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MASTER'S THESIS

The Evolution of Optimum Currency Area Index: Post-crisis Perspective

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DECLARATION OF AUTHORSHIP

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Prague, May 13, 2016

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Abstract

This paper estimates the determinants of exchange rate variability for 21 developed economies in 1980-1998. The results show that traditional criteria implied by the optimum currency area (OCA) theory, such as business cycle synchronisation, trade linkages and economy size, determine to a large extent bilateral exchange rate variability. Using the ordinary least squares estimation, we compute OCA indices for European economies vis-à-vis Germany and identify countries showing consistently large or little signs of convergence. We find that since 1998, most European developed economies have converged to Germany whether or not they are using the euro, suggesting that structural similarity is not driven solely by monetary integration. Our results from the model estimated by the generalized method of moments suggest that two additional criteria reflecting labour market flexibility and private credit growth are significant in explaining the exchange rate variability and lead to a ranking of countries different from the traditional approach. We find a positive relationship between the OCA indices and GDP decline during the economic crisis of 2008-09, which further supports the view that the OCA index is a useful indicator of the candidates' readiness to join the Euro Area. We apply the results to the countries of Central and Eastern Europe and conclude that countries which have already adopted the euro are not those that would benefit the most from it, as predicted by the OCA theory.

JEL Classification	F15, E32, F33
Keywords	Optimum currency area, EMU, Real convergence, GMM, Euro Adoption

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Abstrakt

Tato práce odhaduje determinanty variability měnového kurzu pro 21 vyspělých ekonomik v období 1980-1998. Výsledky ukazují, že tradiční kritéria vyplývající z teorie optimálních měnových zón (OCA), jako například synchronizace hospodářského cyklu, obchodní toky a velikost ekonomiky, významně ovlivňují variabilitu kurzu. Pomocí metody nejmenších čtverců počítáme tzv. OCA indexy pro evropské ekonomiky vzhledem k Německu a identifikujeme země, které stabilně vykazují známky velké či malé konvergence. Jelikož od roku 1998 se většina evropských zemí přiblížila k Německu bez ohledu na to, zda používají euro či ne, konstatujeme, že strukturální podobnost je poháněna i jinými faktory, než pouze měnovou integrací. Naše výsledky na základě zobecněné metody momentů zároveň naznačují, že také další kritéria, flexibilita pracovního trhu a růst dluhu soukromého sektoru, jsou signifikantní proměnné vysvětlující variabilitu měnového kurzu a vedou k rozdílnému řazení zemí ve srovnání s tradičním přístupem OCA. Nalézáme pozitivní vztah mezi OCA indexem a poklesem HDP během hospodářské krize v letech 2008-09, což dále podporuje tezi, že OCA index je užitečný nástroj ke zhodnocení připravenosti kandidátské země na členství v eurozóně. Aplikujeme výsledky na země střední a východní Evropy a konstatujeme, že země, které již euro přijaly, nejsou ty, které by ze společné měny těžily z pohledu OCA nejvíce.

Klasifikace	F15, E32, F33
Klíčová slova	Optimální měnová zóna, HMU, Reálná konvergence, GMM, Přijetí eura

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

BIS	Bank for International Settlements
CEEC	Central and Eastern European Countries
CNB	Czech National Bank
EMU	Economic and Monetary Union
ER	Exchange Rate
EU	European Union
GMM	Generalized Method of Moments
IMF	International Monetary Fund
OCA	Optimum Currency Area
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
SITC	Standard International Trade Classification
ULC	Unit Labour Cost

MASTER'S THESIS PROPOSAL

Author:	Bc. Pavlína Kadlecová
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Proposed Topic:

The Evolution of Optimum Currency Area Index: Post-crisis Perspective

Motivation:

More than fifteen years have passed since the first European countries started to adopt the common currency, yet numerous voices are still doubtful about the real economic gains of the Economic and Monetary Union (EMU) for the participating countries. Although the accession is conditioned by certain nominal criteria (known as the Maastricht criteria), these may fail to capture whether a given country is ready to 'join the club' from the point of view of real economy and structural similarity.

The economic crisis of 2008-09 tested in reality how strong the EMU fundamentals are. One way to look at this problem is through the lens of the optimum currency areas (OCA) theory, coined in the 1960s by Mundell (1961), Kenen (1963) and McKinnon (1969). The main idea of this theory is that a monetary union is beneficial for the participating countries only if asymmetric shocks are scarce and relatively small. In other words, countries have to be very similar to enjoy the benefits of sharing a common currency while minimising the costs. To capture this similarity, several OCA criteria have been proposed: labour mobility, trade diversification and intensity of trade linkages, openness, the size of economies, and financial integration (Ingram, 1962). To test the effect of these properties on the variability of exchange rate (based on which a country may decide on the exchange rate regime) and give them appropriate weights, Bayoumi and Eichengreen (1997) constructed an 'OCA index' which captures the extent to which a given country is similar to a reference country. While the index was further developed by subsequent authors (Horváth, 2005), several criteria were neglected in the empirical literature, e.g. labour market flexibility and private credit growth approximating different degrees of financial development.

The aim of this thesis is to construct a new OCA index for European countries, both the members and non-members of the EU and EMU and see the evolution of the index in time. One problem to be addressed is the *endogeneity hypothesis* proposed by Frankel and Rose (1998), which assesses whether the EMU is justified ex post more than ex ante, mainly by the means of spurring mutual trade and facilitating real convergence. The answer can be particularly relevant for the Central and Eastern European countries (CEEC) considering the EMU accession. It may also be interesting to look at the relationship between the OCA index and the severity of an economic crisis: do countries showing little signs of convergence experience greater economic downturns?

Hypotheses:

1. Hypothesis #1: OCA indices for the EMU member states decrease over time, as monetary integration facilitates real convergence.
2. Hypothesis #2: Criteria reflecting higher labour market rigidity and higher differences in private credit growth rates increase bilateral exchange rate variability.
3. Hypothesis #3: The economic crisis was less severe in those EMU member states which are relatively more similar to Germany.

Methodology:

The thesis will first focus on the theoretical background of the theory of optimum currency areas. I will outline the general idea of the theory in the context of a cost-benefit analysis and describe the economic rationale for individual OCA criteria from the works of Mundell (1961), McKinnon (1963) and Kenen (1969). I will then follow the methodology proposed by Bayoumi and Eichengreen (1997) and estimate a cross-country regression of 21 developed economies over the period of 1980-1998 (before the adoption of the euro), using macroeconomic data from the World Bank, OECD and IMF and other institutions. The aim of this step is to see whether, and to what extent, the traditional OCA properties determine the variability of bilateral exchange rate in a bilateral country setting. With the exchange rate volatility as the dependent variable, I will measure the effect of the OCA criteria: trade linkages, dissimilarity of exports, openness and size of the economy. The main purpose of this step is to assess whether good economic fundamentals and a high degree of similarity, suggesting asymmetric shocks are rare and relatively small, result in lower exchange rate variability. The likely problem with this regression may be endogeneity (exchange rate may influence exports) and as Bayoumi and Eichengreen (1998) and Horváth (1998), I may have to use the IV regression to address this problem.

Next, I will test the effect of variables reflecting labour mobility and labour market flexibility, which received very limited attention in the literature. In addition, I will examine whether differences in financial development increase the exchange rate variability. To approximate financial development, I will use the data on private credit growth, capturing the depth of the financial system. As a following step, I will update the OCA index (which stands for the fitted value of the exchange rate variability based on the regression estimates) for the year 2014, see how they evolved since 1980s and how they compare to previous studies. In particular, I will observe whether the predicted exchange rate variability decreases over time for the EMU member states, which would suggest that monetary integration leads to real convergence.

Consequently, I will examine the relationship between the OCA index and GDP decline during the economic crisis of 2008-09. The aim is to test whether the EMU member states with relatively lower OCA indices experienced deeper recession than member states with relatively high OCA indices. Finally, I apply the results to the CEEC by the means of out-of-sample forecasting and compare the OCA indices to the previous work of Horváth (2005). This will allow to assess the suitability of the eurozone candidates for the adoption of the single currency.

Expected Contribution:

I will test whether and to what extent the OCA properties affect the variability of bilateral exchange rates. In contrast to previous studies in the OCA empirical field, I will include variables capturing labour market flexibility and labour mobility, which are important when an economy deals with an adverse shock. In addition, I will test whether financial variables influence real variables, by including the degree of financial development in the regression equation. I will then update the traditional OCA index proposed by Bayoumi and Eichengreen (1997) to the most recent data and see how it compares to previous results. In addition, I will propose my own model specification and analyse the differences in comparison to the first case. I expect to obtain different results, suggesting that labour market considerations and financial development provide a different picture of the countries' suitability for the euro. I will compute the OCA indices for the CEEC countries and assess their readiness to join the eurozone.

Outline:

1. Introduction
2. Theoretical background: Theory of optimum currency areas
3. Traditional model for the OCA index
4. Modified model including labour mobility and financial development
5. Empirical results for European countries
6. Conclusion
7. Results

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Author **Supervisor**

1 INTRODUCTION

Although it has been over fifteen years since European countries started to adopt the common currency, numerous voices are still doubtful about the real economic gains of the Euro Area for some of the participating countries. While the euro candidates have to fulfil certain nominal criteria (known as the Maastricht criteria) to be allowed into the monetary union, it has been argued that these criteria fail to capture an important prerequisite of sharing the same currency: structural similarity and real convergence. De Grauwe (1996) criticises the Maastricht criteria for lacking theoretical foundation and leading essentially to a 'Great Divide' in the EU. Buti and Sapir (2002) point out that the one-size-fits-all monetary policy is problematic for the EMU member states due to their structural dissimilarity. Bucur and Stangaciu (2012) claim that the criteria fail to reflect the ability of EU countries to achieve economic development required by the EMU integration.

The economic crisis of 2008-09 was a real life test assessing how vulnerable the EU and EMU are to the heterogeneity of its members. It encouraged a heated debate over the Euro Area fundamentals and led many to evaluate whether the EMU is strong enough to assure its long-term existence (De Grauwe, 2013). If we accept that Maastricht criteria are not sufficient to assess the readiness of a country to 'join the club,' we need a complementary view that could allow us to see the bigger picture. The theory of optimum currency areas (OCA) is one way to address this. Coined in 1960s by Mundell (1961), McKinnon (1963) and Kenen (1969), the theory postulates that a monetary union is beneficial for the participating countries only in case where large asymmetric shocks are scarce. In particular, countries should share the same structural characteristics (known as OCA criteria) such as trade integration, commodity export structure, output disturbances and labour market flexibility. Provided that countries are similar enough in these aspects, then exchange rate regime does not constitute an important adjustment tool in dealing with adverse shocks, allowing countries to enjoy the benefits of sharing the same currency while minimising the costs.

Until 1990s, the theory remained more theoretical than operational and its usefulness for the real world was not apparent. Bayoumi and Eichengreen (1997) managed to operationalise the theory by constructing an 'OCA index' based on econometric estimation. Using the OCA criteria as explanatory variables for the bilateral exchange rate variability, the index not only allows to test the OCA theory empirically, but also to rank countries according to their similarity to a reference country.

The aim of this thesis is to use this econometric method to update and extend the OCA index. First, we estimate the traditional OCA equation and find that the variability of bilateral exchange rate is, to a relatively large extent, determined by the business cycle synchronisation, trade linkages, trade dissimilarity and economic size of the two concerned countries. Based on data gathered for 21 developed countries (including European countries, Canada, Australia, New Zealand, Japan and the USA) over the period 1980-1998, we compute the OCA indices vis-à-vis Germany for 15 European countries from the sample for 4 points in time: 1989, 1998, 2007 and 2014. These are chosen to reflect the end of period 1980s, the period prior to the euro adoption, period before the outburst of the economic crisis and finally the most recent period.

Second, we modify the equation to include additional factors which have received only limited attention in the OCA literature: labour market and financial integration. To the best of our knowledge, we are the first in this field to use the measure of labour market rigidity (LAMRIG) from Campos and Nugent (2012) and to include the growth in private credit to approximate the depth of the financial system – Horváth (2005) uses monetary aggregates as a proxy for financial development. We find that both of these variables are significant in explaining the exchange rate variability and thus play a significant role for both the current and the prospective EMU members.

We find that countries including Belgium, the Netherlands, Austria, Switzerland and Denmark are largely and consistently similar to Germany and show signs of convergence in time. France, Portugal and Greece, on the other hand, are the most different when traditional OCA criteria are taken into account. Once labour market rigidity and financial development is included, it is mainly Ireland, Greece and the UK that show little signs of convergence. We also examine the link between the value of the OCA index and the decline in the country's GDP during the economic crisis. The positive relationship tells us that structural dissimilarity might indicate the severity of an upcoming economic crisis and highlights how important greater convergence is to deal effectively with adverse shocks in the EMU.

Last, we apply our results to the countries of Central and Eastern Europe (CEEC) using 'out-of-sample' forecasting and update and extend the index by Horváth (2005). We find that countries which have already adopted the euro are not necessarily those that would benefit the most from the membership according to the OCA theory.

The thesis as organised as follows. We provide a review of both theoretical and empirical literature related to the OCA theory in section 2. In section 3, we discuss the basic OCA criteria and economic reasons for their existence. Section 4 summarizes the empirical methodology, methodological problems of measurement and data description.

In sections 5 and 6, we estimate the OCA equation using the ordinary least squares (OLS) method and the generalized method of moments (GMM) respectively. Section 7 proposes modifications to the traditional equation, specifically the inclusion of labour market rigidity and the similarity of financial development. The application to the CEEC is presented in section 8. Finally, section 9 concludes, followed by appendices.

2 LITERATURE REVIEW

The Theory of Optimum Currency Areas, which originated in 1960s, was to a large extent a reaction to the heated economic debate on floating versus fixed exchange rate regimes in 1950s. As Dellas and Tavlas (2009) point out, three distinguished writers in particular – Friedman (1953), Meade (1951) and Scitovsky (1958) – set the tenets of the OCA analysis.

2.1 Origins of the OCA theory

Milton Friedman, who plays a key role in the evolution of the OCA theory, was one of the first to address the 'fear of floating.' In his *Case for Flexible Exchange Rates*, he argues that fixed rates might be beneficial for an economy where prices and wages are flexible. Changes in external conditions and economic shocks would be immediately corrected via prices and wages and there would be no need to alter the exchange rate. Since, however, prices and wages are sticky in the real world, fixed exchange rate policy leads to imbalances in the economy, which eventually threatens the exchange rate system (Friedman, 1953).

Hanke (2008), who offers a thorough analysis of Friedman's arguments on monetary policy, points out that Friedman's advocacy of floating was motivated mainly by his opposition to trade restrictions. Indeed, Friedman's text was written during the author's involvement in the administration of the Marshall Plan, hence during the time where Europe was employing strict controls to limit free flow of trade and capital. In Friedman's view, floating exchange rate is the right choice for governments that do not want to compromise free trade and that are unable to make prices and wages more flexible (Friedman, 1953).

Nevertheless, Friedman (1953) puts forward the basic intuition of the OCA theory: that there is a rationale for a 'mixed' system where certain economic units share a single currency (or, equivalently, fix their exchange rates), but float against other such economic units (Dellas and Tavlas, 2009). According to Friedman, these economic units should have '*a single central fiscal and monetary authority*' possessing '*ultimate fiscal and monetary powers*' (Friedman, 1953, p. 193). In other words, Friedman seems to consider a monetary and political union as inseparable.

An additional point which is also raised by Meade (1957), although not central to his work, is the movement of production factors, which needs to be made not only

possible, but also easy – a precondition that would later be adopted and elaborated on by a Canadian economist Robert Mundell. While for these authors, factor mobility is a property *ex ante* to a monetary union, Scitovsky (1958) takes a different stand, arguing that a currency union itself and further steps taken by policy makers can induce a greater degree of mobility *ex post*.

The monetary and fiscal mismatch is one of the main reasons why Milton Friedman had been sceptical of the European project. As he states in a 1997 article entitled '*The Euro: Monetary Unity to Political Disunity?',* Europe is unsuitable for a common currency and the euro zone members are making a mistake by abandoning the flexible exchange rate regimes (Friedman, 1997). Cesarano (2007, p. 727) stresses a similar point when he states that '*a common currency for a group of sovereign states might be the worst of all possible worlds,*' because the member countries are left with no effective adjustment mechanism at hand.

2.2 OCA Economic Criteria

Despite taking a different stand on the issue of exchange rates, the emergence of the OCA theory can be partly attributed to Friedman (1953). In an effort to challenge Friedman's view, Mundell (1961) published his famous work '*A Theory of Optimum Currency Areas'* and was soon followed by McKinnon (1963) and Kenen (1969). Their influential papers advocate that the appropriate exchange rate regime is determined by the country's fundamental economic characteristics. This idea became a cornerstone principle for the OCA theory, although the exact choice of the defining *characteristic* differs from one author to another.

Unlike Friedman (1953), Mundell (1961) is a strong advocate of fixed exchange rates and places less importance on a common fiscal authority. Instead, he characterises an optimum currency area as a region with internal factor mobility and external factor immobility, while concentrating in particular on the mobility of labour. According to Mundell (1961), areas comprised by smaller countries and benefiting from a sufficient degree of labour mobility should fix their exchange rates or adopt a common currency, because they adjust easily to asymmetric shocks which might otherwise destabilise the economy.

Sufficient factor mobility can be also found in the works of McKinnon (1963) who further distinguishes between geographic mobility and mobility among industries, arguing that both are equally important. Nonetheless, McKinnon (1963) sees the crucial determinant in the country's degree of openness and trade linkages. Monetary and fiscal policies and flexible exchange rate can be used to achieve the sometimes conflicting

objectives of maintaining full employment, balanced international payments and price stability. In highly open economies, prices and wages are immediately adjusted to any movement in the exchange rate. Any effort to devalue the currency not only compromises internal price level stability, but leads to no improvement in the trade balance. In other words, the currency devaluation as a tool to improve competitiveness is ineffective if economies are open and trade heavily among each other. Such economies form an optimum currency area.

Kenen (1969) further developed Friedman's idea of fiscal integration, advancing a system of fiscal transfers which could compensate regional differences. However, his analysis is mainly concerned with the diversification of production. According to Kenen, diversified economies are less likely to incur adverse symmetric shocks and if these shocks do occur, they have less devastating effects than in the case of low-diversified economies. This is because minor positive and negative disturbances offset the external shocks. There is, therefore, less need for a correction via the exchange rate. Moreover, Kenen (1969) states that output diversification is a prerequisite to Mundell's internal mobility, since it increases employment opportunities.

Although Mundell (1961), McKinnon (1963) and Kenen (1969) laid the foundations for the OCA theory, they were not the last to spell out criteria for optimality. Ingram (1962) stays apart from the original triad, as he considers financial rather than real characteristics of the economy. Ingram (1962) states that financial integration reduces the need for exchange rate adjustments, because it allows to cushion temporary adverse shocks through capital inflows (for example by borrowing from surplus areas). To a certain extent, this is similar to the system of fiscal transfers proposed by Kenen (1969), although it does not rely on a single fiscal authority. Ingram (1969) believes that deeper financial integration would reduce interest rate differentials and induce efficient allocation of resources (Mongelli, 2002).

The last point to be noted in this section was raised by Fleming (1971). The author summarises and comments on the previous criteria, but also adds a new one: similarity in the rates of inflation. Indeed, as Fleming (1971) points out, similarities in inflation rates reflect similarities in other essential policies including national employment goals, productivity growth and a degree of trade union aggressiveness. In particular, if trade unions and employers' organisations exist mainly on a national level, divergencies occuring in the labour market will call for adjustments using the exchange rates regime. This reduces the suitability of a currency union.

2.3 New Theory of Optimum Currency Areas: Empirics

After a relatively rich literature on optimum currency areas in 1960s and 1970s, the theory lost momentum for several years. Mongelli (2002) explains that the main reasons were a limited research interest – virtually no empirical material – and economic difficulties that the Economic and Monetary Union (EMU) was dealing with during the early 1980s. The theory was not reassessed until the overall attitude towards currency union became more supportive and economic analysis shifted towards the benefits of currency union membership. This change of direction gave rise to a so-called New Theory of Optimum Currency Areas, which adopts strictly cost-benefit approach, useful in analysing the choice of appropriate exchange rate regime for a single country (Ishiyama, 1975). Nevertheless, OCA was still criticised for not providing a clear answer and leaving the decision to be based on a political rather than an economic rationale. No country is likely to fulfill the OCA criteria perfectly and so the question of where to draw the line above which the fulfillment is sufficient remained unanswered. Dědek (2013) points out that this is precisely why the EU founders decided to condition the adoption of the euro on nominal rather than real convergence criteria[1] despite the fact that their limits are set arbitrarily. Mihaljek (2006) also suggests that these criteria may be difficult to meet for the Central and Eastern European countries, because these countries are going through a catching up phase after their economic transition. There seems to be an agreement in the literature that real economy convergence is at least as important (if not more) than purely nominal convergence, but empirical literature lacked appropriate methods to asses real convergence implied by the OCA until the end of 1990s.

Bayoumi and Eichengreen (1997) decided to account for this gap and were the first to operationalise the OCA theory. They construct a method to compute an OCA index, which indicates the readiness of a given country to adopt the common currency. Their procedure is based on the premise that suitability for a monetary unification of two countries can be measured using the variability of their bilateral exchange rate. The underlying economic determinants used as independent variables are largely based on the original work of Mundell (1961), McKinnon (1963) and Kenen (1969). They include output disturbances, dissimilarity of trade, trade linkages and the size of economies. The method is based on measuring bilateral relationships between two economies and the

[1] The nominal convergence criteria known as Maastricht criteria are a set of macroeconomic indicators which measure price stability (by controlling the level of inflation), sustainability of public finances (by limiting government borrowing and national debt to avoid excessive deficit), exchange rate stability (by requiring participation in the Exchange Rate Mechanism ERM II for at least two years without strong deviations from the ERM II central rate), and the durability of the convergence (by limiting long-term interest rates. Source http://ec.europa.eu/economy_financ e/euro/adoption/who_can_join/index_en.htm

impact of economic and trade characteristics on the variability of nominal exchange rate. Germany, as Europe's most important economy, is used as a benchmark, so the OCA index refers to a monetary integration with Germany. The authors conduct an econometric cross-section analysis on 21 (mainly European) industrial countries over the period of 1973-1992. Based on the value of the OCA indices, they classify countries into three groups – prime candidates for the EMU, countries gradually converging to the EMU, and countries showing little or no convergence. One of their striking findings is that the French economy and its cyclical performance indicate that France should not share the same currency as Germany.

The question whether or not, and to what degree, the traditional OCA criteria explain the exchange rate variability led Horváth and Komárek (2003) to revisit the theory. The authors follow the methodology proposed by Bayoumi and Eichengreen (1997) and update the OCA indices by including the period of 1990s. Same as their predecessors, they focus on bilateral country relationships and use exchange rate variability as the dependent variable. In their econometric analysis, they use a data matrix with variable proxies for asymmetric shocks, trade dissimilarity, trade linkages and openness of countries. They find that the ranking of economies suitable to form a monetary union in 1990s stayed the same as in 1980s and conclude that the structural characteristics of the economies did not change significantly. The authors also perform an OCA index for the Czech Republic and find that the Czech economy does not differ from the German economy more than EMU countries differ between each other. They conclude that if the eurozone is sustainable, the accession of the Czech economy should not change it.

Following the same methodology, Piłat (2011) investigates the readiness of ten EU member states to join the euro zone based on data from 1999 to 2009. The author constructs OCA indices vis-à-vis the euro zone and vis-à-vis Poland and finds that the set of countries suitable for these monetary unifications differ for each case. While the best candidates for the euro adoption are Hungary, United Kingdom and Poland, countries which are economically similar to Poland are the Czech Republic, Hungary and Bulgaria. Piłat (2011) also examines the evolution of OCA index for Poland vis-à-vis the euro zone and finds that the best (lowest) index values were achieved in 2004 and 2005 following the country's accession to the EU. On the other hand, a significant impact of the financial and economic crises led to a deterioration of the index value in 2009. Piłat (2011) concludes that this is mainly due to suboptimal business cycle synchronisation and important differences in the economic structures.

Borowski (2004) used the OCA framework to balance the costs and benefits associated with the country's potential accession to the eurozone. He concludes that this balance is positive, mainly due to a high degree of economic integration, which reduces the effectiveness of exchange rate adjustment mechanisms. The report suggests that delaying the decision of adopting the euro decreases the welfare gains on higher GDP and consumption and calls for a macroeconomic policy oriented towards the fastest possible participation in the Euro Area.

A similar approach but an opposite result can be found in the report by the UK Treasury, which performed five tests to see if the Pound sterling should be replaced by the euro (HM Treasury, 2003a). The study is based on the OCA theory and indluced convergence and flexibility tests to assess the degree of integration with the EMU. The authors conclude that due to large structural differences and insufficient flexibility the UK's accession to the Euro Area would be difficult and more steps have to be taken to achieve real convergence.

A significant stream of literature focusing on the question whether or not the euro zone itself is an OCA, usually concludes that it is not. Baldwin and Wyplosz (2009), for instance, find that most European countries are relatively open and diversified, but fail on the criteria of labour mobility and fiscal transfers, which means that there will certainly be some economic costs. The Schuman Report acknowledges that the euro zone is not an OCA, but argue that a truly *optimal* currency region does not exist, because the criteria are too strict to be fulfilled in reality (Foundation Schuman, 2012).

Moreover, as Bayoumi and Eichengreen (1998) point out in their work, one should be careful with OCA analyses, because they are often static and do not take into account the evolution in time nor provide comparative perspective for different countries. If the *endogeneity hypothesis* proposed by Frankel and Rose (1997) is correct, then the EMU might satisfy the OCA criteria *ex post* even if it did not satisfy them *ex ante*. The authors suggest that entering a currency union raises trade integration, which, in turn, may lead to a higher synchronisation of national business cycles. This argument has important implications for OCA econometric analysis, because it means that trade integration and business cycles are not only interrelated, but also endogenous processes to a monetary unification (Horváth et al., 2003). Consequently, countries whose economic structure is still far from the EMU member states might be motivated to join the currency union, hoping that the accession itself will contribute to the convergence of the economic cycles.

Nonetheless, the endogeneity hypothesis of OCA is not universally accepted. Although several studies support the view that trade integration leads to more synchronised cycles (Grigoli (2012) for MERCOSUR countries or Babetskii (2005) for

Central and Eastern European countries) the empirical evidence is mixed. Fidrmuc (2004) tests the endogeneity hypothesis on a regression analysis of 21 OECD countries in the 1990s and concludes that while intra-industry trade helps to induce convergence of business cycles, it is not the case for trade in general. Excluding additional supporting structural variables, the author finds no direct relationship between business cycles and bilateral trade intensity.

The opposing paradigm to the *endogeneity hypothesis* originated with Krugman (1993), who argues that closer international trade may in fact reduce the correlation of national business cycles instead of increasing it. His *specialisation hypothesis* is based on the trade theory and increasing returns to scale. As the single currency removes significant trade obstacles and countries become more integrated, they will specialize in goods for which they have a competitive advantage. Consequently, partner countries become less diversified, which makes then more vulnerable to supply shocks and drives their incomes in different directions (Mongelli, 2002). If Krugman (1993) is right, then monetary union brings little reassurance to countries displaying great heterogeneity, because business cycles become even more idiosyncratic *ex post* than they were *ex ante.*

An empirical study that raises doubt over the *endogeneity hypothesis* – but does not support the *specialization hypothesis* either – is conducted by Vieira and Vieira (2011). The authors assess the endogeneity of OCA conditions using a panel data of the same 21 OECD economies analysed earlier by Bayoumi and Eichengreen (1997,1998). They find that the OCA properties in the last decade improved for most of the analysed countries, whether or not they are members of the EMU. Such an improvement can thus be hardly attributed to the endogeneity resulting from monetary integration. In addition, peripheral countries displayed stronger signs of convergence before the adoption of the euro than after it.

Vieira and Vieira (2012) also conduct an OCA analysis on African countries. It shoud be noted that African regional groupings, along with the EMU, have been the main focus of the OCA econometric analysis during the last decade. Bangake et al. (2007) examine the validity of the OCA theory on a sample of 21 African economies. Using a system of simultaneous equations and the generalized method of moments (GMM) estimation, they find strong evidence for the link between exchange rate volatility and OCA variables. Based on the results, Bangake et al. (2007) make recommendations for different African groupings such as CEDEAO, COMESA or SADC. The study of Vieira and Vieira (2012) on the pegging decisions of COMESA concludes that most members would be better off pegging their currency to the euro than to the US dollar. They, too, suggest a different composition of COMESA grouping on the basis of the OCA theory.

The growing stream of literature on the OCA theory, increasing robustness of econometric analyses as well as the growing certainty that structural criteria are a necessary complement to nominal conditions (such as those defined by the Maastricht treaty) have all motivated the focus of this thesis. Recent economic and financial reality in Europe is a clear indication that if the eurozone is to survive in the long term, we need a better understanding of individual countries' structural differences. These differences might cause divergent requirements on the monetary policy, which is something managed with great difficulty in a single currency union.

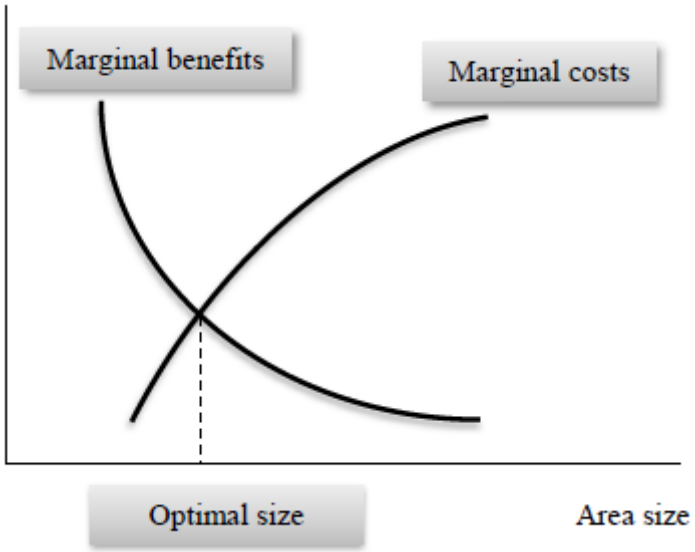
3 THEORY OF OPTIMUM CURRENCY AREAS

In accordance with previous OCA literature, a 'currency area' in this paper refers to an area where countries either share a common currency, or have irrevocably fixed exchange rates (Mongelli, 2002). An *optimum* currency area is then defined as '*an economic unit composed of regions affected symmetrically by disturbances and between which labour and other factors of production flow freely.'* (Eichengreen, 1991, p. 1). To give some perspective to this definition, we now present the OCA in the context of a cost-benefit analysis.

3.1 OCA as a Cost-Benefit Analysis

Members of currency unions benefit from efficiency and growth advantages, but at the same time have to give up an important adjustment tool – the option to alter their exchange rate (Mongelli, 2002). Consequently, the choice of the exchange rate regime is reduced to a cost-benefit problem. This approach is helpful in analysing the eventuality of a currency union membership, because it looks directly at the self-interest of a particular country (Ishiyama, 1975). We can summarise this choice by the following graph:

Figure 1: Marginal costs and benefits of a monetary union



Note: Author; based on Baldwin and Wyplosz (2009)

The benefits of sharing a single currency increase with growing participation of countries in a monetary union, but only up to a certain point (denoted as 'optimal size'). When the union covers too many countries, a single monetary policy can no longer respond to different requirements and marginal costs outweigh marginal benefits (Baldwin and Wyplosz, 2009).

Mongelli (2002) states three main sources of benefits. First, countries tend to improve microeconomic efficiency, because a broader circulation of a single currency increases its usefulness, transparency and competition in the market. Reduced transaction costs foster investment and efficient resource allocation and decrease exchange rate uncertainty. Second, a common currency encourages macroeconomic stability and growth resulting from easier access to financial markets, higher availability of external financing and improved price stability. It may also reduce fluctuations of output and employment, although real economic shocks still remain a risk. Third, adoption of a common currency brings benefits from positive external effects due to a wider circulation of the currency, revenues from international seignorage and a lower need for foreign exchange reserves.

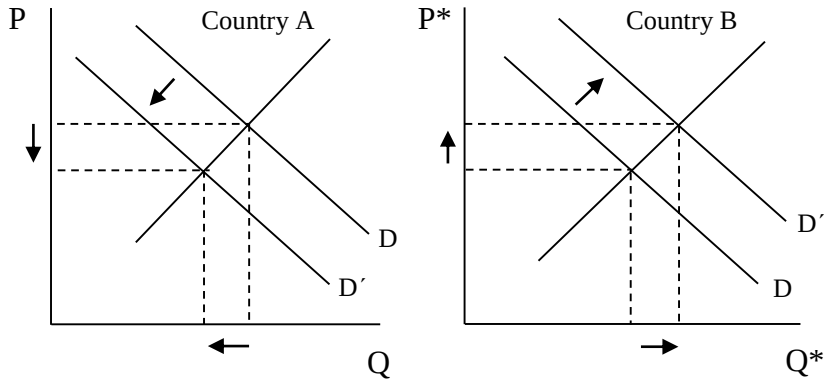
Nonetheless, joining a currency union bears significant costs. The most obvious one is a decreased macroeconomic stability as the country loses an important monetary adjustment tool. The competence of a monetary policy is transferred to a supranational central bank, which cannot always act in the best interest of a single country, as it is designed to serve the needs of the majority (Ishiyama, 1975). This embodies an important risk if countries need to adjust to asymmetric shocks. 'Asymmetric' shock is either a shock that occurs only in some member states or alternatively, a symmetric shock occurring in all member states, but creating asymmetric effects (Baldwin and Wyplosz, 2009). Asymmetric shocks stem from different sources, including economic, financial, political, social and environmental factors. Declining oil prices in Russia and oil exporting Arab countries, terrorist attacks in Paris in November 2015, migrant crisis in Europe, or new regulations on CO_2 emission can serve as recent examples of real life asymmetric shocks.

In the view of the OCA theory, it is possible to minimise costs if countries fulfil certain economic criteria. These criteria define the *optimum* currency area and create a framework to analyse whether or not a given country is suitable to join an already existing monetary union. In the following part, we list three main criteria proposed by Mundell (1961), McKinnon (1963) and Kenen (1969).

3.2 Robert Mundell and Labour Market Flexibility

For Mundell, the *'essential ingredient'* of such an area is a high degree of factor mobility (Mundell, 1961, p. 661). He illustrates his argument with an example of countries A and B, initially in their equilibrium of balanced trade and full employment. Both countries are hit by an asymmetric shift in demand towards products of country B and away from products of country A. This is demonstrated in Figure 2.

Figure 2: Asymmetric shift in demand



Source: Author; based on Mundell (1961) in European Parliament (1998).
P stands for the overall price level, D for aggregate demand, Q for production..

In such a scenario, the likely result for country A is a decline in output and an increase in unemployment. Country B, on the other hand, deals with an increased output and inflationary pressures. In the absence of a common currency, countries can use the exchange rate to depreciate their currency and increase competitiveness (country A) or appreciate their currency and avoid excessive inflation (country B). If both of these countries are members of a currency union, such an adjustment mechanism is no longer available. According to Mundell, both problems can be resolved by a reallocation of the idle production factors (mainly labour) from A to B without the need to change prices or wages (Mundell, 1961). This is made possible by sufficiently flexible labour markets. The capacity to achieve sufficient mobility defines the illusionary borders of an optimum currency area:

> *'If the world can be divided into regions within each of which there is factor mobility and between which there is factor immobility, then each of these regions should have a separate currency which fluctuates relative to all other currencies'* (Mundell R. , 1961, p. 663).

Throughout his argumentation, Mundell puts a great emphasis on the size of optimum currency area as well as the size of its individual members. Subsequent literature

(e.g. Harris, 2001) also supports the view that larger currency areas promote greater volumes of trade and economic growth.

The idea of optimality was further developed as different economists presented their own views as to what should be the main criterion for grouping countries into currency unions. In 1963, Ronald McKinnon proposed an alternative – or rather a complement – to labour mobility: the openness of the economies.

3.3 Ronald McKinnon and the Openness of Economies

McKinnon (1963) defines the 'openness' as the ratio of tradable to non-tradable goods, assuming that all goods can be classified into one of these categories. If they can be transported – exported or imported – they are tradables. If transportation is not feasible, they are non-tradables (McKinnon, 1963, p. 717). The price of a tradable good is determined by the outside world.

McKinnon (1963) uses the term 'optimum' to describe a currency area that is successful in reaching three objectives:

1) Maintenance of full employment;
2) Maintenance of balanced international payments; and
3) Maintenance of a stable average price level

While these objectives can sometimes be conflicting, McKinnon (1963) believes that the appropriate choice of exchange rate regime achieves their best possible resolution. In a simple model of an economy and the rest of the world (i.e. assuming the existence of only two different currencies), he examines what happens after a shock which changes the relative price of tradable and non-tradable goods. In a relatively open economy operating under a flexible exchange rate regime, any change in the exchange rate is directly absorbed by the change in domestic prices and wages. There is, in the end, no improvement in the country's competitiveness. What is more, the third objective of a price level stability is compromised, because a price change in the large tradable sector will cause fluctuations in the overall price level.

> *'Changes in the exchange rate will necessarily be completely offset by internal price-level repercussions with no improvement in the trade balance… If we move across the spectrum from closed to open economies, flexible exchange rates become both less effective as a control device for external balance and more damaging to internal price-level stability'* (McKinnon, 1963, p. 718).

Since currency devaluations are ineffective for changes in competitiveness, the only possibility for policy makers is reducing domestic expenditures (for example increase taxes) while maintaining output levels.

3.4 Peter Kenen and the Diversification of Production

Peter Kenen (1969) refers mostly to Mundell throughout his analysis and provides a thorough discussion of his arguments. He raises several objections to the principle of labour mobility. For instance, what if the production in one region is significantly more labour intensive than in a different region, making it difficult for people to change occupation? What if labour is heterogeneous and skill requirements vary significantly throughout the currency union? Can a simple labour mobility really restore trade balance? Kenen (1969) concludes that defining zones by perfect labour mobility, which never occurs in reality, is impractical. Instead, he insists on the diversification of production. He summarises his arguments in three points:

1) A well-diversified economy does not have to undergo changes in its terms of trade as often as a single-product economy;
2) When such an economy confronts a drop in the demand for its principal exports, the rise in unemployment is not as sharp as it is in a less diversified economy;
3) The links between external and domestic demand – especially the link between exports and investment – is weaker in diversified economies, which stabilises domestic capital formation.

In other words, diversified economies tend to experience fewer asymmetric shocks, because a failure in one export sector is likely to be compensated by a success in another one, keeping overall exports relatively stable[2]. Referring to the law of large numbers, Kenen (1969) concludes that export disturbances are independent and averaged out if diversification is large enough. Thus, there is less need for a change in the exchange rate.

> *'Economic diversification, reflected in export diversification, serves, ex ante, to forestall the need for frequent changes in the terms of trade and, therefore, for frequent changes in national exchange rates'* (Kenen, 1998, p. 66).

[2] As Kenen (1969) point out, this only applies for external shocks, not for changes in export demand, which are a result of business cycle variations.

Moreover, diversification mitigates the effect of a shock even after it occurs, because it provides a 'shield' for the labour force. This is where Kenen's analysis relates to that of Mundell (1961). Diversification is seen as a prerequisite for Mundell's internal factor mobility (particularly occupational mobility), since a diversified economy with a wide range of economic activities increases labour opportunities.

Similarly to Friedman (1953), Kenen (1969) calls for a deeper fiscal integration. He sees the primary function of a fiscal policy as a tool to offset regional differences. In the case of an adverse asymmetric shock, interregional transfers should compensate the losses incurred and facilitate adjustment.

In this paper, we abstract from the fiscal transfers and concentrate on the essential economic characteristics identified by the seminal papers. We collect data on output disturbances, trade, economy size, openness, labour mobility and financial development and observe whether, and to what extent, these factors explain the variability of exchange rates. Consequently, we compute predicted exchange rate variability based on the most recent data and use the predicted variability as a proxy for the usefulness of a country keeping its national currency. If such variability is high, then nominal exchange rate remains an important adjustment tool and the country would probably be better off staying outside of the currency union. In the opposite case, the benefits of adopting a common currency will probably outweigh the costs, because asymmetric shocks should occur only rarely.

4 METHODOLOGY

The methodology used in our analysis originates with Bayoumi and Eichengreen (1997) who developed a procedure allowing for the application of the core implications of the OCA theory to cross-country data. They depart from the premise that the variability of an exchange rate contains considerable information about the underlying economic characteristics such as synchronisation of business cycles, trade diversification, trade intensity and economic size. They construct an OCA index which is based on these characteristics and which should reflect whether or not a monetary integration is beneficial for a pair of economies. This paper is using their original regression equation, although some variables are computed differently in case where more detailed data was accessible. We later propose a modified version of the equation including new variables.

The regression equation proposed by Bayoumi and Eichengreen (1997) is as follows:

$$VOL\,(ER)_{ij} = \beta_0 + \beta_1 AC_{ij} + \beta_2 DISSIM_{ij} + \beta_3 TRADE_{ij} + \beta_4 SIZE_{ij} + e_{ij} \quad (1)$$

Where:

1. $VOL\,(ER)_{ij}$ stands for exchange rate volatility and is measured as the standard deviation of the yearly change in the logarithm of the bilateral exchange rate between countries i and j;
2. AC_{ij}, or asymmetry of business cycles, is the standard deviation of the difference in the logarithm of real output growth between i and j;
3. $DISSIM_{ij}$ accounts for the dissimilarity of exports and is computed as the sum of the absolute differences in the shares of each of nine categories of merchandise trade for countries i and j;
4. $TRADE_{ij}$, or trade linkages, is the mean of the ratio of bilateral exports to domestic GDP for countries i and j;
5. $SIZE_{ij}$ referring to the size of the economy is the mean of the two GDPs in logarithm measured in US dollars;
6. e_{ij} is the stochastic error term.

The underlying exchange rate in the computation of the dependent variable is measured as yearly average. Bayoumi and Eichengreen (1997) use nominal exchange rates on the grounds that they provide an easier benchmark for comparison to a single currency in which the variability is zero. Our analysis maintains this approach. It is important to note, however, that there has not been a unified agreement on this point in

the relating literature. Horváth and Kučerová (2005) and Skořepa (2011) use real exchange rates to account for the existing discrepencies between official and *de facto* rates and to provide a more realistic picture. Barbosa and Alves (2011) also use real exchange rate becauses they analyse European countries after their accesion to the Euro Area. Generally, however, there have not been major differences between the results from real and nominal rates and the choice should not alter the main findings and implications of the analysis.

In this paper we estimate the above mentioned equation for the period before the euro adoption in a cross-sectional regression with 21 advanced economies. The estimation is done in three steps, which not only allows to compare the results to earlier studies conducted by Bayoumi and Eichengreen (1997), Horváth (2005) or Vieira and Vieira (2011), but also to include new variables and study the effect of financial and economic crises on the OCA index.

We estimate the regression for the whole sample period of 1980-1998 and then for two subperiods: 1980-1989 and 1990-1998, just before the euro adoption. The countries in the sample are as follows: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the USA. As the setting is bilateral and each country pair is included only once, the combination of 21 countries leads to 210 observations.

4.1 Methodological problems of measurement

Reviewing the related literature, we have identified several caveats concerning the measurement, in particular relating to the nature of asymmetric shocks. First, studies by the European Parliament (1998) and Komárek et al. (2003) stress the importance of distinguishing between temporary vs. permanent shocks, country specific vs. sector specific shocks and demand and supply shocks. These might require different reactions, which leads to another methodological problem – how to distinguish between a shock and the reaction to it? The '*Lucas critique'* implies that a parlicular adverse shock may seem to have a limited asymmetric effect because, following the shock, the authorities in power will change their behaviour in order to mitigate its negative consequences (European Parliament, 1998). As a result, the quantitative measure used in the analysis (the average exchange rate over a given year) might not perfectly reflect the size of the original shock.

Furthermore, OCA is fundamentally a long-run theory and might lack operational precision for short-term decision making (Komárek et al., 2003). Goldberg (1999) goes even further and states that the theory is not suitable for transition economies at all due to

specific stabilisation and transition issues, which are characteristic only for them. While it is important to be aware of these issues, they are most likely not fatal to the significance and implications of the analysis.

4.2 Data description and measurement

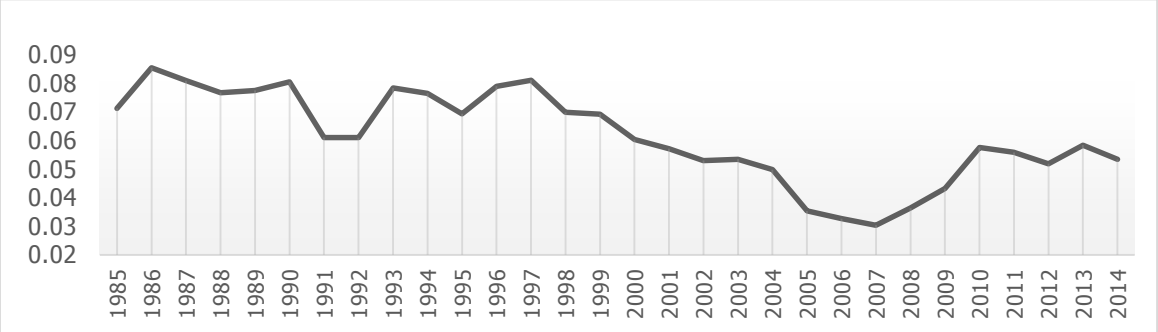
4.2.1 Exchange rate volatility

The volatility of a bilateral exchange rate (ER) is computed as the standard deviation over the sample period of the yearly log-variations of bilateral nominal exchange rates between each two countries in the sample:

$$VOL\ (ER)_{ij} = SD\ (\log ER_{ij,t+1} - \log ER_{ij,t})$$

The data is sourced from the IMF International Financial Statistics. Due to the fact that data for respective bilateral exchange rates was not available for 1980s, the dataset is based on bilateral exchange rates against the US dollar, which are in turn used to compute the respective bilateral exchange rates of the countries in the sample.

Figure 3: Variability of bilateral exchange rates for period 1980-2014



Note: The variability is measured as the standard deviation of the log variations of the bilateral exchange rates. Each year represents here the mean of the standard deviation for the preceding five-year-period (i.e. 1985 stands for 1980-1985).

The average ER variability and the variability for specific relationships are depicted in Figure 3 and Figure 4 respectively. For the sake of comparison, we present the variability of exchange rates up to 2014, although data beyond 1998 is excluded from the analysis.[3] As we can see, exchange rates were on average more volatile in 1980s. In this period, it is primarily the bilateral relationships with Australia and the USA that account for the bulk of the ER variability. This is not the case for the subsequent period

[3] To maintain continuity of the data beyond the period of the euro adoption, the exchange rate against the US dollar throughout the whole period is scaled by the fixed rate set on the date of the euro adoption. This method is taken from Vieira and Vieira (2011). The data on fixed euro rates was retrieved from the European Commission's website.

of 1990s, where exchange rates of European states are significantly more volatile than those of geographically remote countries.

Figure 4: Variability of bilateral exchange rates for specific relationships during 1980s and 1990s

1980s

	AUS	AUT	BEL	CAN	DNK	FIN	FRA	DEU	GRC	IRL	ITA	JPN	NLD	NZL	NOR	PRT	ESP	SWE	CHE	GBR
AUT	0.174																			
BEL	0.180	0.045																		
CAN	0.075	0.150	0.163																	
DNK	0.174	0.028	0.020	0.152																
FIN	0.130	0.060	0.061	0.114	0.054															
FRA	0.174	0.042	0.018	0.155	0.020	0.050														
DEU	0.176	0.003	0.044	0.151	0.027	0.062	0.042													
GRC	0.108	0.085	0.095	0.093	0.086	0.044	0.085	0.086												
IRL	0.164	0.036	0.044	0.139	0.030	0.042	0.029	0.037	0.073											
ITA	0.171	0.033	0.030	0.151	0.025	0.056	0.027	0.032	0.083	0.034										
JPN	0.145	0.089	0.090	0.136	0.086	0.085	0.093	0.091	0.110	0.090	0.097									
NLD	0.178	0.008	0.045	0.154	0.029	0.062	0.041	0.006	0.086	0.036	0.033	0.096								
NZL	0.092	0.101	0.108	0.086	0.100	0.068	0.103	0.103	0.046	0.094	0.101	0.094	0.104							
NOR	0.120	0.064	0.073	0.095	0.062	0.023	0.063	0.066	0.041	0.048	0.065	0.078	0.068	0.056						
PRT	0.145	0.091	0.080	0.143	0.082	0.055	0.071	0.092	0.066	0.074	0.081	0.108	0.091	0.085	0.067					
ESP	0.156	0.082	0.068	0.149	0.070	0.048	0.055	0.083	0.070	0.058	0.065	0.121	0.080	0.099	0.068	0.054				
SWE	0.140	0.076	0.056	0.132	0.059	0.032	0.049	0.077	0.069	0.055	0.063	0.087	0.078	0.084	0.049	0.058	0.043			
CHE	0.173	0.027	0.066	0.149	0.049	0.070	0.064	0.029	0.090	0.055	0.059	0.081	0.032	0.101	0.070	0.100	0.101	0.090		
GBR	0.121	0.075	0.077	0.102	0.068	0.034	0.068	0.077	0.042	0.057	0.075	0.082	0.078	0.047	0.026	0.063	0.067	0.049	0.080	
USA	0.102	0.157	0.172	0.045	0.160	0.124	0.164	0.159	0.115	0.146	0.162	0.139	0.162	0.114	0.106	0.159	0.162	0.141	0.153	0.117

1990s

	AUS	AUT	BEL	CAN	DNK	FIN	FRA	DEU	GRC	IRL	ITA	JPN	NLD	NZL	NOR	PRT	ESP	SWE	CHE	GBR
AUT	0.106																			
BEL	0.107	0.009																		
CAN	0.063	0.093	0.097																	
DNK	0.105	0.010	0.010	0.092																
FIN	0.118	0.089	0.083	0.123	0.084															
FRA	0.102	0.013	0.014	0.089	0.009	0.088														
DEU	0.106	0.000	0.009	0.093	0.010	0.089	0.012													
GRC	0.084	0.054	0.056	0.071	0.049	0.077	0.047	0.054												
IRL	0.087	0.053	0.051	0.075	0.046	0.085	0.044	0.052	0.041											
ITA	0.106	0.087	0.084	0.091	0.080	0.096	0.077	0.087	0.063	0.052										
JPN	0.118	0.115	0.120	0.117	0.123	0.167	0.121	0.115	0.135	0.139	0.174									
NLD	0.106	0.002	0.009	0.094	0.011	0.089	0.013	0.002	0.056	0.054	0.088	0.114								
NZL	0.046	0.115	0.118	0.089	0.115	0.128	0.114	0.115	0.100	0.108	0.138	0.113	0.115							
NOR	0.083	0.040	0.040	0.075	0.035	0.077	0.035	0.040	0.030	0.027	0.066	0.124	0.041	0.099						
PRT	0.103	0.046	0.045	0.086	0.042	0.085	0.041	0.046	0.045	0.039	0.058	0.137	0.047	0.125	0.029					
ESP	0.115	0.058	0.054	0.096	0.051	0.079	0.051	0.058	0.056	0.044	0.044	0.159	0.059	0.138	0.047	0.030				
SWE	0.109	0.091	0.087	0.108	0.085	0.082	0.083	0.091	0.067	0.064	0.045	0.176	0.092	0.138	0.064	0.053	0.050			
CHE	0.107	0.028	0.025	0.104	0.029	0.076	0.032	0.028	0.063	0.067	0.096	0.119	0.027	0.114	0.054	0.063	0.069	0.097		
GBR	0.087	0.091	0.091	0.059	0.087	0.096	0.085	0.091	0.058	0.058	0.066	0.144	0.093	0.116	0.066	0.073	0.077	0.084	0.100	
USA	0.073	0.093	0.098	0.036	0.094	0.132	0.090	0.093	0.075	0.086	0.104	0.100	0.094	0.095	0.082	0.094	0.108	0.121	0.102	0.067

Note: Country abbreviations are: AUS = Australia, AUT = Austria, BEL = Belgium, CAN = Canada, DNK = Denmark, FIN = Finland, FRA = France, DEU = Germany, GRC = Greece, IRL = Ireland, ITA = Italy, JPN = Japan, NLZ = New Zealand, NOR = Norway, PRT = Portugal, ESP = Spain, SWE = Sweden, CHE = Switzerland, GBR = United Kingdom, USA = United States of America.

4.2.2 Dissimilarity of trade

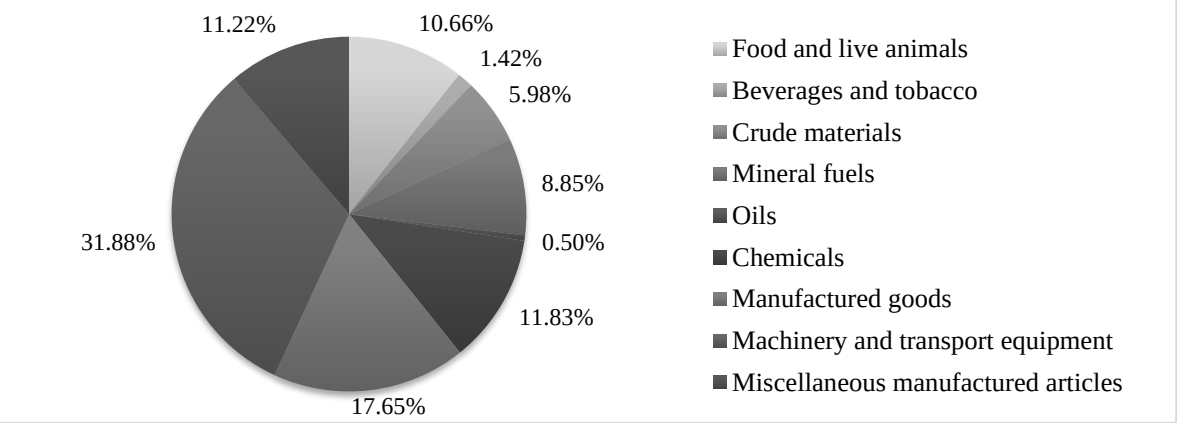
The dissimilarity of trade reflects differences in export patterns of each pair of countries. It is computed as the sum of absolute differences in the relative share of each export category of trade commodities and averaged over the sample period:

$$\mathrm{DISSIM}_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left[\sum_{C=0}^{8}\left|\mathrm{EX}_{i.t}^{C} - \mathrm{EX}_{j.t}^{C}\right|\right]$$

where $\mathrm{EX}_{i.t}^{C}$ and $\mathrm{EX}_{j.t}^{C}$ is the share of given export category in country's i and j total export at time t. While Bayoumi and Eichengreen (1997,1998) and Horváth (2005) consider only three categories of trade (manufactured goods, food and minerals), we choose a more detailed classification of nine categories, using the Standard International Trade Classification (SITC): food and live animals, beverages and tobacco, crude materials, mineral fuels, animal and vegetable oils, chemicals, manufactured goods, machinery and transport equipment and miscellaneous manufactured articles. The data was sourced from the ComTrade database.

Average commodity structure and its evolution in time are presented in Figure 5 and Figure 6 respectively. Machinery and transport equipment account for almost a third of exports, followed by manufactured goods and chemicals. On the other hand, beverages and tobacco combined with oils make approximately 2% of exports. The country pairs with the most similar and the most different export structures are shown in Table 1.

Figure 5: Average commodity export structure for the period 1980-2014



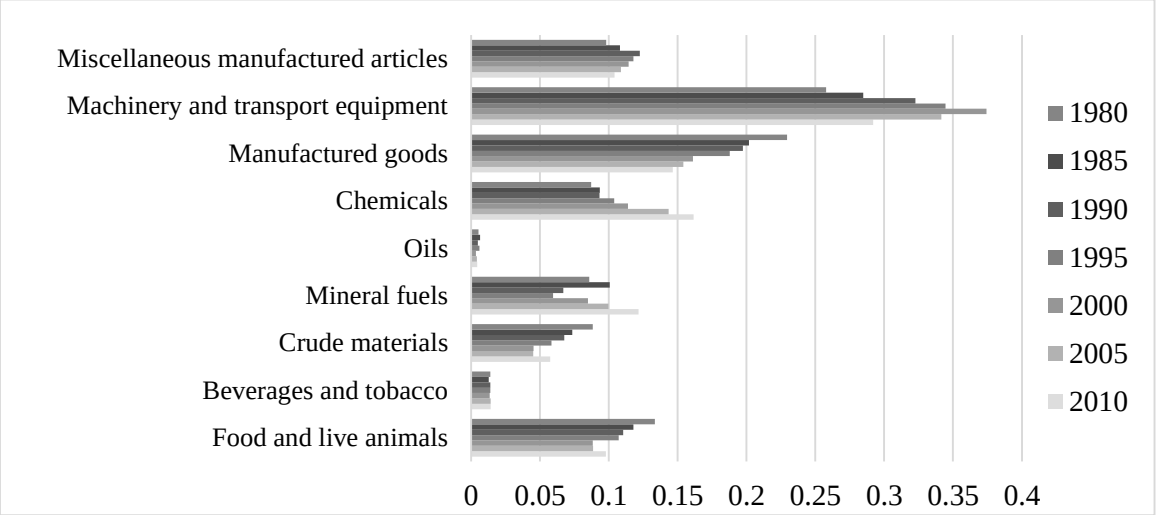
Source: Author; based on data from ComTrade database

Table 1: Top five country pairs with the most different and most similar exports structures measured over 1980-1998

Country 1	Country 2	Trade dissimilarity
Australia	Japan	1.43
Japan	New Zealand	1.39
Australia	Switzerland	1.35
Greece	Japan	1.31
New Zealand	Switzerland	1.29
Austria	Sweden	0.30
Austria	Italy	0.29
Germany	US	0.28
Germany	UK	0.27
France	Spain	0.24

Note: Trade dissimilarity is computed as the sum of absolute differences in the relative share of each export category of trade commodities over the period 1980-1998.

Figure 6: Average export structure for period 1980-2010



Source: Author; based on data from ComTrade Database

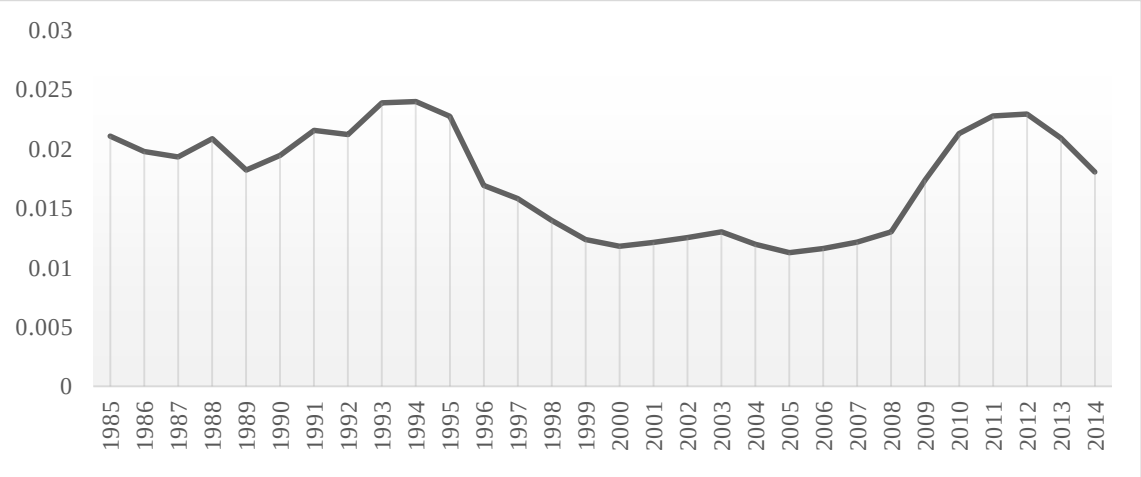
4.2.3 Asymmetry of business cycles

The asymmetry of business cycles (or output disturbances) is computed as the standard deviation of the log differences in the real GDP growth in each of the two countries in the sample:

$$AC_{ij} = SD(\Delta \log real\, Y_{it} - \Delta \log real\, Y_{jt})$$

The data on real output growth rates is calculated from the GDP in constant local currency and sourced from the World Bank database.

Figure 7: Asymmetry of business cycles for the period 1980-2014



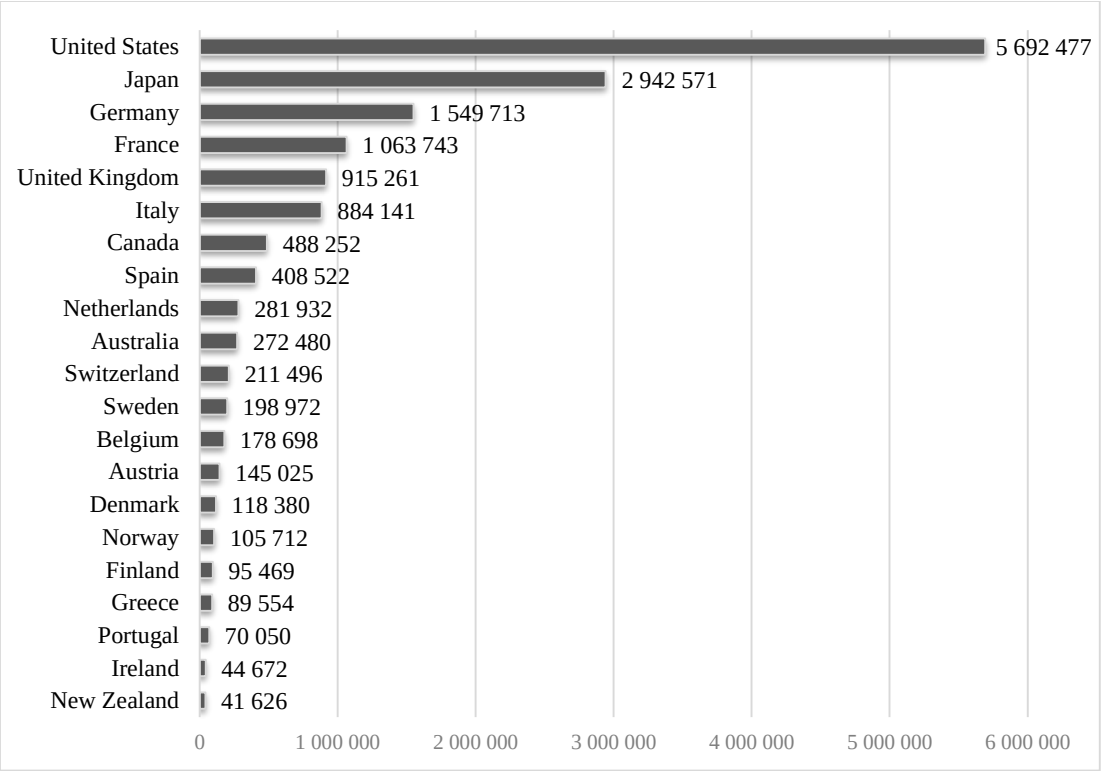
Source: The asymmetry for the purpose of this graph is measured as the standard deviation of the different output growth rates over the preceding five-year-period for each country in the pair (i.e. 1985 stands for 1980-1985).

4.2.4 Economic size

Economic size reflects the nominal GDP of each pair of economies. It is computed as the mean of the two countries' log of GDP, measured in current US dollars and averaged over the sample period. Nominal GDP data is sourced from the World Bank database.

$$SIZE_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{\log Y_{it} + \log Y_{jt}}{2}\right)$$

Figure 8: Economic size in mil US dollars averaged over 1980-1998



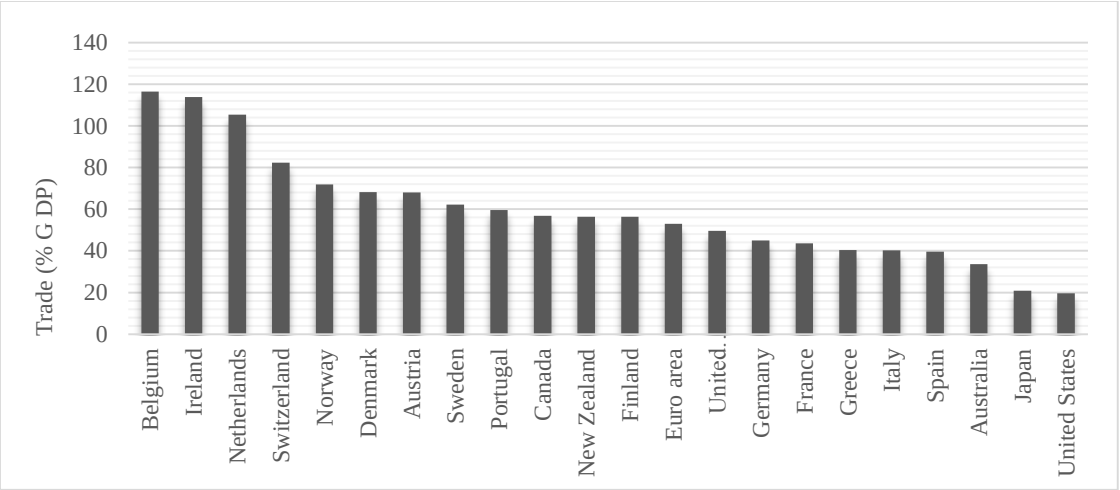
Source: Author; based on World Bank data

4.2.5 Openness

Following Horváth (2005), the openness measure is added to the equation to see whether it is as a better indicator than economic size. Openness measures the ratio of the sum of exports and imports of goods and services to the country's GDP and does not take into account the destination of exports and the source of imports. Again. we use the average value over the sample period. The data was downloaded from the WorldBank database.

$$OPEN_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{EX_{it} + IM_{it}}{Y_{it}} + \frac{EX_{jt} + IM_{jt}}{Y_{jt}}\right)$$

Figure 9: Openness (Trade as % of GDP) averaged over 1980-1998



Source: Author; based on World Bank data

4.2.6 Trade linkages

Trade linkages measure the intensity of bilateral exports between each pair of countries. Unlike the previous indicator, $TRADE_{ij}$ takes directly into account the volume of exports traded with the specific partner country. It is computed as the sum of the ratio of bilateral exports to domestic GDP in both countries:

$$TRADE_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{EX_{ij.t}}{Y_{it}} + \frac{EX_{ji..t}}{Y_{jt}}\right)$$

where $EX_{ij.t}$ (analogously for $EX_{ji.t}$) is the volume of exports measured at current prices from country i to country j at time t. and Y_{it} is the GDP at current prices for country i. Data on bilateral exports was kindly provided by the CHELEM-Cepii database.

As discussed in section 3 of this paper, countries fulfilling the OCA conditions are expected to have a relatively stable exchange rate. This is the reason why monetary integration is suitable in this case; countries will benefit from the advantageous of sharing a currency and they will not be subject to large and frequent asymmetric shocks, which stem from structural differences of their economies. The following analysis will test this premise empirically. Variable $SIZE_{ij}$ and variables showing deviations (AC_{ij} and $DISSIM_{ij}$) are expected to have a positive coefficient, because they add to the instability of exchange rates. On the other hand, coefficient on $TRADE_{ij}$ should be negative, because important trade relationships tend to reduce exchange rate volatility.

5 OLS ESTIMATION

Results for the ordinary least squares regression are presented in Table 2. The OLS* model is considered as the benchmark model including four traditional OCA criteria: the asymmetry of business cycles, trade dissimilarity, trade linkages and the average size of the two economies. Consequently, variable $OPEN_{ij}$, which was identified as a significant factor by Horváth (2005), is added to the equation and the estimation is done separately for the two subperiods (1980-1989 and 1990-1998) and for the whole sample period 1980-1998. In the last column, we include the estimation results from a relatively recent study on the OCA indices by Vieira and Vieira (2011).

For both of the 1980s-1990s estimations (columns 1 and 4), all of the variables are significant at the 5% level and have expected signs. According to our results in Table 2, asymmetry of business cycles has a strong and significant effect on the variability of exchange rate. Economic cooperation between monetary union members seems to play an important role in preventing large exchange rate fluctuations and resulting uncertainty. Intensive trade linkages and structural similarity significantly decrease exchange rate fluctuations, suggesting that international trade contributes to more stable exchange rates. Economic size and openness are two other significant factors affecting the ER variability. Relatively smaller and open economies seem to face lower volatility of bilateral exchange rates. This may be due to a limited influence on the terms of a trade and lower independence of monetary policy (Horváth, 2005). Except for trade dissimilarity, the variables maintain the same sign and significance at the 5% level during all subperiods. Trade dissimilarity is only significant when the size of economies is considered on its own; once we add openness to the equation, it becomes insignificant.

The White's test revealed the presence of heteroscedasticity in the data for 1980s and for 1980-1990s. The standard errors presented in Table 2 are corrected for heteroscedasticity using White's robust standard errors, which allows for more accurate p-values and robust confidence intervals (White, 1980). In the period of 1990s heteroscedasticity was not present.

The cross-country estimation of 21 advanced economies over 1980-1998 from the OLS* benchmark model (which is chosen to allow comparability with the results of previous studies) gives the following equation:

$$VOL\,(ER)_{ij} = 0.0115 + 0.8925\,AC_{ij} + 0.0254\,DISSIM_{ij} - 0.4175\,TRADE_{ij} + 0.0032\,SIZE_{ij} + e_{ij}$$

The adjusted R-squared, which takes into account the sample size and the number of variables, is approximately 0.27 for the benchmark model and 0.40 for the model including the openness of economies, which means that the model explains a considerable part of the ER variability. Testing for the normality of residuals and multicollinearity did not uncover any problematic issues.

Table 2: OLS estimation for 2 sub periods (1980s, 1990s) and the sample period of 1980-1998 for 21 industrial countries. Comparison with Vieira and Vieira (2011).

	OLS*	**OLS (1980s)**	**OLS (1990s)**	**OLS (1980s-1990s)**	**OLS (Vieira and Vieira)**
Constant	0.0115 (0.0200)	0.0591 (0.0196)***	0.0435 (0.0176)**	0.0663 (0. 0183)***	−0.253 (0.028)***
Asymmetry of business cycles	0.8925 (0.3296)***	0.7199 (0.3189)**	1.6889 (0.2197)***	0.8897 (0.2977)***	1.646 (0.167)***
Trade dissimilarity	0. 0254 (0.0082)***	0.0264 (0.0099)***	0.0103 (0.0071)	0.0187 (0.0075)***	0.023 (0.006)***
Trade linkages	−0.4175 (0.0904)***	−0.3763 (0.1001)***	−0.2944 (0.0688)***	−0.3628 (0.0722)***	-0.864 (0.121)***
Size of economy	0.0032 (0.0013)**	0.0034 (0.0011)***	0.0024 (0.0009)**	0.0027 (0.0009)***	0.015 (0.001)***
Openness		−0.0379 (0.0063)***	−0.0298 (0.0048)***	−0.0359 (0.0050)***	
Adjusted R^2	0.27	0.28	0.45	0.40	0.46

The nature of the data, however, suggests that we might deal with an endogeneity problem. In particular, we include trade linkages as an explanatory variable for exchange rate variability, although the value of exports and imports is largely influenced by the changes in the exchange rates. A potential devaluation of a currency means that the country's exports become cheaper for its trading partners and the opposite applies to imports (De Grauwe, 2012, p. 104).

Similarly, asymmetry of business cycles is used here as an explanatory variable for the exchange rate volatility, although there might also be a relationship in the other direction (a simultaneous effect). As pointed out above, depreciation makes exports cheaper and increases demand for domestic goods (due to expensive imports) if these are relatively elastic. Increasing trade balance boosts output and the country may experience a positive economic growth. Although the fact that we use standard deviation of output and of the volume or bilateral trade reduces the influence of the endogeneity problem (Horváth, 2003), it could still violate the consistency of the OLS estimates and make the estimation invalid. The best way to overcome this problem and get consistent estimates is using instrumental variables (IV) regression. The IV analysis is discussed in the following section.

6 IV ESTIMATION

We instrument the endogenous variables ($OPEN_{ij}$, $TRADE_{ij}$ and AC_{ij}) using the log-distance between both countries ($lndist$) and its square ($lndist2$) and three dummy variables indicating whether the countries share a border ($combord$), a language ($comlang$) and whether they have a regional trade agreement ($tradeag$). These instruments are drawn from gravity models and also chosen by Baymoumi and Eichengreen (1998) and Horváth (2005) who encountered, too, the problem of endogeneity. The air distance was sourced from Mapcrow, an online travel distance portal, language was based on the countries' official languages and regional trade agreements (RTA) were sourced from the RTA database of the WTO.

With the set of instruments at hand, we test the presence of endogeneity following the procedure of two-stage-least-squares (TSLS) described for instance by Brooks (2014). We estimate a so-called first-stage equation (or reduced form equation) and regress each endogenous variable on the set of its instruments and other exogenous variables:

$$\mathrm{X}_{ij} = \alpha_0 + \alpha_1 lndist_{ij} + \alpha_2 lndist2_{ij} + \alpha_3 combord_{ij} + \alpha_4 comlang + \alpha_5 tradeag_{ij} + \alpha_6 SIZE_{ij} + \alpha_7 DISSIM_{ij}$$

where X_{ij} is the given endogenous variable ($OPEN_{ij}$, $TRADE_{ij}$ and AC_{ij}). We then test the significance of residuals from the first-stage regression in the original (structural) equation with $VOL\ (ER)_{ij}$ as the dependent variable. In all cases, the coefficient of residuals is significantly different from zero even at a 5% level and we confirm the problem of endogeneity. The same conclusion is drawn from the Hausman test, which rejects the null hypothesis of consistent OLS estimates (see Appendix 2).

In order to get consistent and efficient estimates, we use the TSLS method derived from the Generalized Method of Moments (GMM) estimator, a two-step approach which minimizes a set of orthogonality conditions (Hansen, 1982). In practise, GMM estimation finds parameters such that sample moments are close to their population counterparts. In the case of an overidentified model, where we have more instruments excluded from the equation than endogenous variables, GMM uses a weighting matrix as the inverse of the variance-covariance matrix of the moment conditions. Unlike TSLS, GMM allows for efficient estimation under heteroscedasticity of an unknown form. On the other hand, the GMM estimator can suffer from a finite-sample bias, because it relies on asymptotic characteristics (Beck, 2008).

Another problem arises when we include 'weak instruments' with little explanatory power. Such instruments increase the bias of IV estimates in the same direction as OLS and may result in an incosistent estimation. With weak instruments, neither significance tests nor confidence intervals yield reliable results. It is, therefore, important to check whether the instruments satisfy both of the necessary conditions of validity: relevance and exogeneity:

> **Instrument relevance**: $Corr(Z_i, X_i) \neq 0$, i.e. it neds to be correlated with the endogenous variable;
>
> **Instrument exogeneity**: $Corr(Z_i, \varepsilon_i) = 0$.

where X_i is the endogenous variable, Z_i is instrumental variable and ε_i is the error term (Stock and Watson, 2003).

First of all, we informally test the relevance of instruments. We regress each endogenous variable on the set of instruments. When $TRADE_{ij}$ is regressed on the set of instruments, only $lndist$ and $combord$ are significant, providing the overall R-squared 0.45. Instruments $lndist_{ij.}lndist2_{ij}$ and $combord$ are relevant for $OPEN_{ij}$ and give an R-squared of 0.29. In case of the asymmetry of business cycles AC_{ij}, only $lndist$ and variable $tradeag_{ij}$ are significant, leading to R-squared of 0.20. As expected, the instruments for the asymmetry of business cycles do not perform as well as for trade linkages or openness, since there are many more factors that can influence why one country grows faster than another. The variable AC_{ij} is also not significant when included in the regression (see Table 3) and is excluded from the following model specifications.

Next, we examine the exogeneity property. It is important to note that the condition cannot be tested as such, because we only have the estimate of the error term and not its real value. Since our instruments are geographical factors, however, it is plausible to assume their exogeneity. We can also use the Hansen's J-test[4] for the correct specification and instruments validity. The statistic allows for the evaluation of the model's suitability, because it tests whether the orthogonality condition between the estimated error term and the exogenous variable is satisfied (Beck, 2008). For different specifications of the variables describes above, the Hansen J-test rejects the null hypothesis (p-value 0.03 and 0.01), which can indicate either an incorrect functional form

[4] The Hansen J statistic is called after Hansen (1982) and known also as Hansen-Sargan statistic for its close link to the Sargan test in the IV/2SLS estimation (Lee and Lee, 2010). The test is computed as the value of the GMM objective function evaluated at the efficient GMM estimator and the statistic is asymptotically distributed as chi-square with degrees of freedom equal to the number of overidentifying restrictions, i.e. the difference between the number of instruments and parameters, and consistent in the presence of heteroscedasticity (Baum, 2006).

or invalid instruments. The problem is solved when we include the variable $EUROPE\ dummy_{ij}$ which was identified as significant by Horváth (2005). Now the p-value is 0.37, so the specification is probably correct and instruments uncorrelated with the error term. Results for the different GMM regressions are presented in Table 3.

Table 3: IV estimation for different specifications over the period of 1980-1998 for 21 industrial countries

	GMM (1)	**GMM (2)**	**GMM (3)**
Constant	0.3076 (0.0729)***	0.2000 (0.0243)***	0.1482 (0.0153)***
Trade linkages	−1.0233 (0.3868)***	−0.7455 (0.1906)***	−0.3631 (0.0821)***
Openness	−0.1204 (0.0229)***	−0.1039 (0.0155)***	−0.0268 (0.0145)*
Asymmetry of business cycles	−3.2209 (2.5013)		
Trade dissimilarity	0.0255 (0.0205)		
Size of economy		0.0018 (0.0013)	
EUROPE dummy			-0.0418 (0.0051)***
J test (p-value)	4.53 (0.03)	6.29 (0.01)	2.00 (0.37)

Note: GMM (1) and (3) use instruments $lndist, lndist2, combord, SIZE$
GMM (2) uses $lndist, lndist2, combord$

7 MODIFICATIONS OF THE OCA EQUATION

In order to examine whether the equation could be improved to cover more areas and achieve higher precision. we include four additional variables relating to labour market and financial development. The labour mobility criterion was used to define the optimum currency area in the seminal theoretical paper by Mundell (1961), but was rather neglected in most of empirical works in the OCA field. Financial market integration was first recognised by Ingram (1962), but it is usually analysed in relation to economic growth, not exchange rate differences.

7.1 Including labour market considerations

Even though labour mobility lies at the very foundations of the OCA theory, it has not been examined to a great extent in the related empirical literature, most likely due to a lack of reliable data. While data for economic growth or bilateral trade is easily accessible, there is no database which would track data on foreign labour participation classified by incoming nationality that would go as far as 1980s and would be available for 21 developed countries. What is more, even where it is possible to find some data, they can rarely capture Mundell's original idea, which was temporary job migration in order to avoid unemployment. If this situation is temporary and no change of nationality takes place, these movements are not reported reliably, because the EU grants its citizens freedom of movement (OECD, 2007). Nevertheless, most literature on the topic stresses that EU mobility is increasing, although it is still very low (De Grauwe, 2012).

Some authors have thus dropped this criterion (Horváth, 2005, or Vieira and Vieira, 2011), others have tried to find alternative measurements. Barbosa and Alves (2011) attempt to capture the degree of labour market integration by the dissimilarity of unit labour cost (ULC) growth rate. Although the variable has the predicted positive sign, it is not significant. Since the authors are using a different setting – shorter time period, smaller number of countries, real instead of nominal exchange rates and annual data, we try to test the effect of the ULC growth also in this analysis. We include the measure of unit labour cost as well as two additional measures concerning the labour market conditions in an attempt to extend the empirical findings on that matter.

7.1.1 Difference in the annual growth rate of unit labour costs

The evolution of unit labour costs per output in different countries has direct implications for competitiveness. According to Barbosa and Alves (2011), divergent tendencies in labour markets have a positive effect on bilateral exchange rate volatility and thus the variable should have a positive coefficient. It is important to note, however, that this is not entirely what Mundell (1961) had in mind; the fact that one economy is decreasing unit labour costs while another is increasing them can also reflect a catching up process towards better convergence, which should eventually lead to lower ER variability, not higher. We measure the difference in ULC growth as follows:

$$ULC_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left(\Delta ulc_{i.t} - \Delta ulc_{j.t}\right)$$

where $\Delta ulc_{i.t}$ is the annual growth rate of unit labour cost measured per output for a country i at time t and analogously for country j. The data is downloaded from the OECD database. Switzerland and New Zealand is excluded from the analysis due to the unavailability of data, resulting in 171 observations.

The results for the GMM estimation, reported in Table 5, do not confirm the role of unit labour cost growth. The coefficient on ULC_{ij} is positive, but insignificant. As a next step, we try two other measures to take into account developments in the labour markets:

7.1.2 Proportion of foreign-born population to total population

Since data on foreign labour stock was not available for the desired country sample and desired time period, we use the measure of foreign-born population, i.e. people who have migrated from their home country to their current country of residence, and include the average over the period of 1990s sourced from the OECD database[5].

We depart from the premise that most, yet definitely not all, migrants do so for professional reasons. The difference in these ratios is then used as a proxy to capture the willingness of people to move abroad. Referring back to Mundell's idea, a country whose citizens are willing to move abroad for work might find it easier to overcome economic

[5] As the OECD lacks data for Japanese foreign-born population, we use the data from the Japanese Ministry of Foreign Affairs (section Countries and Regions): http://www.mofa.go.jp/region/index.html

shocks (particularly adverse shocks) and face lower unemployment rates. The variable $FOREIGN_{ij}$is computed as:

$$FOREIGN_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{for\_pop_{i,t}}{pop_{i,t}} + \frac{for\_pop_{j.t}}{pop_{j,t}}\right)$$

where the ratio $\frac{for\_pop_{i,t}}{pop_{i,t}}$ represents the share of foreign born population to the total population in the given country. The analysis is only conducted for the period of 1990s, because earlier data is not available. As in the previous case, variable $FOREIGN_{ij}$ has a positive coefficient, but is insignificant both in the specification with $OPEN_{ij}$ and with $SIZE_{ij}$. It seems that it is not the best proxy to labour market flexibility.

7.1.3 Index of labour market rigidity

The third labour-related variable $LAMRIG_{ij}$ relies on an extensive labour market study conducted by Campos and Nugent (2012) on a set of 140 countries studied over the period of 1960-2004. The authors examine the determinants of labour market rigidity and construct an index capturing the rigidity of employment protection legislation. The variable is computed as the average absolute difference in the index for given country pair over the whole sample period[6]:

$$LAMRIG_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left|LAMRIG_{i,t} - LAMRIG_{j,t}\right|$$

Identically to the previous measures, $LAMRIG_{ij}$ performs well in a simple OLS equation, but the case is more complicated for the GMM. The variable is significant at a 10% level, indicating that differences in the labour market rigidity have some, although limited, explanatory power for exchange rate variability.

[6] LAMRIG index is not reported for each year, but for five-year periods of 1980-1984, 1985-1990, 1991-1994 and 1995-1999 (Campos and Nugent, 2012).

Table 4: Labour market protection index (LAMRIG) over 1980-2004

	1980-84	***1985-89***	***1990-94***	***1995-99***	***2000-04***
Australia	0.387	0.545	0.844	1.055	1.055
Austria	1.247	1.366	1.544	1.520	1.484
Belgium	1.442	1.468	1.392	1.540	1.769
Canada	0.065	0.785	0.785	0.785	0.785
Denmark	2.470	2.534	1.718	1.718	1.718
Finland	1.896	2.104	2.210	2.210	2.210
France	1.935	1.861	2.233	2.233	2.233
Germany	2.677	2.631	2.400	2.105	1.938
Greece	1.024	1.532	1.557	1.557	1.557
Ireland	0.947	0.947	0.933	1.028	0.900
Italy	2.023	2.068	2.068	1.950	1.854
Japan	0.554	0.606	0.554	0.492	0.457
Netherlands	2.263	2.291	2.005	2.177	2.291
New Zealand	0.482	0.482	0.482	0.482	0.503
Norway	2.132	2.132	2.102	2.056	2.056
Portugal	2.295	2.394	2.492	2.426	2.426
Spain	3.500	3.029	2.982	2.234	2.177
Sweden	2.771	2.803	2.612	2.222	2.150
Switzerland	0.452	0.660	1.067	1.356	1.356
United Kingdom	0.899	0.834	0.834	0.847	0.899
USA	0.109	0.218	0.653	0.653	0.653

Note: Author; based on Campos and Nugent (2012). Higher value indicates higher rigidity of labour market legislation.

Table 5: GMM estimation including labour market related variables

	GMM (1)	**GMM (2)**	**GMM (3)**
Constant	0.1546 (0.0183)***	0.1064 (0.0084)***	0.1442 (0.0156)***
Asymmetry of business cycles			
Trade dissimilarity			
Trade linkages	−0.3606 (0.1088)***	−0.4393 (0.0894)***	-0.3473 (0.0836)***
Size of economy			
Openness	−0. 0291 (0.0200)		−0.0279 (0.0144)*
EUROPE dummy			-0.0398 (0.0052)***
Difference in ULC growth	0.00003 (0.0065)		
Difference in foreign population		0.0069 (0.02787)	
Labour market rigidity			0.0040 (0.0022)*
J test p-value	0.63 0.43	0.27 0.60	2.03 0.36
observations	171	210	210

Note: GMM (1) and (3) include instrumental variables $lndist, lndist2, combord, SIZE$
GMM (2) includes $SIZE$ an exogenous regressor and uses instruments $lndist, lndist2, combord$

7.2 Including financial development

The importance of financial markets integration in the context of OCA theory was first stressed by Ingram (1962) and further discussed by Mongelli (2002) and Nellis (2011). Ingram (1962) argued that highly integrated financial markets allow for a flow of funds when inter-regional payments are necessary. In his perspective, financial integration seems to be especially important *ex post* an economic shock, because it redistributes the loss across more parties and reduces the need for exchange rate adjustments. These adjustments are impossible for monetary union members, but as Ingram (1962) suggests, they are harmful even among countries with exchange rate flexibility. Excessive volatility in currency values results in higher exchange rate risks, lower business confidence and has a negative impact on capital flows and investment.

Deeper financial integration, on the other hand, allows to cushion temporary adverse disturbances through capital inflows. This can be done by borrowing from surplus areas or decreasing the amount of net foreign assets until the shock is over. As a result, even relatively minor changes in interest rates will lead to equilibrating capital movements across the member states, easier financing of external imbalances and efficient allocation of resources. Hence rather than a substitute for a permanent adjustment, financial integration is a way to smoothen the long-run adjustment process (Mongelli, 2002).

As is often the case in the OCA theory, the problem arises when these factors are to be tested empirically. How to measure financial markets integration? As Nellis (2011) concludes, policy makers across the EU agree that financial market integration is a key objective for the member states. However, the extent to which it has taken place in reality is a subject of debate and controversy. Moreover, for the purpose of this analysis, it is more useful to measure the effect *ex ante* – in other words, studying whether a similar level of financial development reduces the need for exchange rate adjustments. If this hypothesis is confirmed, financial development might become another factor to consider if a country wants to join the EMU.

To quantify financial development, Horváth (2005) measures the ratio of M2 monetary aggregate to each country's GDP and finds significant effect on the ER variability. In order to make own contribution to the OCA empirical literature, in this analysis we try to examine a different and a relatively new measure of financial development: private credit growth. This measure has become more widely discussed particularly after the financial crisis of 2007-2008 when it was identified as a potential indicator of financial crises. Geršl and Seidler (2011) study excessive credit growth in

relation to financial instability. Arcand et al. (2012) use the ratio to examine whether there is 'too much' finance and what negative effects this can have on output growth. Drehmann (2013) points out that if we take into account all sources of private credit rather than just bank credit, the indicator can predict the risk of systemic crises.

Clearly, private credit is one of the essential parts of countries' financial services and reflects the depth of financial development. In addition, the ratio is easily available. However, even though its role in finance cannot be disputed, it is not an all-embracing indicator. It fails to capture the efficiency and stability of the financial sector and the quality of financial services[7].

Variable $CREDIT_{ij}$ represents the standard deviation of the annual growth of private credit in the log, measured in billion US dollars over the period 1980-1998:

$$CREDIT_{ij} = SD\left(\Delta \log CREDIT_{i.t} - \Delta \log CREDIT_{j.t}\right)$$

where $CRED_{i.t}$ is the total credit to the private non-financial sector for country i at time t (analogously for country j). The data on a quarterly basis was retrieved from the Bank for International Settlements. In Table 6, we present the country pairs with the highest and lowest differences in the private credit growth.

Table 6: Top five country pairs with the highest and lowest difference in private credit growth over 1980-1998

Country 1	Country 2	Difference in private credit growth
Italy	New Zealand	8.05
Italy	Australia	7.95
Belgium	New Zealand	7.77
Australia	Switzerland	7.75
New Zealand	Sweden	7.33
France	Netherlands	1.95
Austria	Netherlands	1.94
France	Germany	1.70
Germany	Netherlands	1.59
Austria	Germany	1.35

Note: Difference in the credit growth is the standard deviation in the growth of the log of total credit to private non-financial sector and multiplied by 100.

[7] The Global Financial Database maintained by the World Bank is an important step forward and seems to have a high potential for similar analyses conducted in the future. Unfortunately, most of the data reflecting access to finance and quality of services is unavailable for the period of 1990s.

The inclusion of credit growth introduces another important issue already discussed in section 5: endogeneity. It is plausible that the value of domestic credit (or its ratio to the country's GDP) is partly determined by the current exchange rate, because borrowers might speculate on the choice of currency when they decide where to obtain financing. It is, therefore, necessary to instrument the credit growth variable.

We first use the same instruments as Cecchetti and Kharroubi (2015) when examining the effects of credit growth on productivity: initial value of credit and long term and short term nominal interest rates in the preceding period and financial liberalisation index drawn from Abiad et al. (2008). Due to the unavailability of earlier data, we only concentrate on the period 1990s.

Because only initial credit is significant and both its exogeneity and informativeness are limited (with R-squared of only 0.07), we try a different set of more general instruments including geographical traits used earlier ($lndist$, $lndist2$, $combord$ and $SIZE$) and specific variables for financial development: financial reform index, financial reform input (both drawn from Abiad et al., 2008) and a variable of legal origin sourced from La Porta et al. (2008).

The financial reform index fin_index_{ij} incorporates information on credit conditions, banking supervision, privatization, international capital flow and security markets (Abiad et al., 2008). Here, we include the difference in the index between the two countries. Because previous research shows that financial reforms spur financial development (Jayaratne and Strahan, 1996, Hasan et al., 2015), we also include variable fin_reform_{ij} indicating different reform inputs in the concerned countries[8]. 'Legal origin' identified originally by La Porta et al. (1997) classifies countries into five categories based on the country's legal and political system. Economic literature and research suggests that whether a country has Anglo-Saxon, British, French, German or Scandinavian legal origin has important economic consequences. Beck et al. (2003) provides an extensive cross-country study, explaining why differences in legal origin help explain differences in financial development. The authors claim that legal traditions influence the ability to respond efficiently to new economic conditions through political and adaptability channels. What is important for this analysis is that $legorigin$ is based on historical experience and so is certainly exogenous. Because we concentrate on studying deviations in the exchange rates, not similarities, the dummy variable $legorigin$

[8] Based on the financial reform dataset from Abiad et al. (2008), we observe whether countries introduced large financial reforms in the same time periods. Because the whole analysis is focused on countries' differences, we set value 1 to time periods in which one country from the pair introduced a large financial reform while the other did not. Variable $fin_reform_{ij}$is the average size of these values over 1980-1998.

takes value 1 if the countries are of a different legal origin and 0 if they are not. Results for the new model including these variables are presented Table 7. Variable AC_{ij} is dropped because it is no longer significant. Except for $DISSIM_{ij}$, the coefficients of all significant variables have expected signs. $DISSIM_{ij}$ now has a negative sign, which complies with the results of Bayoumi and Eichengreen (1997) in the 1980s estimation for European economies, but still raises a question of why it is so.

Table 7: GMM and OLS estimation results for models including LAMRIG and private credit growth

	GMM (4)	**GMM***	**OLS**
Constant	−0.0539 (0.0094)**	0. 0439 (0.0300)	-0.0120 (0.0158)
Asymmetry of business cycles			0.0213 (0.0036)***
Trade dissimilarity	−0.0105 (0.0047)**		0.0166 (0.0071)**
Trade linkages		-0. 2148 (0. 0973)**	−0.2475 (0.0705)***
Size of economy	0.0019 (0.0006)***	0.0013 (0.0005)**	0.0023 (0.0009)**
Labour market rigidity	0.0049 (0.0021)**	0.0045 (0.0018)**	0.0212 (0.0036)***
Difference in credit growth	2.2602 (0.0893)***	0. 8096 (0. 3914)**	
EUROPE dummy		-0.0313 (0.0087)***	
J test p-value	9.688 0.021	4.510 0.211	
observations	210	210	210

Note: **GMM (4)** uses instrumental variables:$legorigin, lndist, lndist2, combord$
GMM* uses instrumental variables: $legorigin, fin\_ind, fin\_ref. lndist, lndist2, combord.$

Perhaps the answer could be found in the simple concept of a *competitive advantage*. Up to now, we have viewed trade dissimilarity in the context of industry-specific shocks, arguing that if countries have a *comparative* advantage in the same

industries, adverse economic shocks will be more symmetric and will not cause excessive volatility in the exchange rate (Bayoumi and Eichengreen, 1997). However, as Porter (1990) insists, countries should be seeking a *competitive* advantage, something they can do better than their neighbours.

> *'Differences in national values, culture, economic structures, institutions, and histories all contribute to competitive success. There are striking differences in the patterns of competitiveness in every country; no nation can or will be competitive in every or even most industries' (M. Porter, 1990, p. 73).*

If we assume that economies choose an industry tailored best to their own historical traditions and knowhow, available resources, skills and technology, one in which businesses are able to react flexibly and effectively to sudden changes in demand, then $DISSIM_{ij}$ can be viewed as a proxy to a well developed competitive advantage in an industry which can best cope with unexpected shocks. This can eventually have a positive effect on the exchange rates stability.

Nonetheless, we decide to drop the variable $DISSIM_{ij}$ in the final GMM* model due to its ambiguity. Model GMM* thus includes variables $TRADE_{ij}$, $SIZE_{ij}, EUROPE\ dummy_{ij}, LAMRIG_{ij}$ and $CREDIT_{ij}$. It excludes some of the 'traditional' OCA characteristics (trade dissimilarity and openness) which do not perform well in the combination with the 'modern' criteria (labour market flexibility and private credit growth).

The fact that both labour market rigidity and private credit growth are significant in explaining the exchange rates stability is an important finding for several reasons. First, it suggests that the existence of large differences across European labour markets is one of the reasons why the current monetary union is not functioning properly. Taking actions to unify labour market law and regulations and making the markets more flexible could be an important step in improving the competitiveness of the EMU. Second, we have seen that different degrees of financial development (proxied by private credit growth) undermine the exchange rate stability. These pressures are also present in countries sharing the same currency, although the actual impact on exchange rates can no longer be observed. Hence, a 'reminder' that financial markets have moved in different directions may come too late and in the form of a financial crisis. To prevent such a scenario, policymakers ought to keep a close watch on the private credit growth and other financial indicators or better still, develop automatic policies which will raise alarm well in advance. Third, taking all of these conditions, i.e. trade intensity and structure, openness, labour markets similarity and the level of financial development, into consideration is of vital importance not only to the current EMU countries, but also to its prospective

members. Monetary unions can be a source of tremendous benefits, but they do not guarantee success through a simple accession. Giving up a currency comes with an undisputable cost of losing an important monetary instrument and if such a step is not taken after careful economic analysis, it can undermine competitiveness for many years to come.

8 OCA INDICES

The two equations estimated above can be used, as in Bayoumi and Eichengreen (1997), to compute an OCA index, which compares the similarity of each individual country to a reference country. The index corresponds to the fitted value for the exchange rate variability using the parameter estimates obtained in the OLS and GMM regressions. These parameters indicate to what extent asymmetric shocks (caused for instance by different export structures, deviations in private credit growth or divergent labour markets) contribute to the volatility of an exchange rate between the given country and the reference country. In other words, the index is a weighted sum of each country's OCA conditions, where a lower value indicates higher benefits from pegging a currency to the reference country.

Such an index can be useful in different contexts. The first and most common use is to assess the readiness of a country to form an actual monetary union with the reference country. Small differences in the economic variables, trade structure, financial development and labour market indicate that bilateral exchange rates – if countries were to keep their own currencies – should not fluctuate too much. In such a case, a common currency does not represent a huge risk and the numerous benefits of a monetary union membership most probably outweigh the costs. Horváth (2005), for instance, uses this interpretation in in his analysis.

Second, it can be used to test the endogeneity hypothesis put forward by Frankel and Rose (1998). The authors suggest that countries do not have to wait until they are 'optimal' candidates to form a monetary union, because it is monetary union itself that will help them converge: *'A country is more likely to satisfy the criteria for entry into a currency union ex post than ex ante' (p. 22).* If this hypothesis is correct, then the OCA indices should improve, i.e. decrease in value, over time for the EMU members. $TRADE_{ij}$ and

This paper attempts to answer both of these questions. Tables 8 and 10 present the OCA indices resulting from the OLS* estimated benchmark model (including variables $AC_{ij}, DISSIM_{ij}, TRADE_{ij}$ and $SIZE_{ij}$) and GMM* estimated model (including $TRADE_{ij}, SIZE_{ij}, EUROPE\ dummy_{ij}, LAMRIG_{ij}$ and $CREDIT_{ij}$). The two modifications reflect different perceptions of the OCA empirical literature in the past. While trade variables were considered essential in 1960s, the importance of financial development increased in particular after the recent financial crisis. At the same time, a better availability of data concerning labour markets allowed researchers to better capture

the labour market rigidity (for instance by the LAMRIG index used in this analysis), which can then be incorporated into the OCA models.

8.1 OCA indices for European countries in the sample

The OCA indices are computed for all European countries from the sample (i.e. EU member states plus Norway and Switzerland) for 4 points in time: 1989, 1998, 2007 and 2014. The first two years mark the end of observed periods of 1980s and 1990s (before the euro adoption), year 2007 is chosen to demonstrate the values before the financial and economic crisis and year 2014 serves the purpose of updating the index to the most recent data. Similarly to the previous empirical literature, we choose Germany as the 'anchor' country against which we report bilateral settings. The countries are presented in an ascending order with the top being the 'best candidates' with lowest OCA index values and the bottom being the 'worst candidates'. Tables 9 and 11 show the 'improvement' in the indices between the years 1989 and 2014. In this context, 'improvement' refers to a change in the index towards a lower value, which indicates higher similarity.

Table 8: Rankings of OCA indices for European countries based on the standard OLS model

1989		**1998**		**2007**		**2014**	
Belgium	0.020	Belgium	0.028	Belgium	0.015	Belgium	0.004
Netherlands	0.026	Austria	0.029	Austria	0.017	Austria	0.008
Austria	0.039	Netherlands	0.041	Netherlands	0.025	Netherlands	0.009
Switzerland	0.043	Switzerland	0.057	Switzerland	0.043	Switzerland	0.028
Italy	0.051	Italy	0.061	Italy	0.054	Sweden	0.042
Sweden	0.056	Spain	0.067	Sweden	0.055	Denmark	0.042
Ireland	0.062	Denmark	0.067	Denmark	0.057	UK	0.047
UK	0.063	Ireland	0.069	UK	0.058	Ireland	0.048
Finland	0.065	Portugal	0.071	Ireland	0.058	Finland	0.051
Spain	0.071	Sweden	0.074	Spain	0.059	Spain	0.057
Denmark	0.073	UK	0.076	Finland	0.059	Italy	0.061
France	0.074	France	0.081	Portugal	0.066	France	0.063
Greece	0.081	Norway	0.088	France	0.073	Portugal	0.069
Norway	0.083	Greece	0.093	Norway	0.082	Norway	0.071
Portugal	0.084	Finland	0.099	Greece	0.088	Greece	0.097

Note: For the computation of the variables, see section 4.2 (Data and measurement). OCA index is calculated as the fitted value for the exchange rate variability based on OLS* estimates reported in Table 2, column 1. Lower value indicates better alignment with Germany.

Table 9: Improvement in the OCA index between 1989 and 2014 (based on standard OLS model)

Austria	0.031
Denmark	0.031
Netherlands	0.017
Belgium	0.016
UK	0.016
Switzerland	0.015
Portugal	0.015
Ireland	0.014
Sweden	0.014
Spain	0.014
Finland	0.014
Norway	0.012
France	0.011
Italy	-0.010
Greece	-0.016

Note: Improvement stands for the change in the OCA index (computed from OLS regression estimates) between years 1989 and 2014. Since a lower value of the index indicates higher similarity, the actual change is reported here with an opposite sign.

If we compare the values of OCA indices based on the OLS and GMM models (Tables 8 and 10 respectively), we observe that although the actual values of OCA indices differ, the relative positions of countries have several common factors. Two groups of countries stand out in particular. The first one is formed by Austria, the Netherlands, Belgium – three of the EU 'core' countries – which are always in the top three. Regardless of the estimation method or time period, these countries obtained the lowest OCA values also in the studies by Bayoumi and Eichengreen (1997), Horváth et al. (2003) and Vieira and Vieira (2011).

In the indices based on the standard OLS model (Table 8), the order of these countries is almost unchanged over time and from 1998, the absolute value of the index has a decreasing trend. Although this is not always the case in the GMM model (Table 10), the difference in value is relatively small. In the context of the OCA theory, the benefit-cost ratio for Austria, Belgium and the Netherlands arising from the single currency seems to be largely positive.

Table 10: Rankings of OCA indices vis-à-vis Germany for European countries based on GMM labour and credit augmented model

1989		**1998**		**2007**		**2014**	
Netherlands	0.014	Netherland	0.020	Belgium	0.011	Belgium	0.008
Belgium	0.021	Austria	0.020	Austria	0.016	Netherlands	0.009
Austria	0.025	Belgium	0.020	Netherlands	0.020	Austria	0.013
Denmark	0.034	Denmark	0.033	Switzerland	0.025	Switzerland	0.029
France	0.041	France	0.038	Denmark	0.035	Denmark	0.034
Ireland	0.044	Switzerland	0.038	Italy	0.036	Italy	0.034
Switzerland	0.044	Portugal	0.043	France	0.037	Finland	0.036
Italy	0.046	Norway	0.046	Finland	0.038	France	0.038
Portugal	0.047	Spain	0.046	Sweden	0.042	Portugal	0.040
Norway	0.048	Ireland	0.047	Portugal	0.044	Spain	0.043
Sweden	0.048	Finland	0.049	Spain	0.049	Sweden	0.044
Spain	0.049	Greece	0.050	Norway	0.051	Ireland	0.048
Finland	0.051	Italy	0.051	Ireland	0.053	UK	0.050
Greece	0.056	Sweden	0.052	UK	0.054	Norway	0.051
UK	0.064	UK	0.057	Greece	0.057	Greece	0.052

Note: The index is computed with the regression estimated for the GMM* regression for bilateral relationships vis-à-vis Germany.

Table 11: Improvement in the OCA index from 1989 to 2014 (based on GMM model)

Finland	0.015
Switzerland	0.015
UK	0.014
Belgium	0.013
Austria	0.012
Italy	0.012
Portugal	0.007
Spain	0.006
Netherlands	0.005
Greece	0.004
Sweden	0.004
France	0.003
Denmark	0.000
Norway	-0.003
Ireland	-0.004

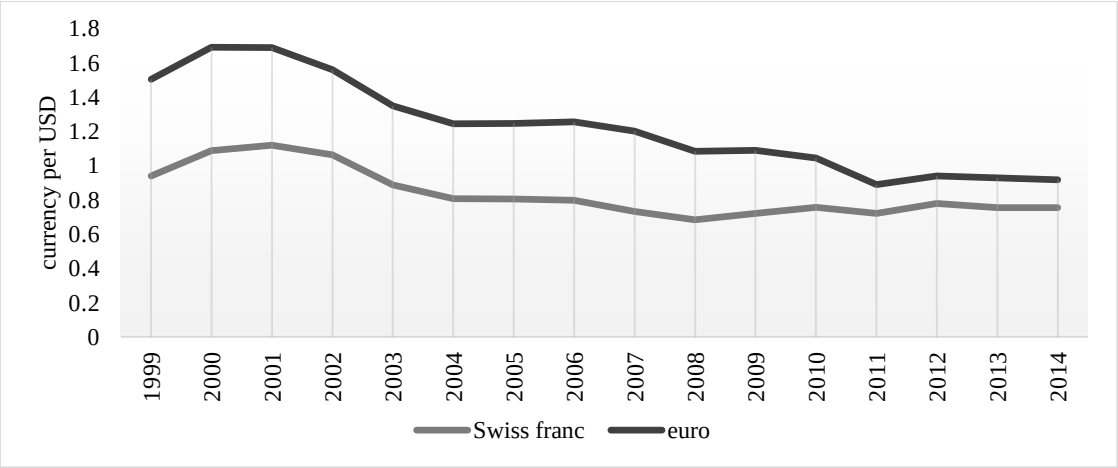
Note: Improvement stands for the change in the OCA index (computed from GMM regression estimates) between years 1989 and 2014. Since a lower value of the index indicates higher similarity, the actual change is reported here with an opposite sign.

Interestingly, Switzerland, which keeps a stable fourth position in the OCA indices based on OLS model is closer to Germany than most of the EU (and EMU)

countries, although it is not a member itself. For instance, it is much closer to Germany than France, politically considered as indispensable for the EMU project. The OCA indices based on OLS estimation, which rank France worse than Spain or Italy, almost raise doubts whether France should share the same currency with Germany. This mirrors the findings by Bayoumi and Eichengreen (1997) computed for the period of 1990s and shows that the relative position of the country has not changed very much.

In fact, Switzerland has had very tight economic and trade relations with the EU, governed by a free trade agreement signed in 1972 and later extended to include agricultural products (EUROPA, 2016). As an isolated state surrounded by countries all sharing the same currency, Switzerland is inevitably impacted by anything happening behind its borders. In a paper from the Swiss National Bank, Roth (2000) recognizes that European business cycle will strongly influence that of Switzerland and that *'Switzerland's economic destiny will be linked to that of Europe'* (Roth, 2000, p. 2). In 2015, the EU accounted for 65% of Switzerland's foreign trade, making it by far the most important trading partner (EUROPA, 2016). According to the the OCA theory, the exchange rate for such countries should follow the same paths, because they are fundamentally driven by the same factors (McKinnon's principle of trade linkages). Figure 10 confirms this hypothesis by showing the evolution of Swiss franc and the euro against the US dollar. The currencies are moving very much in the same direction and slowly convergening, making the eventuality of Switzerland adopting the euro not unimaginable. It should be noted, however, that the relative position predicted by the labour and credit augmented GMM model (Table 10) is considerably more volatile, making the case for Switzerland rather ambigous. In this respect, Roth (2000) raises concerns for Switzerland, suggesting that European and Swiss labour markets are driven by different factors; while European unemployment is largely structural and usually managed with great difficulty, the Swiss unemployment is driven by seasonal factors. According to Roth (2002), labour productivity has also greater potential to rise in the flexible Swiss market, which is active in making structural reforms, rather than in the large and more rigid common market of the EU.

Figure 10: Swiss franc and euro against US dollar over 1999-2014



Source: Author; based on IMF International Financial Statistics

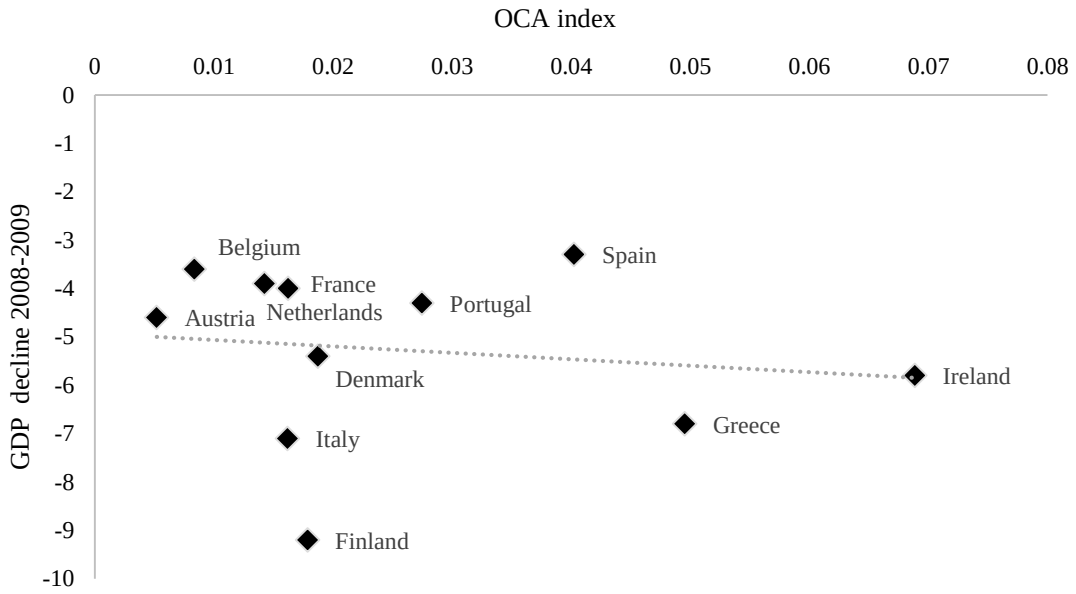
The second group of countries, which can be more distinctly seen from the OCA indices based on the GMM model (Table 10), comprises of Norway, Greece, the UK and Ireland, with the latter two being positioned close to each other in most of the time periods and both model variations. High index values for all of these countries may indicate potential problems with monetary union membership. This result is easily reconciled with reality. The Greek debt crisis, which started in 2009, called the country's participation in the EMU into question – both by other EMU citizens and policymakers disinclined to sponsor the 'bad student,' and by Greeks themselves thinking they would be better off with no euro at all (Lapavitsas, 2015). Arghyrou and Tsoukalas (2011), as well as many other writers, agree that Greece's economic fundamentals are inconsistent with its long-term participation in the EMU. This paper does not intend to provide a definite answer to the 'Grexit' but simply shows that – leaving political considerations aside – the existing monetary union between Germany and Greece results in an unappealing cost-benefit ratio.

The case is quite similar for the UK. On the positive side, the country has significantly improved its OCA ranking (see Table 8 and 10) and marked a very large improvement in the OCA index over time (Table 11). On the negative side, the predicted ER variability is still high and, from the OCA perspective, we would probably not recommend adopting the single currency. In fact, the UK has conditioned the participation in the EMU on five economic tests grounded mainly in the OCA theory. They emphasise, among other things, the convergence of business cycles, labour market flexibility and financial services considerations (HM Treasury, 2003b). It seems that at least in terms of the latter two, the UK is converging towards the core EMU countries. Some degree of comfort could be also drawn from Frankel and Rose (1998); the convergence trend might take a faster pace once the country enters the Euro Area.

The last country that may raise concerns is Ireland. The index deteriorated from an inital index of 0.044 in 1989 to 0.048 in 2014, marking the biggest difference among the fifteen countries (albeit still relatively small). Along with Greece, the country had the worst 'ranking' out of all EMU members, which could have served as a good early warning signal of looming problems in the financial sector. These came only a year later, when the country has been hit by a banking crisis. As Eichengreen (2015) points out, the Irish case as well as the Greek case brough fears that it is the structure and the very existence of the EMU that helped to set the stage for the crisis. Countries are becoming more and more aware of the degree of heterogeneity and economic as well as financial imbalances that this heterogeneity can result in. We may, therefore, ask whether a high OCA index indicating that a given country is a 'poor fit' towards the existing monetary union could be useful in predicting the impact of a future economic crisis.

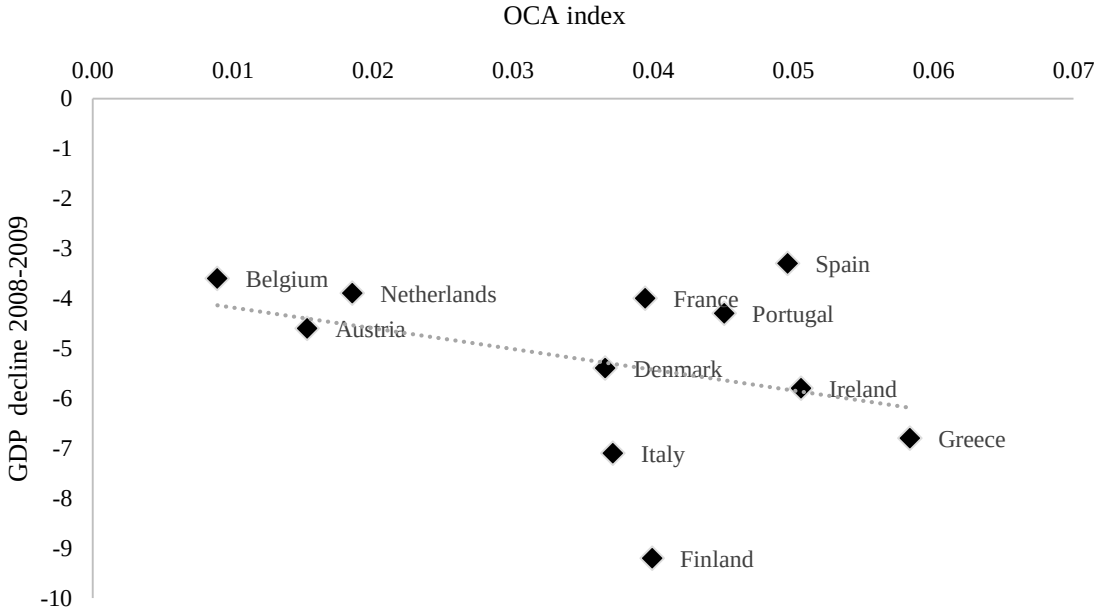
The scatter plots in Figure 11 and 12 combine the OCA indices (based on OLS and GMM models respectively) for the current EMU members with the decline in the country's GDP between the the first quarter of 2008 and the first quarter od 2009, a period in which most of the European countries faced deep recession. Even though there are a few exceptions, the general trend supports the view that countries with lower indices faced a lower GDP decline, especially using the GMM labour market and credit growth augmented model. The main exception is Finland, a country which not long ago was characterized by excellent credit rating, standard of living and healthy public finances. The harsh recession that accounted for almost 10% of GDP was caused by a number of country specific factors including a decline in forestry industry or electronics sector, but also by factors embedded in the OCA such as divergent evolution of unit labour costs (Milne, 2015). Figure 12 shows the evolution of unit labour costs in Finland in comparison to four different EMU countries and the EU average. Clearly, unit labour costs have been one of the reasons behind Finland's lost competitiveness.

Figure 11: GDP decline in 2009 and the 2007 OCA index based on the standard OLS model



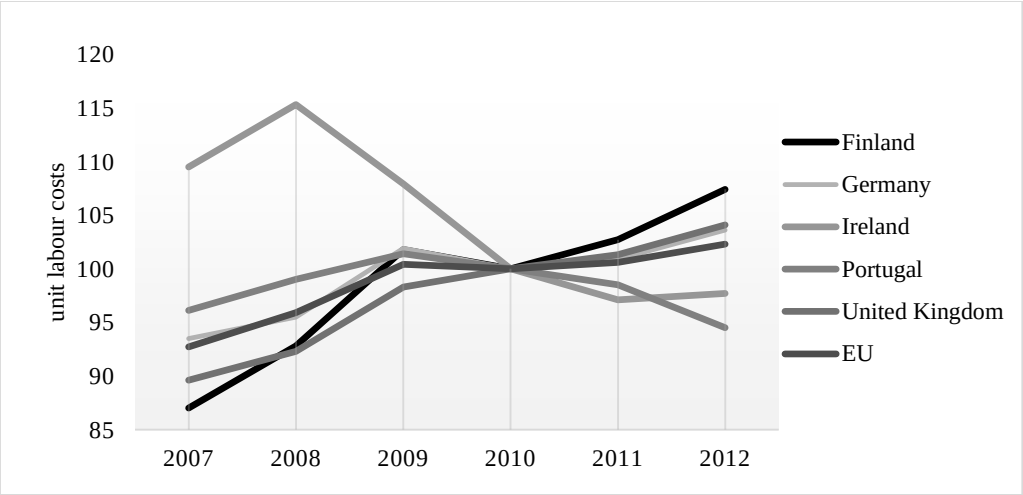
Source: Author; based on computed OCA indices and a GDP decline between Q1 2008 and Q1 2009

Figure 12: GDP decline in 2009 and the 2007 OCA index based on labour and credit augmented GMM model



Source: Author; based on computed OCA indices and a GDP decline between Q1 2008 and Q1 2009

Figure 13: Unit labour costs for selected countries in 2007-2012 (2010=100)



Source: Author; based on OECD data. Unit labour costs are indexed to year 2010.

Overall, the OCA theory and its empirical application seem to play in important role in determining the suitability of a country's participation in the EMU and give an indication of the extent to which a country might be affected during an economic crisis. Consequently, we apply the results of the estimation to the Central and Eastern European Countries to assess their readiness for the euro adoption.

8.2 OCA indices for Central and Eastern European countries

The adoption of the euro in the Central and Eastern European Countries (CEEC) has been subject of debate ever since these countries joined the EU. Lavrač and Žumer (2003) studied the prospect of inclusion of CEEC in the Euro Area and observed diverging attitudes of the CEEC and of the EU concerning the timing of entry. While the better prepared CEEC were in favour of an early accession, the EU warned against a premature entry, preferring a slower 'wait and see' approach. In addition to the nominal Maastricht criteria, a new concept of 'real convergence' was introduced specifically for these CEEC to take into account their economic transition. According to the authors, the rationale behind the real convergence condition was to provide some discretion for the EU to '*keep CEEC out of Eurozone for a while, if necessary' (p. 20)*. The risks associated with the premature entry to the Eurozone are often discussed in the context of the OCA theory (Lavrač and Žumer, 2003, Hobza, 2002, or Frenkel, 2002). These studies stress the importance of standard OCA conditions fulfilment and suggest that additional mechanisms might have to be put in place in order to deal with regional asymmetric shocks.

To date, five of the CEEC have joined the Eurozone: Slovenia, Slovakia, Estonia, Latvia and Lithuania. The rest of the countries – Bulgaria, Croatia, the Czech Republic,

Hungary, Poland and Romania – are obliged to adopt the euro at some point in the future. In many of these countries, the overall attitude towards the euro is as ambiguous as at the time of their accession to the EU. Public and political debate still deals with the issue of real convergence and the most appropriate ways of measuring it, with the actual benefit-cost ratio that euro would bring to the domestic economy, and with the best timing for the euro adoption.

In order to shed some light on these questions using empirical rather than purely theoretical approach, we now provide an application of the OCA index to the CEEC and predict their exchange rate volatility vis-à-vis the euro. The aim here is to assess the alignment of these countries with Germany, taking on the role of the reference country and the 'anchor' of the EMU. The approach of using the coefficients estimated on a different set of 21 developed countries for the CEEC is 'out-of-sample forecasting' (Horváth, 2005). The OCA indices (fitted values for the exchange rate variability) are an indication of the country's readiness for the euro adoption. As in the previous section, we compute these indices also for countries which are already members of the EMU. While we have to keep in mind that the result may be endogenous, because individual trade linkages may have intensified as a result of monetary integration (Frankel and Rose, 1998), the effect is likely to be small, especially for small and EMU-trade oriented countries such as the Czech Republic, which trades heavily with Germany, even though it is not a member of the EMU.

Table 12: OCA conditions vis-à-vis Germany in the CEEC, 2005-2014

	Asymmetry of business cycles	**Trade dissimilarity**	**Trade linkages**	**Size of economy**	**Labour market rigidity**	**Private credit growth**
Bulgaria	0.028	0.814	0.049	12.917	0.198	0.117
Croatia	0.025	0.519	0.023	13.012	0.182	0.068
Czech Republic	0.018	0.213	0.226	13.620	0.678	0.064
Estonia	0.055	0.563	0.030	12.508	0.462	0.103
Hungary	0.019	0.256	0.198	13.423	0.438	0.097
Latvia	0.061	0.794	0.030	12.626	0.548	0.145
Lithuania	0.050	0.736	0.048	12.818	0.238	0.131
Poland	0.025	0.343	0.104	14.043	0.162	0.089
Romania	0.037	0.436	0.055	13.536	0.078	0.148
Slovakia	0.026	0.280	0.156	13.220	0.332	0.040
Slovenia	0.026	0.299	0.123	12.907	0.142	0.114

Note: For the computation of the variables, see section 4.2 (Data and measurement). Computation method and data source remain the same, with the exception of Trade linkages (sourced from the IMF Directions of Trade) and Private credit growth (sourced from the World Bank database).

The descriptive statistics of the OCA conditions (asymmetry of business cycles, trade dissimilarity, trade linkages, economy size, labour market rigidity and private credit growth) are presented in Table 12. The computation of the values corresponds to that

outlined in section 4.2 and is based on the data from a ten-year period of 2005-2014. Since the Bank for International Settlements does not cover the majority of CEEC, we retrieve the data for private credit growth from the World Bank database instead. Different frequency of the data and a different way of measurement (reported annually and as a % of GDP), however, may contribute to higher average values for the difference in private credit growth (reported in the last column of Table 12). Accordingly, OCA indices based on the GMM estimation may be slightly overestimated, yet still allowing the assessment of the relative positions of the CEEC. The indices based on OLS model can be used for a fair comparison with the European countries in the original sample.

The OLS and GMM model based indices are presented in Table 13. The potential 'best candidates' for successful euro adoption with only a limited risk of large asymmetric shocks seem to be the Czech Republic, Hungary, Slovakia and Slovenia (with the last two being already members of the EMU). With the exception of Estonia, these relative positions correspond to those identified by Horváth (2005) using a GMM estimation method for a slightly different model and for the period of 1999-2004.

Table 13: Exchange rate variability: Actual and predicted by OLS and GMM estimation for CEEC, 2005-2014

Exchange rate variability				
Predicted (OLS)		**Predicted (GMM)**		**Actual**
Czech Republic	-0.018	Slovakia	0.026	
Hungary	-0.016	Czech Republic	0.027	0.056
Slovakia	-0.008	Hungary	0.056	0.046
Slovenia	-0.004	Poland	0.073	0.085
Poland	0.004	Croatia	0.077	0.012
Romania	0.015	Slovenia	0.085	
Lithuania	0.023	Estonia	0.101	
Bulgaria	0.024	Bulgaria	0.106	0.000
Croatia	0.025	Lithuania	0.116	
Estonia	0.029	Romania	0.127	0.063
Latvia	0.035	Latvia	0.131	

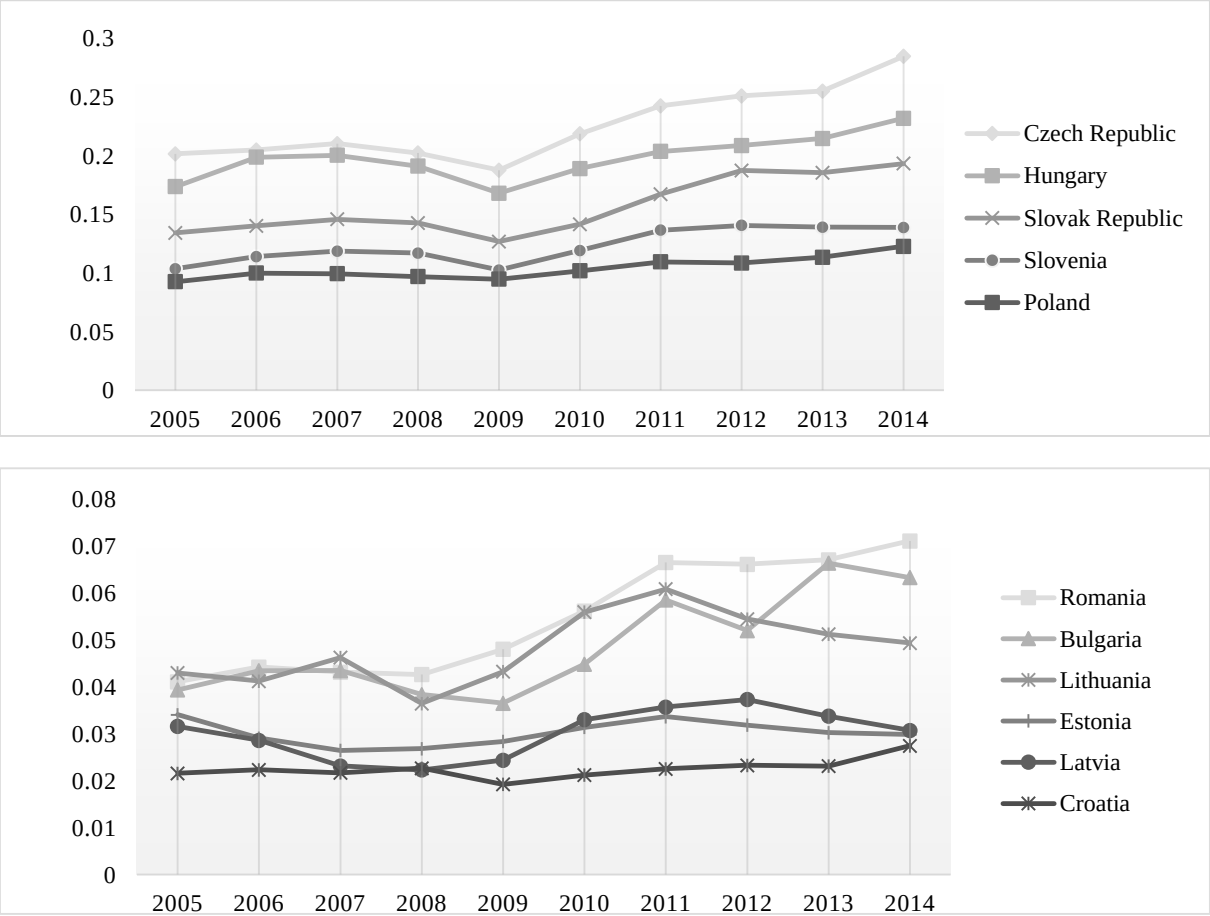
Note: OCA index predicted by the OLS includes the asymmetry of business cycles, trade dissimilarity, trade linkages and economy size (Table 2, column 1). OCA index predicted by the GMM includes trade linkages, EUROPE dummy, labour market rigidity and private credit growth (Table 7, column 2). The differences between OLS and GMM-based OCA indices may be partly caused by a different source of data for private credit (World Bank) which is reported annually as a % of GDP. The actual variability refers to the standard deviation of the national currency towards the euro and is based on annual data over the period 2005-2014 from the Eurostat database.

For the Czech Republic, Hungary, Slovakia and Slovenia, the OLS index is negative. At the risk of stating the obvious, negative values for the fitted values of *standard deviation* have to be interpreted with caution. It is, however, not a rare case in the related literature (see Bayoumi and Eichengreen (1997) in Table A11 of the Appendix,

reporting negative indices for Austria, Belgium and the Netherlands, or Horváth (2005) in Table A13 for Slovakia and Estonia). The reason here is a particularly large value for bilateral trade linkages with Germany, which is the main trading partner of all of the four countries.

Being EMU member states or not, the intensity of mutual trade with Germany has increased for the majority of CEE countries, which can be seen in Figure 14. It seems, therefore, that the *endogeneity hypothesis* proposed by Frankel and Rose (1997) does not apply solely to monetary union members. The trade links, for instance, increased largely for the Czech Republic and Romania although neither of the countries is using the euro. Another reason why the value is small in the case of the Czech Republic is a similar pattern of trade, which is focused mainly on machinery and transport equipment in both countries (accounting for 54% in Czech exports and 50% in German exports).

Figure 14: Mutual trade with Germany, CEE countries, 2005-2014



Source: Author; based on IMF Directions of Trade data

The indices incorporating different labour market conditions and growth in private credit (GMM estimation) present a slightly different picture. Again, Slovakia and the Czech Republic are very close to Germany, followed surprisingly by Croatia and Poland.

Except for Estonia, the Baltic countries are positioned almost at the bottom of the table, with only Romania being lower. These countries had the highest predicted exchange rate variability also in 2004 according to Horváth (2005). Nonetheless, all three Baltic countries have adopted the euro already (Lithuania being the last one to join in 2015) without any particular difficulties.

To date, six of the CEEC are still using their national currencies: Bulgaria, Croatia, the Czech Republic, Hungary, Poland and Romania. Their actual exchange rate volatilities are presented in column 3 of Table 13. For most of them, the actual variability is larger than the one predicted by the model. This may be due to institutional factors (central bank credibility), which are not captured by the model, speculative attacks on the currencies, or due to excessive 'non-fundamental volatility' which vanishes after the monetary integration (Horváth, 2005). Straub (2004) defines non-fundamental volatility as one which is not caused endogenously by fundamental factors such as output, but rather by external components. If non-fundamental volatility causes the differences between actual and predicted variability, then countries where this difference is particularly high would benefit the most from adopting the euro.

For Bulgaria and Croatia, actual variability is in fact smaller than the one implied by the model. This may be due to measures taken by policy makers (especially central banks) in order to mitigate imbalances in the economy, or a specific monetary arrangement. It should be noted that we use historical data to forecast future development, without considering that central banks may nowadays respond to shocks in a different way than in 1980s and 1990s. This argument is implied by the *Lucas critique* of macroeconomic models, which states that empirical models often fail to recognise changes in policy and decision rules, and thus may provide weak forecasts on the basis of coefficients which are no longer valid (Lucas, 1976). The Czech Republic, for example, has intervened in the foreign exchange market in 2013 to devalue its national currency in order to stimulate exports, increase inflation and boost the economy (ČNB, 2013). This is something that could not have been predicted by the model. Furthermore, countries may have specific monetary arrangements which explicitly set the exchange rate variability to zero. Bulgaria, for instance, has a currency board arrangement which keeps the Bulgarian lev fixed to the euro and at the same time gives up the possibility of changing the regime during its participation in ERM II (Bulgarian National Bank, 2004). As a result, the actual variability is zero, although the pressures resulting from economic imbalances may be large.

For the CEEC countries in particular, it is essential to thoroughly analyse these imbalances prior to a final decision for adopting the euro. The application of OCA indices

on the CEEC revealed several important conclusions. First, we have seen that the economies of the Czech Republic, Slovakia and Hungary very much approximate that of Germany, especially in terms of trade linkages and structure of exports. In such a case, adopting the euro would most probably be beneficial, as the exchange rate regime does not constitute a very effective adjustment tool. On the other hand, Bulgaria, Estonia and Latvia show little signs of convergence. Interestingly, the latter two countries have already adopted the euro and Bulgarian's lev is pegged to the euro. Moreover, we have showed that the *endogeneity hypothesis* by Frankel and Rose (1997) does not entirely hold in reality, because trade linkages do not seem to spur as a result of a monetary integration, but tend to increase in time whether or not the country is using the euro.

9 CONCLUSION

This thesis contributes to the growing stream of empirical literature on the OCA theory. We apply the OCA properties and test the hypotheses in the context of the European and Monetary Union. In particular, we use the OCA as an alternative view of assessing a country's readiness to join the single currency area. We argue that the Maastricht criteria, currently used to assess nominal convergence, fail to identify countries which are a 'poor fit' for the rest of the monetary union members, as was shown during the economic crisis of 2008-09.

The OCA theory, on the other hand, postulates that countries should only enter a monetary union if they are similar enough to minimise the incidence and consequences of adverse asymmetric shocks. This 'similarity' is reflected by the OCA criteria, which include economic size and openness, asymmetry of business cycles, trade linkages, similar export structure, labour market flexibility and financial integration. To use this theory in practice, we follow the methodology proposed by Bayoumi and Eichengreen (1997) and construct an OCA index for 26 European countries. We find that the OCA criteria are important determinants of the variability of bilateral exchange rates and advocate them as indicators of real convergence and structural similarity.

We update the OCA indices using the OLS and GMM estimation methods to the most recent data and extend the empirical literature by including two variables which have not yet been examined in OCA applications: the index of labour market rigidity composed by Campos and Nugent (2012) and private credit growth. Flexible labour markets play an important role in monetary unions, because they aid the recovery of economy after an adverse asymmetric shock. Higher financial integration approximated by the similarity in private credit growth, on the other hand, allows to cushion temporary disturbances through capital inflows and smoothen the long-run adjustment process. We find that large differences between both the labour market flexibility and private credit growth contribute to a higher variability of exchange rates. This leads us to state that policymakers should ensure higher labour market flexibility and monitor private credit growth in order to enhance the stability and long-term sustainability of the EMU.

Comparing the ranking of countries over time, we identify certain groups which show consistently high signs of convergence to Germany. In particular, Belgium, Austria, the Netherlands and Switzerland are very close to Germany in both traditional and extended model specifications. On the other hand, Portugal, France, Norway and Greece show little signs of convergence when traditional OCA criteria are considered,

i.e. excluding labour market flexibility and financial development. When we include these variables, Portugal and France are replaced by Ireland and the UK. The evolution of the OCA indices from 1989 to 2014 shows significant improvements in the OCA indices both for member and non-members countries of the EMU. Consequently, we conclude that the *endogeneity hypothesis* does not entirely hold in reality, as it is not monetary integration alone that catalyses higher convergence and structural similarity.

We also identify a positive relationship between the value of the OCA index and GDP decline during the economic crisis, which may be taken as supporting evidence in favour of the OCA application. Since the OCA index seems to be a good indicator of a country's readiness to join the monetary area and signal its ability to cope during economic hardships, the OCA could be particularly relevant for those CEEC that are now considering the euro adoption. Interestingly, our analysis shows that the CEEC which have already entered the EMU (especially Lithuania and Latvia) are not the best candidates for the euro adoption predicted by the OCA theory. Based on the results, we would recommend the EMU participation to the Czech Republic and Hungary, which are both small and open economies and thus largely affected by the economies of their trading partners (mostly Germany). In such a case, giving up the exchange rate mechanism – which is relatively ineffective – is likely to offer more benefits than costs. The OCA analysis is, thus, useful both for the current EMU members to assess the endogeneity hypothesis over time, and for the prospective members that wish to evaluate their degree of real convergence with the core EMU countries.

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APPENDIX

Appendix 1 – Summary statistics

Table A 1: Summary statistics, using the observations 1 – 210

Variable	**Mean**	**Median**	**Minimum**	**Maximum**
Exchange rate variability	0.0842378	0.0784517	0.00244125	0.145805
Asymmetry of shocks	0.0237542	0.0237882	0.00859434	0.0442518
Trade dissimilarity	0.706593	0.664436	0.240217	1.43129
Trade linkages	0.0182093	0.00891808	0.000348770	0.205226
Size	12.9159	12.4785	10.5731	21.1805
LAMRIG	0.955488	0.831181	0.0693312	2.52834
Foreign born population	0.0643727	0.0556366	0.000472000	0.207395
ULC growth	-0.105409	-0.0625000	-5.90625	4.84375
Credit growth	0.0511717	0.0502257	0.0134877	0.0855689
EU dummy	0.576190	1.00000	0.000000	1.00000

Variable	**Std. Dev.**	**C.V.**	**Skewness**	**Ex. Kurtosis**
Exchange rate variability	0.0342628	0.406739	-0.0302678	-0.822585
Asymmetry of shocks	0.00711344	0.299460	0.147192	-0.359174
Trade dissimilarity	0.276463	0.391263	0.495949	-0.697840
Trade linkages	0.0274105	1.50530	3.74057	17.6449
Size	1.99010	0.154082	2.48340	6.20898
LAMRIG	0.612763	0.641308	0.457632	-0.863457
Foreign born population	0.0503393	0.781997	0.909919	0.0840224
ULC growth	1.73623	16.4713	-0.0878275	0.727773
Credit growth	0.0156725	0.306273	-0.125601	-0.675690
EU dummy	0.495342	0.859684	-0.308363	-1.90491

Note: Data for developed countries only.

Table A 2: Summary statistics for instruments, using the observations 1 – 210

Variable	**Mean**	**Median**	**Minimum**	**Maximum**
Lndist	8.01812	7.72744	5.39812	9.88950
Lndist2	65.6473	59.7133	29.1397	97.8022
Tradeag	0.580952	1.00000	0.000000	1.00000
Comlang	0.138095	0.000000	0.000000	1.00000
Combord	0.100000	0.000000	0.000000	1.00000
Legal origin	0.771429	1.00000	0.000000	1.00000
Financial index	0.175964	0.152256	0.0238095	0.458647
Financial reform	0.122306	0.105263	0.000000	0.315789

Variable	**Std. Dev.**	**C.V.**	**Skewness**	**Ex. kurtosis**
Lndist	1.16773	0.145636	0.0119984	-1.15352
Lndist2	18.7840	0.286135	0.188463	-1.23686
Tradeag	0.494582	0.851330	-0.328139	-1.89232
Comlang	0.345824	2.50424	2.09800	2.40160
Combord	0.300717	3.00717	2.66667	5.11111
Legal origin	0.420916	0.545632	-1.29279	-0.328704
Financial index	0.0945237	0.537177	0.909401	0.325437
Financial reform	0.0669298	0.547233	0.397752	-0.161241

Note: Data for developed countries only.

Appendix 2 – Additional results

White's test for heteroscedasticity:

Null hypothesis: heteroskedasticity not present
Test statistic: LM = 23.7724
with p-value = P(Chi-square(14) > 23.7724) = 0.0488062

Breusch-Pagan test for heteroscedasticity:

Null hypothesis: heteroskedasticity not present
Test statistic: LM = 4.34371
with p-value = P(Chi-square(4) > 4.34371) = 0.361484

Testing for multicollinearity

Variance Inflation Factors
Minimum possible value = 1.0
Values > 10.0 may indicate a collinearity problem

Asymmetry of shocks	1.328
Trade dissimilarity	1.267
Trade linkages	1.148
Size	1.132

Testing for normality of residuals

Test for null hypothesis of normal distribution:
Chi-square(2) = 4.578 with p-value 0.10135

Testing for endogeneity using Hausman test

Hausman test -

Null hypothesis: OLS estimates are consistent
Asymptotic test statistic: Chi-square(2) = 30.7268
with p-value = 2.12694e-007

Table A 3: Testing for endogeneity using 2SLS procedure

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0401125	0.0176678	2.2704	0.02423	**
Asymmetry of shocks	0.44991	0.313519	1.4350	0.15281	
Trade dissimilarity	0.0185116	0.00775218	2.3879	0.01786	**
Trade linkages	−0.952974	0.113729	-8.3794	<0.00001	***
Size	0.00291973	0.00100826	2.8958	0.00419	***
Trade_residual	0.898948	0.145478	6.1793	<0.00001	***

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.00745403	0.018404	0.4050	0.68589	
Asymmetry of shocks	0.996312	0.330876	3.0111	0.00293	***
Trade dissimilarity	0.0251824	0.00824565	3.0540	0.00256	***
Trade linkages	−0.421881	0.0791628	-5.3293	<0.00001	***
Size	0.00332968	0.00108411	3.0713	0.00242	***
Openness_residual	−0.0156988	0.00657099	-2.3891	0.01780	**

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−0.28939	0.0226395	-12.7825	<0.00001	***
Asymmetry of shocks	10.1315	0.62225	16.2820	<0.00001	***
Trade dissimilarity	−0.0140009	0.00611131	-2.2910	0.02299	**
Trade linkages	−0.0427125	0.058581	-0.7291	0.46677	
Size	0.0111207	0.000887164	12.5351	<0.00001	***
Asymmetry_residual	−10.1208	0.636672	-15.8964	<0.00001	***

Table A 4: Testing for relevance of instruments: Trade linkages

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0553836	0.0114181	4.8505	<0.00001	***
Lndist	−0.00524975	0.00137909	-3.8067	0.00019	***
Combord	0.0491884	0.00535519	9.1852	<0.00001	***

Mean dependent var	0.018209	S.D. dependent var	0.027410
Sum squared resid	0.084672	S.E. of regression	0.020225
R-squared	0.460784	Adjusted R-squared	0.455575
F(2, 207)	88.44552	P-value(F)	1.73e-28
Log-likelihood	522.7106	Akaike criterion	−1039.421
Schwarz criterion	−1029.380	Hannan-Quinn	−1035.362

Table A 5: Testing for relevance of instruments: Openness

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	8.35068	1.43474	5.8203	<0.00001	***
Lndist	−1.589	0.353484	-4.4953	0.00001	***
Lndist2	0.086248	0.0214998	4.0116	0.00008	***
Combord	−0.435569	0.102995	-4.2290	0.00004	***

Mean dependent var	1.228256	S.D. dependent var	0.370863
Sum squared resid	20.29723	S.E. of regression	0.313895
R-squared	0.293904	Adjusted R-squared	0.283621
F(3, 206)	28.58168	P-value(F)	1.71e-15
Log-likelihood	−52.63164	Akaike criterion	113.2633
Schwarz criterion	126.6517	Hannan-Quinn	118.6757

Table A 6: Testing for relevance of instruments: Asymmetry of shocks

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−0.0144949	0.00783444	-1.8502	0.06572	*
Tradeag	0.00483945	0.00199333	2.4278	0.01604	**
Lndist	0.0044197	0.000844259	5.2350	<0.00001	***

Mean dependent var	0.023754	S.D. dependent var	0.007113
Sum squared resid	0.008428	S.E. of regression	0.006381
R-squared	0.203029	Adjusted R-squared	0.195328
F(2, 207)	26.36663	P-value(F)	6.30e-11
Log-likelihood	764.9639	Akaike criterion	−1523.928
Schwarz criterion	−1513.887	Hannan-Quinn	−1519.869

Table A 7: Testing for validity of instruments using Hansen J-test

	Coefficient	*Std. Error*	*z*	*p-value*	
const	0.14821	0.0153848	9.6335	<0.00001	***
Trade linkages	−0.363181	0.082071	-4.4252	<0.00001	***
EUROPE dummy	−0.0418278	0.00512178	-8.1666	<0.00001	***
Openness	−0.0268461	0.0147098	-1.8250	0.06799	*
Mean dependent var	0.084238				
S.D. dependent var	0.034263				
GMM criterion: Q = 0.00953409 (TQ = 2.00216)					
J test: Chi-square(2) = 2.00216 [0.3675]					

Note: 2-step GMM, using observations 1-210, using instruments: $lndist, combord, lndist2$. The Hansen J statistic is called after Hansen (1982) and known also as Hansen-Sargan statistic for its close link to the Sargan test in the IV/2SLS estimation (Lee and Lee, 2010). The test is computed as the value of the GMM objective function evaluated at the efficient GMM estimator and the statistic is asymptotically distributed as chi-square with degrees of freedom equal to the number of overidentifying restrictions, i.e. the difference between the number of instruments and parameters, and consistent in the presence of heteroscedasticity (Baum, 2006).

Table A 8: Testing for the significance of labour market rigidity in standard OLS model

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−0.0101375	0.0182495	-0.5555	0.57917	
Trade dissimilarity	0.0317237	0.00781032	4.0618	0.00007	***
Trade linkages	−0.303656	0.088185	-3.4434	0.00070	***
Size	0.00308863	0.00113621	2.7184	0.00713	***
LAMRIG	0.13839	0.0223627	6.1885	<0.00001	***
Asymmetry of shocks	0.912445	0.327709	2.7843	0.00587	***

Mean dependent var	0.084238	S.D. dependent var	0.034263
Sum squared resid	0.156973	S.E. of regression	0.027739
R-squared	0.360216	Adjusted R-squared	0.344535
F(5, 204)	29.68727	P-value(F)	1.33e-22
Log-likelihood	457.8958	Akaike criterion	−903.7916
Schwarz criterion	−883.7090	Hannan-Quinn	−895.6730

Table A 9: Testing for relevance of instruments for the difference in credit growth

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0304256	0.00253116	12.0204	<0.00001	***
LT_1993-1995	−0.00011612	0.00366935	-0.0316	0.97478	
Initialcredit_1990-1995	0.0136031	0.00352804	3.8557	0.00015	***
ST_1993-1995	0.0002599	0.000731758	0.3552	0.72283	
Fin_indexdummy1990s	0.00872148	0.0183446	0.4754	0.63499	

Mean dependent var	0.038267	S.D. dependent var	0.016789
Sum squared resid	0.054037	S.E. of regression	0.016236
R-squared	0.082771	Adjusted R-squared	0.064874
F(4, 205)	4.624815	P-value(F)	0.001352
Log-likelihood	569.8687	Akaike criterion	−1129.737
Schwarz criterion	−1113.002	Hannan-Quinn	−1122.972

Note: Dependent variable is the difference in credit growth averaged over 1996-1998.

Table A 10: Final GMM model

	Coefficient	*Std. Error*	*z*	*p-value*	
const	0.0439163	0.0300564	1.4611	0.14398	
Trade linkages	−0.214844	0.0973638	-2.2066	0.02734	**
Size	0.00126841	0.00052088	2.4351	0.01489	**
LAMRIG	0.00458686	0.00179169	2.5601	0.01046	**
Credit growth	0.80962	0.391398	2.0685	0.03859	**
EUROPE dummy	−0.0313321	0.00866745	-3.6149	0.00030	***

Mean dependent var	0.084238
S.D. dependent var	0.034263

GMM criterion: Q = 0.0214783 (TQ = 4.51043)
J test: Chi-square(3) = 4.51043 [0.2114]

Note: Using instruments $lndist, combord, legorigin, fin\_index, fin\_reform$.

Final GMM model: Testing for heteroscedasticity using Pasaran-Taylor test:

	coefficient	std. error	t-ratio	p-value
const	0.000217031	3.99908e-05	5.427	1.59e-07 ***
yhat^2	0.00258385	0.00425703	0.6070	0.5445

Unadjusted R-squared = 0.001768
Test statistic: HET_1 = |0.002584| / 0.004257 = 0.606961,
with p-value = 2 * P(z > 0.606961) = 0.544

Appendix 3 – Results of previous studies

Bayoumi and Eichengreen (1997)
Horváth (2005)
Vieira and Vieira (2011)

Table A 11: OCA indices for European countries versus Germany, 1987-1995

	1987	1991	1995
France	0.068	0.067	0.074
Italy	0.070	0.065	0.059
UK	0.099	0.094	0.089
Austria	0.008	-0.004	0.008
Belgium	0.003	-0.008	0.013
Denmark	0.063	0.060	0.074
Finland	0.098	0.095	0.087
Greece	0.053	0.054	0.054
Ireland	0.043	0.036	0.021
Netherlands	0.003	-0.008	0.007
Norway	0.078	0.078	0.077
Portugal	0.068	0.066	0.062
Spain	0.088	0.082	0.073
Sweden	0.068	0.063	0.056
Switzerland	0.038	0.030	0.023

Source: Bayoumi and Eichengreen (1997)

Table A 12: OCA indices for European countries versus Germany, 1988-2008

	1988	1998	2008
Belgium	0.012	0.014	0.002
Austria	0.032	0.012	0.004
Nertherlands	0.034	0.044	0.036
Finland	0.057	0.108	0.038
Switzerland	0.062	0.063	0.041
Sweden	0.065	0.086	0.066
Italy	0.067	0.073	0.072
France	0.069	0.069	0.063
Denmark	0.069	0.058	0.044
Ireland	0.076	0.087	0.106
Greece	0.089	0.097	0.099
UK	0.093	0.102	0.079
Norway	0.094	0.101	0.085
Spain	0.099	0.081	0.078
Portugal	0.102	0.078	0.069

Source: Vieira and Vieira (2011). Indices are only reported up to 3 decimal points.

Table A 13: OCA indices for CEEC versus Germany, 1999-2004

Czech Republic	0.001
Estonia	-0.002
Hungary	0.001
Latvia	0.030
Lithuania	0.017
Poland	0.016
Romania	0.015
Slovakia	-0.001
Slovenia	0.004

Source: Horváth (2005)