.082375	0.080644	0.088800	0.091831	0.085874	0.077652	0.086639	0.092254	0.095326	0.098584	0.107053	0.108971	0.111166	0.107756	0.105277	0.101689	0.105160	
Ireland	0.045000	0.061466	0.050086	0.065198	0.050440	0.048468	0.049086	0.044969	0.046556	0.046325	0.045337	0.041490	0.042548	0.037230	0.029655	0.025439	0.023657	0.021522	0.022810	0.020707	0.022452	0.026985	0.029879	
Italy	0.023116	0.023059	0.024668	0.024049	0.022884	0.022803	0.023230	0.023526	0.025817	0.026365	0.026249	0.022934	0.024864	0.026134	0.024740	0.023845	0.024022	0.024264	0.024993	0.025889	0.027412	0.025752	0.025382	
Poland	0.029828	0.031606	0.034984	0.034670	0.036919	0.044078	0.042597	0.038510	0.044800	0.045465	0.043761	0.042466	0.046569	0.050730	0.050160	0.053399	0.056654	0.060520	0.063166	0.063100	0.064976	0.063632	0.065627	
Portugal	0.016282	0.016444	0.016049	0.013435	0.013079	0.014747	0.012743	0.009736	0.009019	0.008121	0.007422	0.006893	0.007255	0.007516	0.007399	0.007633	0.007581	0.007658	0.007943	0.008052	0.008350	0.008494	0.007477	
Spain	0.017531	0.017631	0.018520	0.017091	0.016898	0.017383	0.018024	0.018225	0.018636	0.019248	0.018243	0.015413	0.017053	0.017055	0.016904	0.017153	0.017958	0.018655	0.018969	0.020078	0.020066	0.019710	0.019639	
Sweden	0.019638	0.018674	0.020837	0.019415	0.018547	0.019096	0.019679	0.021389	0.023099	0.023776	0.023882	0.019876	0.021497	0.021251	0.019866	0.019397	0.019664	0.019125	0.019317	0.020250	0.020759	0.019803	0.019201	
EMU; EU p	0.02182	0.02517	0.02323	0.0253	0.02184	0.02176	0.02164	0.02045	0.02125	0.02117	0.02056	0.01841	0.01945	0.01874	0.01687	0.01598	0.01579	0.01562	0.0162	0.01619	0.01693	0.01752	0.018	
Non-EMU;	0.05242	0.05807	0.06445	0.06344	0.05947	0.06192	0.05904	0.05582	0.06233	0.06465	0.06104	0.05686	0.06344	0.06748	0.06769	0.07009	0.07642	0.07754	0.07968	0.0788	0.07772	0.07447	0.07465	

Annex 5 – Table with the Mean Openness Index

Mean Openness Index																							
Location	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average
Czech Rep	0.848718	0.918891	1.127835	1.146092	1.012488	0.89363	0.923107	0.943577	0.959284	0.890483	0.774685	0.7743	0.881832	0.865694	0.964999	0.944033	1.007239	1.207065	1.201729	1.165247	1.087114	1.111731	1.056539	0.993527
Greece	0.540429	0.60453	0.795586	0.799321	0.713148	0.59167	0.563929	0.577596	0.597715	0.570202	0.528387	0.488418	0.549701	0.541899	0.598082	0.585745	0.607072	0.758024	0.765752	0.774813	0.763989	0.809501	0.75083	0.651632
Hungary	0.830181	0.920525	1.179602	1.147789	1.016232	0.87116	0.844217	0.867947	0.967774	0.9163	0.86008	0.879935	0.977107	0.957652	1.03106	1.00949	1.048715	1.267419	1.275017	1.241482	1.177547	1.235034	1.201007	1.040595
Ireland	1.245667	1.313707	1.597417	1.659721	1.513515	1.194966	1.085313	1.100215	1.107462	1.039611	0.980306	1.091245	1.211855	1.173174	1.239212	1.194805	1.241943	1.505324	1.593763	1.515845	1.433766	1.659008	1.581228	1.3197
Italy	0.574537	0.609688	0.757769	0.773773	0.716673	0.598716	0.569295	0.586323	0.615339	0.576802	0.527258	0.500548	0.572357	0.555863	0.596913	0.574739	0.579971	0.71325	0.715482	0.714496	0.685158	0.717945	0.663296	0.632802
Poland	0.72296	0.757741	0.914836	0.869157	0.844582	0.800805	0.750494	0.724154	0.7595	0.701208	0.631914	0.652295	0.708561	0.689961	0.745016	0.727758	0.743339	0.908641	0.955774	0.943832	0.905017	0.937528	0.901407	0.798796
Portugal	0.6543	0.694073	0.833512	0.843103	0.783599	0.663103	0.629104	0.636542	0.66901	0.623026	0.578636	0.56037	0.631245	0.615496	0.673709	0.663637	0.678155	0.833602	0.838748	0.838292	0.800944	0.841912	0.758687	0.713109
Spain	0.632642	0.68616	0.831913	0.840881	0.779313	0.653943	0.616651	0.623454	0.638008	0.595383	0.540124	0.5137	0.582238	0.57413	0.622089	0.608004	0.619817	0.752218	0.755671	0.750272	0.715938	0.746358	0.679843	0.669368
Sweden	0.686663	0.733207	0.887237	0.940584	0.871412	0.734065	0.705124	0.739217	0.762743	0.706984	0.67433	0.66832	0.702291	0.667694	0.711082	0.674715	0.695462	0.849807	0.855493	0.849109	0.836096	0.893094	0.831718	0.772263
EMU; EU p	0.729515	0.781631	0.963239	0.98336	0.90125	0.74048	0.692858	0.704826	0.725507	0.681005	0.630942	0.630856	0.709479	0.692112	0.746001	0.725386	0.745392	0.912483	0.933883	0.918744	0.879939	0.954945	0.886777	0.797323
Non-EMU;	0.77213	0.832591	1.027378	1.025906	0.936179	0.824915	0.805736	0.818724	0.862325	0.803744	0.735252	0.743713	0.817448	0.79525	0.863039	0.838999	0.873689	1.058233	1.072003	1.049918	1.001443	1.044347	0.997668	0.901295

Annex 6 – Table with the financial cycle gaps

	PC1_gap_lambda400k									
	Germany	Czech Repu	Greece	Hungary	Ireland	Italy	Poland	Portugal	Spain	Sweden
Q1-1999	0.0558	-5.53E-02	0.0046	0.0236	0.0162	-0.004	0.0286	0.0799	0.0375	-0.025
Q2-1999	0.0786	-0.01198	0.0269	0.028	0.0164	0.0107	0.0635	0.0607	0.0454	0.0175
Q3-1999	0.0664	-0.00063	0.0442	0.0641	0.0067	0.0017	0.0926	0.0417	0.0345	0.0199
Q4-1999	0.1039	0.013255	0.0662	0.0758	0.0078	0.0276	0.0656	0.0824	0.0599	0.0773
Q1-2000	0.1824	0.093585	0.0673	0.173	0.0231	0.0868	0.1593	0.1549	0.1059	0.1792
Q2-2000	0.173	0.079309	0.0539	0.1443	0.0333	0.0892	0.1325	0.1363	0.0906	0.1914
Q3-2000	0.2055	0.075514	0.0597	0.139	0.0505	0.124	0.1247	0.1518	0.107	0.2172
Q4-2000	0.1485	0.026847	0.0407	0.0957	0.0595	0.1028	0.047	0.1077	0.0691	0.157
Q1-2001	0.162	0.024036	0.0418	0.0904	0.0679	0.101	0.023	0.109	0.0764	0.1641
Q2-2001	0.1712	-0.00835	0.0502	0.044	0.0834	0.1048	-0.022	0.0835	0.0797	0.1551
Q3-2001	0.1027	-0.0463	0.0242	0.0021	0.068	0.0622	-0.089	0.0117	0.02	0.1062
Q4-2001	0.106	-0.04294	0.0257	0.0185	0.056	0.0577	-0.082	0.0257	0.0317	0.0987
Q1-2002	0.1235	-0.03283	0.0366	0.054	0.057	0.0687	-0.039	0.0293	0.0382	0.1057
Q2-2002	0.0475	-0.06265	0.0043	0.0226	0.0328	0.028	-0.071	-0.012	0.0015	0.0239
Q3-2002	-0.012	-0.06962	-0.001	-0.029	0.0095	-5E-04	-0.138	-0.061	-0.048	-0.046
Q4-2002	-0.076	-0.08118	-0.026	-0.06	-0.002	-0.023	-0.153	-0.1	-0.071	-0.088
Q1-2003	-0.13	-0.07789	-0.034	-0.078	-0.008	-0.041	-0.144	-0.114	-0.085	-0.109
Q2-2003	-0.134	-0.0619	-0.04	-0.06	-0.006	-0.044	-0.137	-0.118	-0.079	-0.12
Q3-2003	-0.106	-0.04164	-0.024	-0.067	0.0001	-0.037	-0.033	-0.109	-0.061	-0.102
Q4-2003	-0.123	-0.04389	-0.038	-0.064	-0.006	-0.048	-0.031	-0.106	-0.075	-0.109
Q1-2004	-0.088	-0.01113	-0.022	-0.061	0.0119	-0.032	0.0196	-0.065	-0.043	-0.054
Q2-2004	-0.082	-0.00591	-0.022	-0.039	0.0219	-0.028	0.0232	-0.054	-0.043	-0.051
Q3-2004	-0.102	-0.01674	-0.029	-0.04	0.0206	-0.036	0.0069	-0.064	-0.052	-0.068
Q4-2004	-0.131	-0.00976	-0.041	-0.037	0.0136	-0.044	-0.027	-0.077	-0.058	-0.098
Q1-2005	-0.096	0.030538	-0.015	0.0195	0.0356	-0.019	0.0049	-0.047	-0.025	-0.058
Q2-2005	-0.066	0.047701	-0.007	0.0422	0.0393	-0.002	0.0198	-0.035	-0.01	-0.015
Q3-2005	-0.04	0.069842	0.0019	0.0982	0.047	0.0158	0.0664	-0.03	0.0141	0.0085
Q4-2005	-0.014	0.084908	0.0121	0.1076	0.0548	0.028	0.0956	-0.009	0.0247	0.0314
Q1-2006	0.0036	0.087831	0.0229	0.1195	0.0617	0.0368	0.1359	0.0244	0.0366	0.0603
Q2-2006	-0.013	0.051809	0.0146	0.1049	0.0482	0.0252	0.1455	0.0321	0.0264	0.0346
Q3-2006	-0.017	0.049529	0.0117	0.0828	0.0516	0.0269	0.1487	0.0377	0.0338	0.0319
Q4-2006	-0.004	0.050902	0.0106	0.0603	0.0632	0.0339	0.1492	0.0511	0.0612	0.0347
Q1-2007	0.0128	0.070943	0.0182	0.0529	0.0756	0.0397	0.1772	0.0765	0.0708	0.064
Q2-2007	0.0315	0.095478	0.0227	0.0608	0.0746	0.0435	0.211	0.0997	0.0687	0.0665
Q3-2007	0.0131	0.071462	0.0151	0.0655	0.0432	0.0208	0.1775	0.0933	0.0502	0.026
Q4-2007	-4E-04	0.057364	0.0111	0.0276	0.0222	0.0052	0.1087	0.0779	0.0535	-0.013
Q1-2008	-0.066	-0.0056	-0.016	-0.036	-0.016	-0.049	-0.019	0.0129	-8E-04	-0.098
Q2-2008	-0.069	-0.01001	-0.018	-0.075	-0.031	-0.047	-0.069	0.0067	-0.002	-0.1
Q3-2008	-0.052	-0.0091	-0.017	-0.075	-0.07	-0.042	-0.099	-0.032	-0.02	-0.101
Q4-2008	-0.125	-0.09709	-0.049	-0.205	-0.152	-0.087	-0.18	-0.112	-0.081	-0.146
Q1-2009	-0.144	-0.10685	-0.056	-0.234	-0.171	-0.11	-0.196	-0.111	-0.107	-0.128
Q2-2009	-0.152	-0.09135	-0.049	-0.196	-0.155	-0.108	-0.164	-0.087	-0.094	-0.116
Q3-2009	-0.143	-0.05322	-0.048	-0.136	-0.139	-0.1	-0.135	-0.065	-0.054	-0.125
Q4-2009	-0.114	-0.01899	-0.032	-0.09	-0.131	-0.077	-0.092	-0.032	-0.027	-0.099
Q1-2010	-0.083	-0.00112	-0.033	-0.061	-0.12	-0.063	-0.088	-0.031	-0.029	-0.074
Q2-2010	-0.038	0.036922	-0.017	-0.012	-0.092	-0.043	-0.018	-0.025	-0.035	-0.032
Q3-2010	-0.086	-0.01086	-0.043	-0.053	-0.12	-0.078	-0.079	-0.047	-0.048	-0.086
Q4-2010	-0.066	0.012186	-0.038	-0.045	-0.124	-0.059	-0.036	-0.028	-0.044	-0.061

Annex 7 – Table with the financial cycle gaps

Q1-2011	-0.068	0.012679	-0.046	-0.071	-0.124	-0.065	-0.055	-0.037	-0.05	-0.083
Q2-2011	-0.077	0.011048	-0.051	-0.063	-0.12	-0.073	-0.058	-0.047	-0.058	-0.083
Q3-2011	-0.091	-0.00636	-0.051	-0.095	-0.137	-0.084	-0.063	-0.066	-0.083	-0.099
Q4-2011	-0.091	-0.02609	-0.05	-0.092	-0.126	-0.077	-0.08	-0.081	-0.083	-0.115
Q1-2012	-0.079	-0.02773	-0.039	-0.089	-0.109	-0.084	-0.112	-0.093	-0.09	-0.105
Q2-2012	-0.07	-0.02412	-0.05	-0.107	-0.1	-0.086	-0.099	-0.108	-0.129	-0.096
Q3-2012	-0.071	-0.03042	-0.059	-0.107	-0.101	-0.086	-0.105	-0.109	-0.117	-0.12
Q4-2012	-0.067	-0.02192	-0.053	-0.099	-0.092	-0.083	-0.091	-0.091	-0.096	-0.108
Q1-2013	-0.039	-0.00426	-0.029	-0.081	-0.069	-0.062	-0.057	-0.048	-0.072	-0.092
Q2-2013	-0.042	-0.0214	-0.036	-0.098	-0.055	-0.068	-0.063	-0.05	-0.08	-0.08
Q3-2013	-0.047	-0.03262	-0.042	-0.104	-0.046	-0.067	-0.067	-0.053	-0.072	-0.084
Q4-2013	-0.036	-0.00989	-0.026	-0.109	-0.042	-0.055	-0.042	-0.039	-0.036	-0.07
Q1-2014	-0.026	-0.00795	-0.016	-0.124	-0.023	-0.047	-0.03	-0.016	-0.024	-0.063
Q2-2014	-0.025	-0.00631	-0.014	-0.123	-0.019	-0.037	-0.033	0.0052	-0.005	-0.04
Q3-2014	0.0046	0.003626	0.0017	-0.105	-0.01	-0.019	-1E-04	-0.019	0.0171	-0.007
Q4-2014	0.016	0.010513	-0.002	-0.107	-7E-04	-0.019	0.0207	-0.048	0.0192	0.0122
Q1-2015	0.0955	0.044435	0.0179	-0.08	0.0199	0.027	0.0429	-0.007	0.0555	0.0881
Q2-2015	0.0946	0.040917	0.0127	-0.014	0.0335	0.0433	0.0594	0.0249	0.0705	0.078
Q3-2015	0.0724	0.032905	0.0077	-0.018	0.0435	0.0393	0.0301	-7E-04	0.0531	0.0682
Q4-2015	0.0858	0.026926	0.0083	0.0062	0.0525	0.0513	0.0206	0.0094	0.0507	0.0581
Q1-2016	0.0397	-0.00556	-0.012	0.0025	0.0354	0.0112	-0.036	-0.011	0.0011	0.0265
Q2-2016	0.0528	-0.00523	0.0038	0.0427	0.0413	0.0162	-0.004	0.0064	0.0089	0.0448
Q3-2016	0.0569	-0.01343	0.0037	0.0501	0.0413	0.0113	-0.013	0.0088	0.0072	0.0601
Q4-2016	0.0945	0.013204	0.0223	0.0917	0.0667	0.0415	0.0298	0.027	0.0372	0.0895
Q1-2017	0.1061	0.015322	0.03	0.1091	0.0693	0.0605	0.0683	0.0316	0.0576	0.0892
Q2-2017	0.0887	-0.00057	0.0344	0.0987	0.0729	0.0565	0.0657	0.0447	0.0711	0.0804
Q3-2017	0.0676	0.000291	0.0378	0.1102	0.0698	0.0563	0.0783	0.0438	0.0604	0.0592
Q4-2017	0.0754	-0.0018	0.0272	0.1202	0.0804	0.0615	0.0658	0.0521	0.0539	0.0612
Q1-2018	0.0565	-0.00473	0.0328	0.1105	0.0732	0.0552	0.0472	0.0493	0.0426	0.0529
Q2-2018	0.0781	0.009216	0.0436	0.1155	0.0847	0.0798	0.0552	0.0805	0.0544	0.0816
Q3-2018	0.0701	0.003116	0.0367	0.1025	0.0818	0.0773	0.0486	0.0895	0.0511	0.0836
Q4-2018	0.0483	-0.003	0.0304	0.1189	0.0615	0.0619	0.0441	0.0624	0.038	0.0657
Q1-2019	0.0483	-0.00466	0.0442	0.1349	0.066	0.0772	0.069	0.0758	0.0455	0.0808
Q2-2019	0.0468	-0.00902	0.0591	0.1294	0.0762	0.0794	0.0542	0.0875	0.0474	0.0928
Q3-2019	0.0559	0.000497	0.0756	0.1367	0.0767	0.0893	0.0721	0.0998	0.0493	0.113
Q4-2019	0.0617	-0.00276	0.0743	0.1417	0.0998	0.0981	0.0483	0.1098	0.057	0.1078

Annex 8 – Table with the capital flows volatility

Rolling window 5 year standard deviation														
From Germany; Dta(Dto)/FDI														
Greece	0.0002	0.0003	0.0003	0.003	0.0029	0.0031	0.0033	0.0033	0.0011	0.0005	0.0004	0.0004	0.001	0.001
Portugal	0.003	0.003	0.0035	0.003	0.002	0.0018	0.0018	0.0009	0.0007	0.0007	0.0007	0.0005	0.0005	0.0003
Spain	0.0021	0.0009	0.001	0.0033	0.0028	0.0034	0.0034	0.0037	0.0017	0.0011	0.0009	0.0017	0.0018	0.002
Ireland	0.0065	0.0082	0.0077	0.0076	0.0087	0.0092	0.0077	0.0083	0.0083	0.0064	0.0057	0.0046	0.0035	0.0189
Italy	0.006	0.006	0.0059	0.0059	0.0023	0.001	0.0008	0.0018	0.0017	0.0016	0.0019	0.0021	0.0006	0.0005
Czechia	0.0057	0.006	0.006	0.0034	0.0044	0.0033	0.0022	0.003	0.0032	0.0031	0.0018	0.0031	0.0033	0.0031
Hungary	0.0127	0.0051	0.0055	0.0063	0.0071	0.0071	0.0067	0.0085	0.0091	0.009	0.0095	0.0062	0.0058	0.0051
Poland	0.0028	0.0034	0.0029	0.0021	0.0021	0.0021	0.0016	0.001	0.0006	0.0017	0.0016	0.0023	0.0023	0.0024
Sweden	0.0048	0.0054	0.0063	0.0078	0.0069	0.007	0.0066	0.0064	0.0024	0.007	0.009	0.0097	0.0091	0.0088
From Germany; PT/Portfolio														
Greece	0.0074	0.0107	0.0126	0.0134	0.014	0.0241	0.0278	0.0296	0.031	0.0313	0.0027	0.0057	0.0066	0.0079
Portugal	0.0105	0.0105	0.0104	0.0071	0.0048	0.0081	0.0189	0.0199	0.0201	0.0186	0.0068	0.0015	0.0029	0.0031
Spain	0.008	0.0096	0.0111	0.0165	0.0175	0.0165	0.0046	0.0047	0.0046	0.0051	0.0062	0.0064	0.0054	0.0054
Ireland	0.0245	0.0271	0.0129	0.0144	0.0247	0.0257	0.033	0.031	0.0224	0.0244	0.0194	0.015	0.014	0.0143
Italy	0.0077	0.0066	0.0068	0.0069	0.006	0.006	0.0074	0.0071	0.0059	0.0063	0.0089	0.0066	0.0048	0.0045
Czechia	0.0023	0.0028	0.0027	0.0027	0.0022	0.0025	0.0017	0.002	0.0022	0.0036	0.0034	0.0033	0.0029	0.0029
Hungary	0.0071	0.007	0.007	0.0024	0.007	0.0071	0.0109	0.0105	0.0093	0.0091	0.0063	0.0027	0.001	0.0017
Poland	0.0031	0.0028	0.0028	0.0025	0.0026	0.0033	0.0029	0.0029	0.0031	0.0031	0.0015	0.0018	0.0015	0.0019
Sweden	0.0018	0.003	0.0034	0.0029	0.0033	0.0028	0.0037	0.0041	0.0036	0.0035	0.0036	0.0031	0.0029	0.0033
To Germany; Dta(Dto)/FDI														
Greece	0.0006	0.0006	5E-05	3E-05	3E-05	8E-05	0.0003	0.0005	0.0005	0.0006	0.0006	0.0004	0.0003	0.0004
Portugal	0.0013	0.0014	0.0008	0.0009	0.0009	0.0009	0.0015	0.0014	0.0012	0.0011	0.0013	0.001	0.0011	0.0011
Spain	0.0026	0.0026	0.0022	0.0018	0.0021	0.0029	0.0029	0.0028	0.0027	0.002	0.0005	0.0007	0.0006	0.0006
Ireland	0.0113	0.0108	0.0127	0.0133	0.0164	0.0095	0.0082	0.0093	0.0093	0.0065	0.0056	0.0039	0.0057	0.0101
Italy	0.0059	0.0061	0.0059	0.0059	0.0058	0.001	0.001	0.0006	0.0005	0.0005	0.0005	0.0006	0.0006	0.0008
Czechia	0.0023	0.0029	0.0023	0.0037	0.0039	0.0039	0.0023	0.0025	0.0072	0.0092	0.0093	0.0092	0.0092	0.0043
Hungary	0.0014	0.0011	0.0049	0.0051	0.0063	0.0071	0.0072	0.0043	0.0042	0.0041	0.0077	0.0099	0.0127	0.0127
Poland	0.0006	0.0004	0.0004	0.0003	0.0003	0.0001	0.0003	0.0006	0.0006	0.0006	0.0006	0.0008	0.0005	0.0005
Sweden	0.0015	0.001	0.0011	0.0024	0.0021	0.0018	0.0018	0.0017	0.0019	0.002	0.0029	0.004	0.005	0.0058
To Germany; PT/Portfolio														
Greece	0.0048	0.0035	0.0033	0.009	0.008	0.0065	0.0063	0.0058	0.0007	0.0007	0.0007	0.0012	0.0012	0.0013
Portugal	0.0053	0.0061	0.0066	0.0052	0.0035	0.0034	0.0092	0.0098	0.0092	0.0131	0.0136	0.0085	0.0107	0.0115
Spain	0.011	0.0078	0.0079	0.0074	0.0072	0.0044	0.0042	0.0039	0.0041	0.0036	0.0026	0.0025	0.0015	0.0016
Ireland	0.075	0.0538	0.0519	0.0341	0.0342	0.0326	0.0297	0.0417	0.0451	0.048	0.0481	0.0485	0.0379	0.0212
Italy	0.0105	0.0091	0.0086	0.0085	0.0083	0.0036	0.008	0.0086	0.0086	0.0086	0.0072	0.0048	0.0024	0.002
Czechia	0.0028	0.0028	0.0028	0.0007	0.0009	0.0009	0.0009	0.0004	0.0004	0.0003	0.0005	0.0005	0.0008	0.0008
Hungary	0.0025	0.0013	0.0011	0.0007	0.0011	0.0012	0.001	0.0008	0.0005	0.0007	0.0007	0.0008	0.0006	0.0003
Poland	0.0011	0.0006	0.0006	0.0007	0.0006	0.0008	0.0006	0.0005	0.0006	0.0004	0.0008	0.0009	0.0009	0.0009
Sweden	0.0036	0.0037	0.0035	0.003	0.002	0.0064	0.0091	0.0091	0.0095	0.0096	0.0053	0.0044	0.0063	0.0068
From Germany; Dta(Dto)/FDI														
EMU; EU	0.0036	0.0037	0.0037	0.0046	0.0037	0.0037	0.0034	0.0036	0.0027	0.0021	0.0019	0.0019	0.0015	0.0045
Non-EM	0.0065	0.005	0.0052	0.0049	0.0051	0.0049	0.0043	0.0047	0.0038	0.0052	0.0055	0.0054	0.0051	0.0049
From Germany; PT/Portfolio														
EMU; EU	0.0116	0.0129	0.0108	0.0116	0.0134	0.0161	0.0183	0.0185	0.0168	0.0171	0.0088	0.007	0.0067	0.007
Non-EM	0.0036	0.0039	0.004	0.0026	0.0038	0.004	0.0048	0.0049	0.0046	0.0048	0.0037	0.0027	0.0021	0.0024
To Germany; Dta(Dto)/FDI														
EMU; EU	0.0043	0.0043	0.0043	0.0044	0.0051	0.0029	0.0028	0.0029	0.0028	0.0022	0.0017	0.0013	0.0017	0.0026
Non-EM	0.0015	0.0013	0.0022	0.0029	0.0032	0.0032	0.0029	0.0023	0.0035	0.004	0.0051	0.006	0.0068	0.0058
To Germany; PT/Portfolio														
EMU; EU	0.0213	0.0161	0.0157	0.0128	0.0122	0.0101	0.0115	0.0139	0.0135	0.0148	0.0145	0.0131	0.0107	0.0075
Non-EM	0.0025	0.0021	0.002	0.0013	0.0011	0.0023	0.0029	0.0027	0.0028	0.0028	0.0018	0.0016	0.0021	0.0022