Charles University in Prague
Faculty of Social Sciences

Institute of Economic Studies

MASTER THESIS

Sovereign Debt Crisis: An Opportunity to Redesign the EMU?

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Declaration of Authorship

The author hereby declares that she compiled the thesis *"Sovereign Debt Crisis: An Opportunity to Redesign the EMU?"* independently, using only the listed resources of literature.

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Prague, January 7, 2013

Signature

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Abstract

This master thesis focuses on the assessment of the recent development in the Economic and Monetary Union (EMU) in the light of current sovereign debt crisis. The main goal is to reassess the alignment of business cycles within the EMU with the use of a simple semi-structural model in quarterly frequency and the Kalman filter, in order to examine the harmonization of the individual economies which is necessary for an efficient functioning of the monetary union. Moreover, an ex-post analysis of the fulfillment of the Optimum Currency Area criteria by the EMU area is performed. The results suggest that after more than a decade of the euro playing the role of common currency, the predictions of self-fulfilling convergence did not come true and that in the context of the asymmetric impact of the sovereign debt crisis, divergent tendencies arose in business cycle alignment, inflation differentials and in OCA index as well.

JEL Classification: C39, C53, E12, E37, F15, F33
Keywords: Sovereign debt crisis, euro area, monetary union, business cycles alignment, OCA index
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Abstrakt

Tato diplomová práce se zaměřuje na zhodnocení posledních událostí v ekonomické a monetární unii (EMU) ve světle současné dluhové krize. Hlavním cílem je prozkoumat zarovnání hospodářských cyklů v rámci EMU pomocí jednoduchého semistrukturálního modelu ve čtvrtletní frekvenci a Kalmanova filtru a zhodnotit harmonizaci mezi jednotlivými ekonomikami, která je pro efektivní fungování monetární unie nezbytná. Kromě toho je zanalyzováno, zdali EMU splňuje kritéria optimální měnové unie (OCA) alespoň ex post. Výsledky poukazují na to, že ani po více než deseti letech, kdy euro hraje roli společné měny, se předpovědi o sebenaplňující se konvergenci se nestaly skutečností. Ba naopak, v kontextu asymetrického působení dluhové krize se objevily divergující trendy v zarovnání hospodářských cyklů, inflačních rozdílech i indexu OCA.

Klasifikace JEL: C39, C53, E12, E37, F15, F33
Klíčová slova: Dluhová krize, euro oblast, monetární politika, zarovnání hospodářských cyklů, index OCA
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List of Acronyms

EA	Euro Area
ECB	European Central Bank
ECOFIN	Economic and Financial Affairs Council
ECU	European Currency Unit
EDP	Excessive Debt Procedure
EFSF	European Financial Stability Facility
EMS	European Monetary System
EMU	Economic and Monetary Union
ERM	Exchange Rate Mechanism
ESM	European Stability Mechanism
EU	European Union
EURIBOR	Euro Interbank Offered Rate
GDP	Gross Domestic Product
HICP	Harmonized Index of Consumer Prices
NCB	National Central Bank
OCA	Optimum Currency Area
SGP	Stability and Growth Pact
S&P	Standard & Poor's Rating Agency

Country codes

AT	Austria
BE	Belgium
BG	Bulgaria
CY	Cyprus
CZ	Czech Republic
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GR	Greece
HU	Hungary

IE	Ireland
IT	Italy
LT	Lithuania
LU	Luxembourg
LV	Latvia
MT	Malta
NL	Netherlands
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovakia

Master Thesis Proposal

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Proposed Topic:

Sovereign Debt Crisis: An Opportunity to Redesign the EMU

Topic Characteristics:

My thesis will focus on the assessment of recent development of the European Economic and Monetary Union (EMU) in the light of the current sovereign debt crisis. While Maastricht criteria were set up as an indicator of country's readiness to join the common currency area, in the context of current sovereign debt crisis, they seem to have failed in guaranteeing an efficient functioning of the EMU.
The main goal of this thesis is to revisit the fulfillment of an alternative set of criteria - Optimum Currency Area (OCA) criteria - by the EMU area and figure out whether, after more than a decade of the euro playing the role of common currency, the predictions of future convergence were fulfilled or whether the time has shown that the composition and setting of the EMU is neither an optimal, nor a viable solution. Furthermore, alternative possibilities of the currency area composition will be assessed.

Hypotheses:

1. The sovereign debt crisis proved the Maastricht criteria not to be an appropriate guarantee of the EMU's functioning.
2. More than a decade since the introduction of the euro, the prophecy of Frankel and Rose hasn't fulfilled itself.
3. The business cycle misalignment of individual eurozone countries has not disappeared.
4. The sovereign-debt crisis further enhanced the divergence between the peripheral and core countries of the EMU.
5. While the current EMU members do not form the OCA, an alternative combination of countries could form the OCA, or potentially two OCAs would correspond better to the two-speed EU situation.

Methodology:

In the first part of the thesis, data series related to both Maastricht criteria and the OCA criteria will be analyzed. The OCA criteria will be further analyzed by calculating the so-called OCA index. The variables explaining the variability of bilateral exchange rates will be: bilateral trade openness ratio, commodity export structure, size of the economy and correlation of economic cycles.

The methodology for assessing the correlation of economic cycles will be based on output gap correlations between individual economies. The output gap will be simulated based on a set of equations modeling the economies of individual EU member countries that will be calibrated to become country-specific. The model will be described by the following relationships: IS curve, Phillips curve, uncovered interest rate parity and policy reaction function in the form of Taylor rule. Moreover, expected inflation will be based both on historical values and on currently available information.

Outline:

1. Theoretical and Historical Background
    a. Maastricht Criteria
    b. Optimum Currency Area
    c. Sovereign Debt Crisis
2. Alignment of Business Cycles
    a. Model Specification
    b. Model Calibration
    c. Output Gap Simulation
3. OCA Index
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Supervisor

1. Introduction

Throughout the history of economy as a science, the world has seen many periods of economic downturn. The two most recent ones, the subprime mortgage crisis that transformed into a world-wide financial crisis and the subsequent sovereign debt crisis spreading through several countries of the euro area, have posed several question marks about the accountability of both financial sector and governments for their actions and most importantly, it reopened the debate about the functioning of the euro area monetary union and its ability to withstand the current events without being shattered.

This thesis will focus on the assessment of recent development of the Economic and Monetary Union (EMU) in the light of current sovereign debt crisis. While the Maastricht criteria were set up as an indicator of a country's readiness to join the common currency area, in the context of current sovereign debt crisis, they seem to have failed in guaranteeing an efficient functioning of the EMU. Their institutional setting of one-time goals without a credible institutional follow-up led several countries to take steps that were unsustainable in the longer run or even to misreport in order to comply with the requirements in the assessment year.

The main goal of this thesis is to reassess the alignment of business cycles within the EMU with the use of a simple semi-structural model in quarterly frequency and the Kalman filter in order to examine the harmonization of the individual economies which is necessary for an efficient functioning of the monetary union. Moreover, an ex-post analysis of the fulfillment of the Optimum Currency Area criteria by the EMU area will be performed in order to figure out whether, after more than a decade of the euro playing the role of common currency, the predictions of self-fulfilling convergence came true or whether the time has shown that the composition and setting of the EMU is neither an optimal, nor a viable solution. Moreover, alternative possibilities of the currency area composition will be assessed.

The following hypotheses are to be tested:

The sovereign debt crisis proved the Maastricht criteria not to be an appropriate guarantee of the EMU's functioning.

More than a decade since the introduction of the euro, the prophecy of Frankel and Rose (1997) about self-fulfilling convergence among the euro area countries hasn't fulfilled itself.

The business cycle misalignment of individual euro area countries has not disappeared.

The sovereign debt crisis further enhanced the divergence between the peripheral and core countries of the EMU.

While the current EMU members do not form the OCA, an alternative combination of countries could form the OCA, or potentially two OCAs would correspond better to the two-speed EU situation.

Chapter 2 will focus on explaining the main theoretical concepts and outline the historical background, nevertheless, both will be narrowed down to the issues within the scope of this thesis. Chapter 3 will outline the semi-structural model used for the output gap filtration and provide a brief description variables used. The methodology will be summarized in Chapter 4 and it will cover both the derivation of business cycles for all 27 member states of the European Union based on a simple model calibrated to be country-specific and also the calculation of the so-called Optimum Currency Area index. Chapter 5 will discuss the results received from the techniques described in Chapter 4, whereas Chapter 6 will sum up the conclusions that can be reached.

2. Theoretical and Historical Background

In this Chapter, the main milestones of the formation of the monetary union will be described along with the subsequent functioning of the euro area and the events that led up to the sovereign debt crisis. As the aim of this thesis is not providing an in-depth historical description, this Chapter will be limited only to those aspects of formation and functioning of the Economic and Monetary Union (EMU) that are pivotal to understanding how it functions and how the sovereign debt crisis emerged.

First of all, the formation of the EMU and the fulfillment of the Maastricht criteria, the prerequisite to a country's accession, will be discussed. Since two of these convergence criteria deal with the government finance (they set limits for debt-to-GDP and deficit-to-GDP ratio), it was expected that by complying with these, a sufficient level of similitude in the fiscal sector would be established, nevertheless the ongoing sovereign debt crisis indicates that it just wasn't enough. The Stability and Growth Pact that was established as a follow-up to the fiscal moderation promoted by the Maastricht criteria will be also analyzed further in this Chapter.

Secondly, the key aspect of functioning of the monetary union will be discussed, i.e. the common monetary policy, and finally, an overview of the events that led up to the unleashing of the sovereign debt crisis and its consequences will be summed up.

2.1. The Road to the EMU

The road to forming and actually launching the monetary union, from what officially started as a peace-keeping initiative, was long and not so straight-forward. Although as early as in 1970 a three-stage approach to the formation of the Economic and Monetary Union was presented in the so-called Werner Report, its implementation had to be postponed due to uneasy economic conditions at the time and in the end it got replaced by the Delors Report in 1989.[1]

[1] European Commission (iii)

It wasn't until 1978 when the European Monetary System got launched (EMS) including the Exchange Rate Mechanism (ERM) that introduced the concept of semi-pegged currency system aimed at limiting the exchange rate variability by setting a fixed band for the bilateral exchange rates of participating currencies. Originally, the margin was set at ±2.25%,[2] nevertheless, in order to contain pressures on the participating currencies that arose due to speculative attacks in the early 1990s it was increased to ±15%. Until replaced by the euro twenty years later, the European Currency Unit (ECU) served as a unit of account and its value was determined as a weighted average of the participating currencies.

Officially, the launch of the first stage of the EMU, whose aim was to coordinate economic policy more closely and liberalize the capital movements, did not take place until the year of 1990, however, the integration process has speeded up afterwards. The second stage got launched only four years later, creating the European Monetary Institute and working towards the fulfillment of the Maastricht convergence criteria established in 1992 that will be discussed further in this Chapter along with the Stability and Growth Pact and the functioning of the European Central Bank that started operating in June 1998.

The three-stage integration process towards the Economic and Monetary union was finalized in January 1999 when the exchange rates between the euro and the currencies of Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain got irrevocably fixed and the euro was launched, although still not in a physical form, as the single currency. The euro coins and banknotes were finally introduced in January 2002 and gradually replaced the individual national currencies.

2.1.1. Maastricht Criteria

The so-called Maastricht criteria are a set of criteria that were introduced in 1992 with the aim of enhancing the economic integration among the individual member states. They are stipulated in the Article 121(1) of the Treaty Establishing the European Community and

[2] 6% respectively for Italian lira

subsequently covered by the Article 140(1) of the Consolidated Version of Treaty on Functioning of the European Union.[3] They are the prerequisites that all countries wanting to access the European Economic and Monetary Union (EMU) and subsequently adopt the euro as their national currency have to meet.

The criteria cover the following four spheres:[4]

- price stability – the inflation rate must not exceed that of the three best-performing member states by more than 1.5 percentage points during the year prior to the examination,
- government finance – the annual government deficit must not exceed 3 percent of the GDP and the gross government debt must not go beyond 60 percent of the GDP at the end of financial year or at least must be systematically approaching these levels at a satisfactory pace,
- long-term interest rates – the nominal long-term interest rate must not exceed the interest rate of three best-performing member states in terms of price stability by more than 2 percentage points,
- exchange rates – the member states must be members of the exchange rate-mechanism (ERM II) under the European Monetary System (EMS) for two consecutive years prior to examination and throughout this period, it must not devalue its currency.

In addition to the criteria stated above, the member states were obliged to align the national rules and laws concerning their National Central Banks (NCB) and monetary issues. Moreover, monetary financing of government deficits via Central Banks was prohibited and sharing of liability for government debt between the individual member states was prohibited by the "no-bailout" principle.[5]

[3] EUR-Lex
[4] Europa
[5] Moutot, Rother, Schuknecht and Stark (2011)

While these criteria were supposed to "ensure that a member state's economy was sufficiently prepared for the adoption of the single currency,"[6] many countries took such steps to meet the criteria that were unsustainable and in case of Greece, even systematical misreporting on the state of government finance took place when attaining the goal to enter the currency union.[7] Moreover, the Maastricht criteria were only supposed to be fulfilled in a specified year and did not provide for the follow-up of their fulfillment. Such follow-up was supposed to be secured by the introduction of the Stability and Growth Pact, nevertheless, it turned out deficient due to its lack of credible punishment when breached.

Furthermore, as some critiques of the Maastricht criteria point out, the criteria weren't even met in the first place. It was the inclusion of vague provisions into the criteria that caused that the decision about what country can enter or not was basically left at European institutions' discretion. Among these vague clauses, there is the possibility for a country to enter the EMU when the ratio of government debt to GDP has declined and is approaching the reference value of 60% at a satisfactory pace as well as exceptional and a temporary excess in case of budget deficit from the 3% reference value is also allowed. What is a satisfactory pace or what can be considered only temporary and exceptional is left to discussion.

Figure 1 shows the situation of the gross government debt as a percentage of GDP of the original member states that formed the euro area in 1999. It covers four years prior to the EMU's formation and in its formation year with examination year, that is when the criteria should be meet, being 1997. Moreover, Greece is included as it joined the euro area before the actual euro banknotes and coins in physical form were introduced, nevertheless, the data are provided for the corresponding four years prior to its entry plus the accession year: 1997-2001.

As can be seen in Figure 1, most of the member states breached the 60% debt-to-GDP ratio. In the examination year of 1997, Austria, Belgium, Ireland, Italy, Netherlands and Spain all breached the reference ratio, nevertheless, in the 1998 Convergence Report, it

[6] European Commission (i)
[7] Eurostat (2004)

was concluded that all of these countries have made significant progress in diminishing this ratio and hence should be admitted into the euro area.

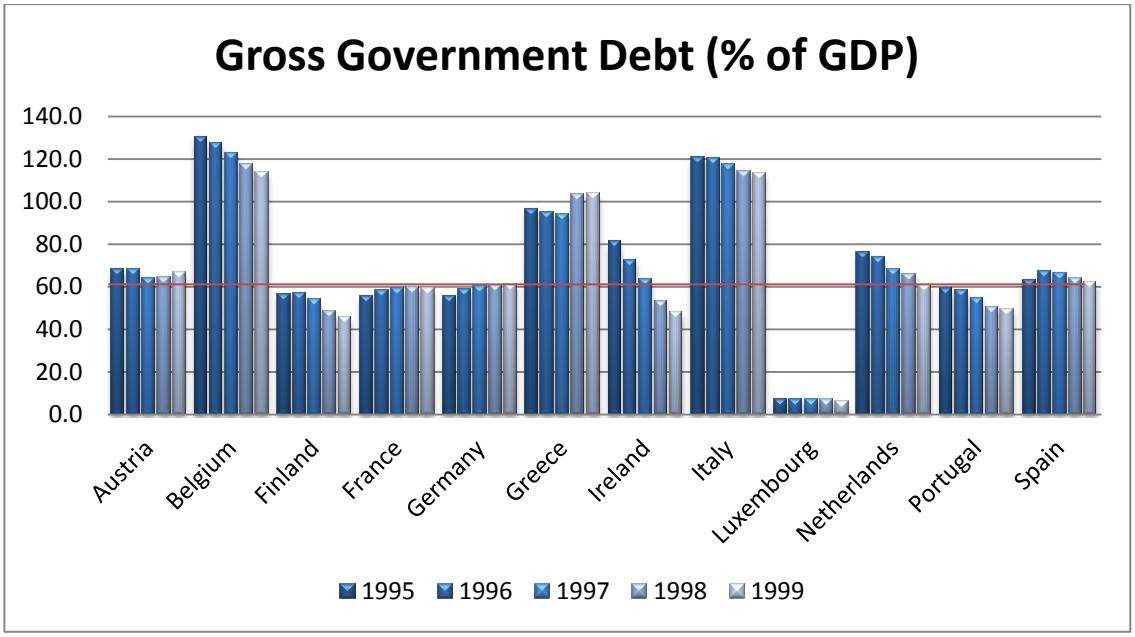

Figure 1: Gross Government Debt (% of GDP) Prior to the Euro Area Formation,[8] Source: ECB Statistical Data Warehouse

While in case of Belgium, Ireland, Italy and Netherlands, there is at least a visible decreasing trend, this cannot be said about the debt-to-GDP ratio of Austria or Spain. The same thing holds for Greece in its examination year of 1999. Disregarding that Greece has not made much of a progress in diminishing its debt-to-GDP ratio prior to the examination year and that the following two years (2000 and 2001) were even marked by an increase in this ratio, Greece was still allowed to join the monetary union.

As can be seen in Figure 2, the situation with fulfilling the 3% deficit-to-GDP ratio was significantly better than in case of the debt criterion. In 1997, only France, Portugal and Spain breached this criterion and so did Greece in 1999. Nevertheless, all these economies made a substantial progress in cutting the government deficit and were able to get very close to the reference level.

[8] In case of Greece, the corresponding years are covered: 1997-2001

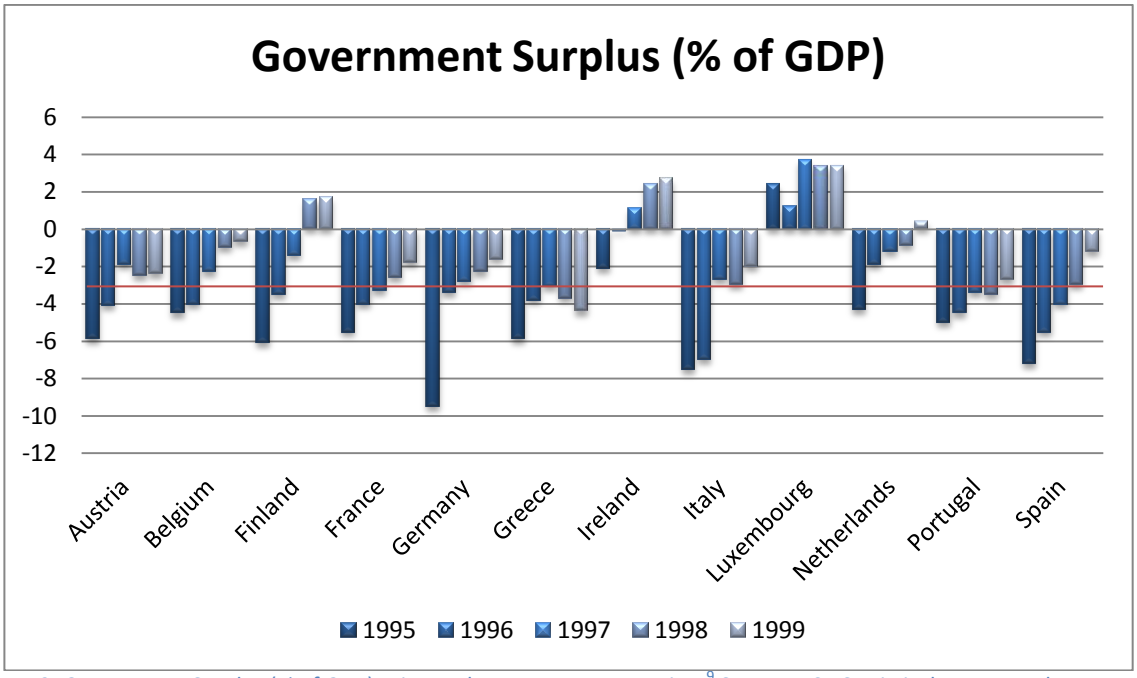

Figure 2: Government Surplus (% of GDP) Prior to the Euro Area Formation,[9] Source: ECB Statistical Data Warehouse

While France, Portugal and Spain continued in cutting their budgets in the two years following the assessment year and were able to decrease them under the threshold of 3% of GDP, Greece once again reverted to increasing its deficit right after the examination year of 1999.

2.1.2. Stability and Growth Pact

The Stability and Growth Pact (SGP) is a framework that was designed to coordinate the national fiscal policies within the EMU and promote sound public finances of individual euro area member states. More formally, the original version passed in 1997 states that two (Maastricht) criteria should be respected once the euro is launched: the government's deficit must not surpass 3% of GDP, whereas the debt must not exceed 60% of GDP.[10] Nevertheless, Germany and France refused to follow these rules in 2003 and so in 2005, a reformed version of SGP appeared allowing exceptions from the fiscal rules,[11] the time frame for corrective actions was loosened and procedural deadlines postponed.[12]

[9] In case of Greece, the corresponding years are covered: 1997-2001
[10] European Commission (ii)
[11] De Grauve (2010)
[12] Moutot, Rother, Schuknecht and Stark (2011)

The framework consists of two arms – a preventive one and a dissuasive one. While the preventive arm obliges the member states to report annually on the steps planned to take in order to safeguard sound public finance and the Commission subsequently gives its opinion about them, the dissuasive arm exercises the so-called excessive deficit procedure (EDP) that follows when the 3% deficit to GDP ratio threshold is breached.

Even though the possibility of sanctions formally exists in case that recommendations issued by the Council within the EDP framework are not implemented by a given deadline, in reality it is not a very credible threat as no sanctions, at least to author's knowledge, were imposed and actually collected for breaching the deficit to GDP level.[13] Since its introduction, it has been heavily criticized for its weak enforcement provisions. Given the number of countries whose state of government finance remains on the edge of the permitted benchmark, it is not too hard for a country breaching these limits to find the support of other countries and prevent the formation of a qualified majority in the ECOFIN Council, hereby halting further procedural steps against it.[14]

The unleashing of euro area sovereign debt crisis can be blamed, apart from the member states' inability to resist the temptation of substantial drop in borrowing costs, at the policy failures and deficiencies in coordinating the fiscal policy as well as at the spillovers from the financial crisis that aggravated the state of fiscal sector in the euro area. The now even more pronounced fiscal imbalances within the monetary union threaten not only the economic growth and stability in the countries concerned but it can even jeopardize the sustainability of the union itself. Therefore, the weaknesses in the fiscal governance of the EMU viewed in the light of ongoing sovereign debt crisis have been recently reopened to discussions and have so far resulted in the introduction of new set of rules on December 13, 2011 and even more ambitious reform entered in force on January 1, 2013.

A strengthening reform of the SGP, the so-called "six-pack", entered into force with the aim of reinforcing both the preventive and corrective arm for all of the 27 EU member states. It

[13] For an overview of all closed and ongoing excessive deficit procedures see: http://ec.europa.eu/economy_finance/economic_governance/sgp/deficit/index_en.htm
[14] Moutot, Rother, Schuknecht and Stark (2011)

defines quantitatively what is considered a significant deviation from the country-specific medium-term objective and introduces a reversed qualified majority voting[15] for most sanctions and hence increases the probability of their implementation.[16]

Moreover, 25 out of the 27 member states[17] signed the Treaty on Stability, Coordination and Governance in the EMU in March 2012 with the aim to strengthen budgetary discipline, coordination of economic policies and improve the governance of the euro area. The fiscal part of the Treaty, called the Fiscal Compact, introduces a lower limit in terms of permitted structural deficit[18] and most importantly, the budget rules including an automatic correction mechanism in case of non-compliance are to be implemented at a national level.

While the fact that the Fiscal Compact is an intergovernmental agreement rather than a supranational EU law could be perceived as a step back in the integration process, it may paradoxically lead to really attaining the fiscal cohesion that the original SGP was aiming at,[19] nevertheless, whether it will be implemented in the correct way remains an open question. However, such a solution can be considered a compromise between the need for harmonization of fiscal sector and member states´ unwillingness to give up their power over the fiscal policy which is basically the last instrument they´re left with to influence their economy,[20] being deprived of the right to implement their own monetary policy and devaluate their currency when the lack of competitiveness arises.

2.2. Common Monetary Policy

By accepting the euro to replace the national currency, countries not only lose their banknotes and coins but also the privilege to choose and implement their own monetary policy, specifically tailored to the economic situation of an individual country. The National

[15] Under the reversed qualified majority voting, a proposal of the Commission is adopted by the ECOFIN Council unless there is a qualified majority of countries that vote against it.
[16] European Commission (iv)
[17] All with the exception of the United Kingdom and Czech Republic.
[18] The permitted structural deficit is 1% of GDP for those member states that have their debt-to-GDP ratio significantly below 60% and 0.5% of GDP for other member states.
[19] For a more in-depth analysis see for example Cantore and Martinico (2012)
[20] Moutot, Rother, Schuknecht and Stark (2011)

Central Banks (NCBs) handed their policy-making power over to the European Central Bank (ECB) whose primary objective is to maintain price stability defined as a year-on-year increase in the Harmonized Index of Consumer Prices (HICP) close to but below 2%. The ECB's institutional framework was enshrined in the Maastricht Treaty ordaining its political independency and formulating other objectives that should be pursued by the ECB, such as high employment, but these shall never interfere with attaining the primary objective of price stability.

In order to meet this objective, the ECB's decision-making body, the Governing Council, meets every month and assesses the recent monetary and economic developments and sets the level of the key interest rates in line with their monetary policy strategy. It consists of the Governors of the National Banks of the euro area member states, President, Vice-President and four Directors of the ECB. Since each of the members has one vote, smaller economies have a more-than proportionate influence on the monetary policy with respect to the size of their economies than larger ones. Even though the statutes of the ECB order the Council members to act in the interests of euro area as a whole, most probably there are occasions when they strive for the national benefit.[21]

Since January 1, 1999 the ECB has conducted a common monetary policy for the whole euro area and this centralization of monetary policy on euro-area level has raised many doubts whether the individual countries will behave similarly in the face of common monetary policy action. Many studies have been performed on the topic of monetary policy effectiveness within the euro area and the implied costs of having a common monetary policy. It is clear that unless there is a high extent of harmonization among the participating economies, then the common monetary policy is not going to be the one size that fits all. The larger is the difference between the ECB's policy applied and the policy that the National Central Banks would choose to undertake if they had the power to do so,[22] the more likely is the ECB going to experience political pressures.[23]

[21] Aksoy, De Grauwe and Dewachter (2001)
[22] This difference is called monetary stress. See: Clarida, Galí and Gertler (1998)
[23] Sturm and Wollmershäuser (2008)

Moreover, the uniform monetary policy may even lead to asymmetric business cycles across the euro area once there are differences in the transmission mechanism among the euro area member states[24] and according to some authors, the launch of EMU has even led to stronger degree of uncertainty about the transmission mechanism of monetary policy. Since the output gap is traditionally one of the inputs (along with the deviation of expected inflation from the targeted one) to the guidance tool on how to set the optimal interest rates, called the Taylor rule (see equation 12 in Chapter 3) and commonly used by the inflation targeting Central Banks, it is of key importance that the output gaps are harmonized across the individual members of the monetary union.

2.3. Sovereign Debt Crisis

The sovereign debt crisis comes into existence when difficulties in servicing the country's debt arise. These difficulties turned up as a consequence of the financial crisis spreading throughout Europe and the launch of different rescue packages, mainly for the construction sector and banking system, and other fiscal plans to prevent the economy from being hit as hard by the crisis. The increased government spending and dampened economic activity led to a substantial rise in debt-to-GDP ratios of most of the euro area countries and some non-euro area member states such as the United Kingdom or Hungary. The ongoing sovereign debt crisis that started in the late 2009 has mainly impacted the countries of Portugal, Italy, Ireland, Greece and Spain, often referred to as PIIGS.

2.3.1. Timeline

Although already in 2008, Ireland raised concerns over its fiscal spending as it pledged to guarantee its banks' deposits and most of debt liabilities;[25] the beginning of the sovereign debt crisis is usually associated with November 2009 when first alerts about overly increased deficits and debts started to emerge. The situation further intensified when Greece admitted that its debt has reached the highest level in its modern history that amounted up to 113% of its GDP and a revision of its 2009 deficit shows that it reached 15.8% of GDP, in other words more than five times the allowed 3% under the Stability and Growth Pact. Moreover, fiscal spending was not expected to moderate as the socialist

[24] De Grauwe and Sénégas (2003)
[25] Bloomberg article

party led by Papandreou just won elections on the grounds of pledges to boost spending and wages. Already in December 2009, the Standard&Poor's rating agency cuts Greece's sovereign rating from A- to BBB+, only three notches above becoming a non-investment grade.

While in January 2010, the default of Greece was not seen as an option and even a financial rescue package was claimed unnecessary, the threat became much more existent already in April 2010, when Standard & Poor's rating agency cut Greece's sovereign rating to the non-investment grade. The set-up of rescue mechanism for countries in financial distress known as the European Financial Stability Facility (EFSF) along with Greece's first bailout package and the implementation of austerity measures followed soon after. Few months after Greece, Ireland becomes the second member state to be granted a bailout package.

In the first half of 2011, the powers of European Financial Stability Facility were expanded in order to be able to buy bonds in primary markets and the emergency loans to Greece were made cheaper and their maturities were extended. As Greece further increases its austerity measures and plans out state assets sales in order to cut the budget deficit to 1% of GDP in 2015,[26] Portugal becomes the third euro-area member state that receives an approval for the bailout in May 2011. Shortly after S&P granted Greece its world-wide lowest sovereign rating of CCC a second bailout package was granted and investors started to be aware that they wouldn't be able to recollect completely their investments in Greek bonds.

Despite Italy's introduction of two austerity packages, S&P downgrades its sovereign debt rating from A+ to A- with a negative outlook in September, Spain suffers one-notch downgrade one month later despite the fact that it had amended its constitution in order to include a commitment to budget-discipline. As the sovereign debt crisis spread, the euro area member states agreed to increase the capacity of EFSF to €1 trillion; another aid package was launched for Greece along with forcing private investors to accept a 50% loss of their investments in Greek bonds.

[26] Bloomberg article

The year 2012 was marked mainly by intensified discussions about reforms concerning restoring fiscal stability, creation of Fiscal compact and designating additional budget to rescue packages. Moreover, Greece was downgraded to selective default by S&P for several months, where Cyprus requested EU bailout. Although EU leaders declared the end of financial crisis already in March 2012 and turn their attention to economic growth, the countries where the sovereign debt crisis took place continue struggling, facing the effects of the huge cuts in their fiscal sectors.

2.3.2. Long-Term Interest Rates

A striking convergence in the long-term nominal interest rates took place until the Maastricht criteria examination period came along and since then, the interest rates stayed tightly together, as can be seen in Figure 3. This drop in sovereign risk premiums has, however, raised doubts about the fiscal discipline of some euro are member countries known for practicing unsound fiscal policies even when paying much higher price for it historically.

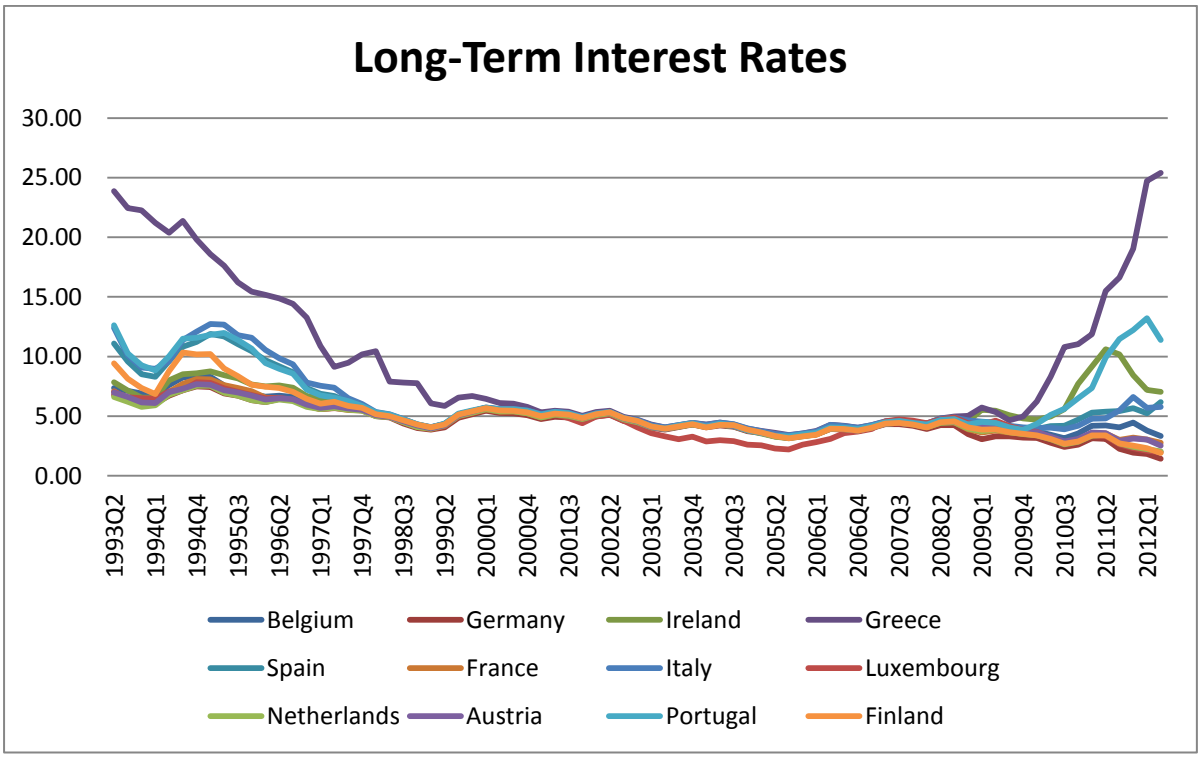

Figure 3: Long-Term Interest Rates, Source: Eurostat, Author

Almost a decade went by since the formation of the EMU, characterized by the long-term interest rates moving close together, but then in the late 2009, fears of debt-servicing problems started to spread which have led to increasingly higher spreads between the

euro area sovereign risk premiums. The direct causes of the spread surge vary from one country to another, while in case of Greece, the most important impulse for the markets was the unveiling of the real extent of its debt and deficit, Ireland for example paved its path to the increase of its sovereign risk premium by extending the guarantee to the banking system.

As Chinn and Frankel (2005) assessed, expected future deficits have a significant effect on the long-term interest rates and so the increase in these rates reflects, among other factors, that the markets do not believe that the countries concerned would be able to take appropriate austerity measures. Moreover, the announcement of planned rescue packages for troubled banks resulted in a transfer of some degree of risk from the private banking sector onto the government and has further increased the expected future deficits.

Furthermore, as several papers suggest,[27] since the end of 2008, the markets have been becoming increasingly more aware of and worried about the possible consequences of irresponsible behavior of both financial and government sector. Consequently, the risk premiums were reassessed higher at a global scale.

2.3.3. Sovereign Debt Rating

The current sovereign debt crisis has been marked by a series of downgrading of sovereign debt credit ratings and widening of the sovereign bond spreads as well as credit default swap spreads. Moreover, the openness and interdependence of the economies as well as the interconnections of the financial markets within the euro area has led to a contagion of debt-servicing distress throughout the euro area even though it originated in just a few countries. The most common negative spillover channel is when a certain bank holds a substantial amount of sovereign debt securities that have been downgraded.[28] This leads to an increase of risk associated with such investment.

The alarming news spreading around resulted also in the downgrading of the sovereign debt ratings in several member states and subsequently, the interest rates of these

[27] See for example Sgherri and Zoli (2009)
[28] Arezki, Candelon and Sy (2011)

problematic countries rose and therefore started to diverge. Figure 4 shows the evolution of the downgrading in time from January 2009 until August 2012 as carried out by Fitch credit rating agency. While the media's attention is drawn mainly towards the troublesome countries (Portugal, Ireland, Italy, Greece and Spain), it is important to note that they are not the only countries that recently suffered a downgrading.

Moreover, it is necessary to say that the euro area countries are not the only ones out of the European Union who are undergoing troubles with meeting their debt obligations as downgrading was seen in Hungary, Latvia and Lithuania as well. Nevertheless, this downgrading took place mostly in 2008 and so it cannot be considered as a result of sovereign debt crisis contagion that is going on in the euro area. Moreover, Latvia and Lithuania already managed to break the trend of downgrading and seem to be recuperating.

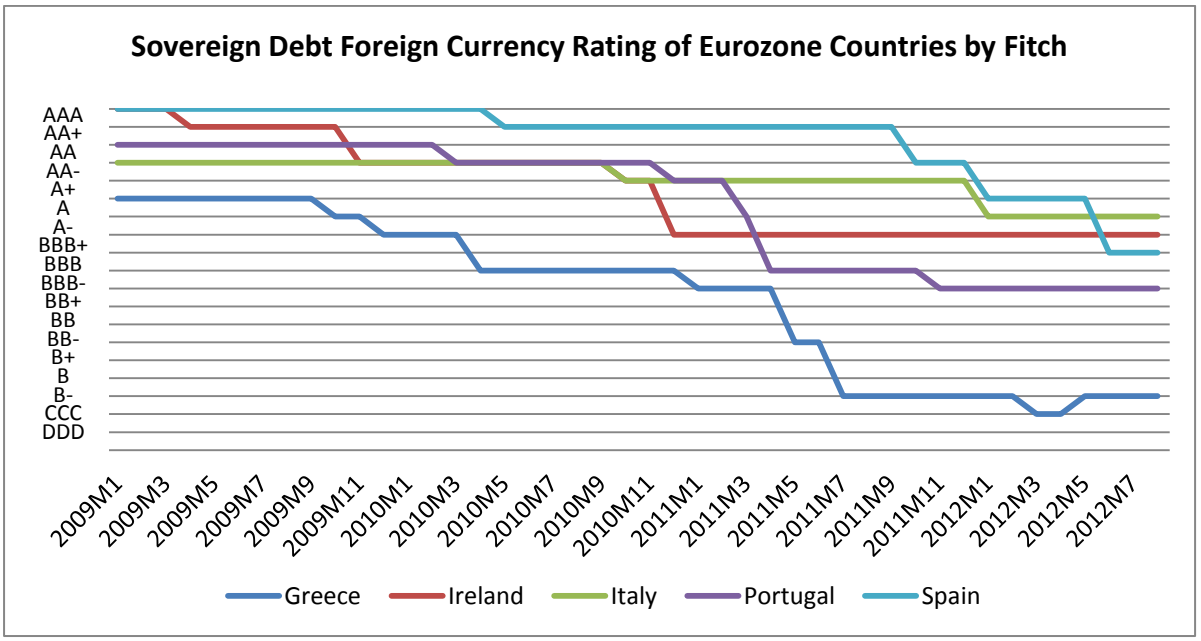

Figure 4: Sovereign Debt Foreign Currency Rating of Euro Area Countries by Fitch, Source: Fitch, Author's Representation

Coming back to the troublesome countries, i.e. Greece, Ireland, Italy, Portugal and Spain, it can be seen that while the permanently highly indebted Italy has so far suffered just a one-notch drop by Fitch, Greece's coming-out led to a series of downgrades that left its long-kept A-rating in the dust. Since the beginning of 2009, Greece has dropped 11 notches down on Fitch's rating scale not only getting itself to the non-investment grade but arriving to CCC-rating where default is seen as a real possibility and "capacity for meeting financial

commitments is solely reliant upon sustained, favorable business or economic developments."[29] Moreover, as already mentioned, it arrived to a selective default rating by S&P in February 2012 and stayed there for several months. Portugal became the second country to fall into the non-investment grade of BB+ at the end of 2011 after his sovereign rating was downgraded several times since 2009 totaling up to 8 notches down.

As indicated by Arezki, R., Candelon, B., and Sy, A., N., R. (2011), some rating announcements, especially those downgrading the sovereign debt rating near speculative grade, which is the case of Greece and Portugal, have proved to lead to a systematic statistically significant spillover effects across other euro area member countries.

2.3.4. Gross Government Debt

The evolution of gross government debt as a percentage of GDP in all the member states of the European Union that do not comply with the 60% debt-to-GDP limit is depicted in Figure 5. These include most of the euro area countries except for Finland, Slovenia, Slovakia, Estonia and Luxembourg plus two non-euro area member states – United Kingdom and Hungary.

The individual bars scaled on the left axis represent the change in debt-to-GDP ratio in three periods of the same length 1999-2003, 2003-2007 and 2007-2011, respectively, whereas the points indicate the level of debt-to-GDP ratio in 2011 on the right-hand-side scale.

It can be seen that basically all countries demonstrate an increase in the debt-to-GDP ratio over this period, which is not surprising considering the mitigation of crisis, nevertheless, the pace at which this is done differs significantly. While the average increase of the debt-to-GDP ratio of the whole European Union is 8.85% from 2008 to 2009 and 5.4% from 2009 to 2010, the problematic countries are demonstrating much higher growth rates. The following countries mark a cumulative growth of more than 20 percentage points in their

[29] Fitch, Sovereign Ratings, Rating Methodology, p.16

debt-to-GDP ratios over the four-year period from the lowest to the highest debt-to-GDP increase: Netherlands, France, Spain, Portugal, United Kingdom, Greece and Ireland.

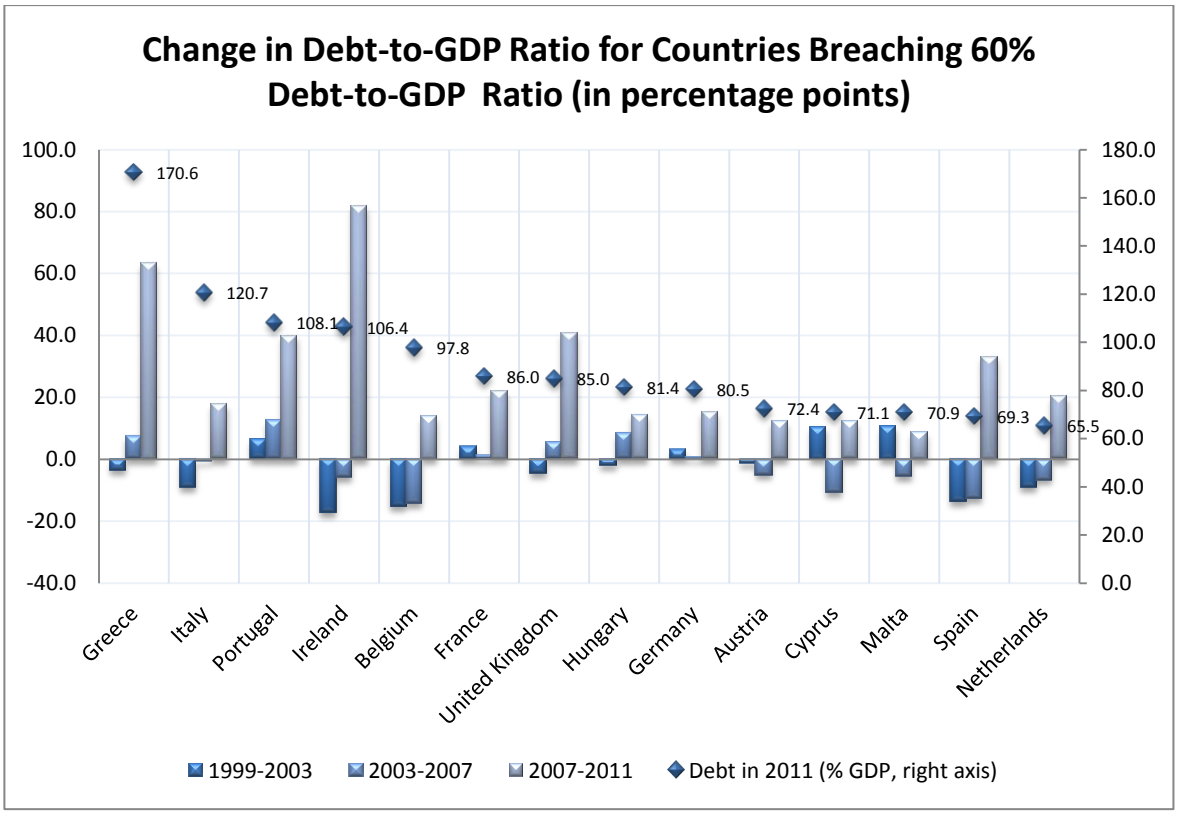

Figure 5: Gross Government Debt (% of GDP), Source: Eurostat

What calls for attention is that while Ireland that demonstrated an increase of more than 80 percentage points of its debt-to-GDP ratio reached an accumulated debt-to-GDP ratio of 106%, the 60 percentage-point increase of Greece's debt-to-GDP ratio left it at whopping 170.6% in cumulative terms.

2.3.5. Deficit

While it is understood that during a period of economic turmoil, such as the recent financial crisis is, the governments tend to proceed to fiscal stimuli of the economy, it is of key importance to reassure the markets that these steps will not undermine the country's fiscal sustainability.

The global financial crisis resulted, apart from the economic activity breakdown, subsequent reduction in tax revenue, rise in unemployment resulting in higher government expenditure, also into stimulus packages of, in many cases, unheard volumes. These stimulus packages led to a sharp increase in most countries' deficits and it may take several

years to bring them down again. In addition to the stimulus packages, many steps were taken to provide guarantee for the liabilities of certain financial institutions in order to preserve their soundness, in some cases even financial injections, purchasing illiquid assets, and recapitalization measures were conducted. Unfortunately such measures led to the fact that Greece, Ireland, Italy, Portugal and Spain were not able to save their faces of sound European economies and the markets just didn't believe that their excessive deficit-to-GDP ratios will not threaten their ability to meet their obligations.

2.4. European Stability Mechanism

In response to increasingly troublesome situation of several euro area economies, in July 2011, the Treaty on Establishing the European Stability Mechanism (ESM) was signed by the financial ministers of the euro area member states. It is previewed to come into force in July 2013 after being ratified at least by signatories that make up 95 % of the total subscriptions by the end of 2012. The European Stability Mechanism is set up to take up the tasks of the provisional institutions of the European Financial Stability Facility (EFSF) and the European Stabilization Mechanism (EFSM).

The Treaty sets up the circumstances under which a loan or credit line may be granted to a member state in severe economic or financial situation that was caused by exceptional events out of the country's control.[30] Moreover, the financial assistance will only be granted if such the country's situation poses a threat to the financial stability of the euro area as a whole. Even though it was only signed by the euro area member countries so far, the mechanism is also open for the EU members outside of the euro area in participating in financial assistance operations. The euro area member states are obliged to participate to a certain extent that is set by a contribution key.[31] Nevertheless, whether such a borrowing mechanism will be able to prevent a similar debt-servicing crisis from happening remains an open question.

[30] Council of the European Union (2010), p.2

[31] A temporary exemption from the contribution obligation can be granted to new euro-area members with a GDP below 75% level of the EU average.

3. Model Specification

This Chapter provides an overview of the methodology used in this thesis. The first approach covers the simple semi-structural model of the economy that is used to derive the output gaps for each member state of the EU27 in quarterly frequency. The second one revisits the methodology of calculating the so-called Optimum Currency Index as originally proposed by Bayoumi and Eichengreen (1997).

3.1. Model Structure

The model is partially based on Bulíř and Hurník (2006) and it consists of several equations representing the crucial relationships of aggregate demand, aggregate supply, uncovered interest rate parity, policy-reaction function, Fisher equation and the real exchange rate formation. The equations are in natural logarithms and the data are in quarterly periodicity if not stated otherwise. All shocks are assumed to be independently and identically distributed with homoskedastic variance σ^2.

The major changes made to the model include introduction of foreign demand, real monetary conditions and real marginal cost. Moreover, unlike in the original paper, this thesis will cover all 27 member states of the European Union.

The aggregate demand is modeled by the IS curve of the following open-economy form:

$$y_t^{gap} = \alpha_1 y_{t-1}^{gap} - \alpha_2 rmci_{t-1} + \alpha_3 y_{t-1}^{*\,gap} + \varepsilon_{y,t} \qquad (1)$$

Where y_t^{gap} is the output gap and y_{t-1}^{gap} is its one-quarter lag, $rmci_{t-1}^{gap}$ is lagged real monetary conditions index, y_{t-1}^{*gap} is the lagged foreign output gap and $\varepsilon_{y,t}$ are disturbances. Moreover, the coefficient α_1 represents the persistence of output gap in time, α_2 captures the weight of lagged real monetary conditions on the output gap and α_3 captures the influence of foreign economy on domestic output gap. Foreign economy is represented by a lagged output gap of the EU27 derived from a seasonally adjusted series of nominal GDP level with the use of Hodrick-Prescott filter.

The real monetary conditions index is taken in its simplest form as a linear combination of real exchange rate gap q_t^{gap} and real interest rate gap r_t^{gap} as follows:

$$rmci_t = \alpha_4(-q_t^{gap}) + (1-\alpha_4)r_t^{gap} \quad (2)$$

The weights reflect the relative effects of the respective real monetary conditions index component on the output gap.

The aggregate supply relationship is modeled by the Phillips curve linking overall inflation to its one-quarter lag, future expected inflation, imported inflation and the real marginal cost:

$$\pi_t = \beta_1[\beta_2\pi_{t-1} + (1-\beta_2)E_t\pi_{t+1}] + (1-\beta_1)\pi_{t-1}^{im} + \beta_3 rmc_{t-1} + \varepsilon_{\pi,t} \quad (3)$$

where π_t is annualized quarter-on-quarter change in the price level, $E_t\pi_{t+1}$ are inflation expectations, π_t^{im} is the rate of growth of import prices, rmc_{t-1} is one-quarter lagged real marginal cost, $\varepsilon_{\pi,t}$ is an exogenous supply shock and $(1-\beta_1)$ represents the weight of imported goods in the consumption basket. The coefficient β_2 reveals how persistent the inflation is and whether the inflation formation is more forward-looking or backward-looking. The larger β_2 is (and implicitly the smaller $1-\beta_2$ is), the larger is the inflation persistence and hence current inflation is more backward-looking than forward-looking.

Unlike its traditional form, the Phillips curve used in this model[32] is based on the real marginal cost rather than the output gap[33] and the real marginal cost is defined as a weighted average of the output gap y_t^{gap} and real exchange rate gap q_t^{gap} as follows:

$$rmc_t = \beta_5 y_t^{gap} + (1-\beta_5) * q_t^{gap} \quad (4)$$

[32] In its simpler version as a weighted average of lagged inflation and real marginal cost, it is often referred to as new Keynesian Phillips curve

[33] See Galí and Gertler (1999)

The imported goods inflation π_t^{im} is assumed to depend on its one-quarter lag π_{t-1}^{im}, lagged foreign inflation and the difference between lagged real appreciation of the exchange rate and lagged real exchange rate trend:

$$\pi_t^{im} = \beta_4 \pi_{t-1}^{im} + (1 - \beta_4)(\Delta s_{t-1} + \pi_{t-1}^{*} - \Delta q_{t-1}^{tnd}) \quad (5)$$

The q-o-q inflation expectations are formed as a weighted average of both the value in the previous period and model-consistent expectations π_{t+1}^{e} developed as rational expectations encompassing all currently available information:

$$E_t \pi_{t+1} = \gamma_1 \pi_{t+1}^{e} + (1 - \gamma_1)\pi_{t-1} \quad (6)$$

Analogically to q-o-q inflation expectations, y-o-y inflation expectations are defined as:

$$E_t \pi_{t+1,4} = \gamma_2 \pi_{t+1,4}^{e} + (1 - \gamma_2)\pi_{t-1,4} \quad (7)$$

where $\pi^{e}_{t+1,4}$ are model-consistent year-on-year inflation expectations and $\pi_{t-1,4}$ is one-period lag of year-on-year inflation rate.

The so called Fisher equation describes the relationship between the nominal interest rate i_t and real interest rate r_t as follows:

$$r_t = i_t - E_t \pi_{t+1,4} \quad (8)$$

where $E_t\pi_{t+1,4}$ are y-o-y inflation expectations.

The uncovered interest parity captures the relationship with the rest of the world and it links the forward-looking change in nominal interest rate Δs_{t+1} with the current change in nominal exchange rate Δs_t, and the nominal interest rate differential that includes domestic and foreign long-term nominal interest rates, i_t and i_t^*, respectively, and nominal risk premium $prem_t$. Moreover, the term $\varepsilon_{\Delta s,t}$ represents the nominal exchange rate shock.

$$\Delta s_{t+1} = \delta_1 \Delta s_t + (1 - \delta_1)(i_t - i_t^{*} - prem_t) + \varepsilon_{\Delta s,t} \quad (9)$$

Almost identical equation is derived for the uncovered interest parity in real terms, nevertheless in this case a shock is not included. This is done because the real exchange rate q_t is linked to the nominal exchange rate s_t via the following identity:

$$q_t = s_t + cpi_t^* - cpi_t \tag{10}$$

where cpi_t^* is foreign price level (represented by overall Harmonized Index of Consumer Prices for EU27) and cpi_t is domestic price level (also represented by Harmonized Index of Consumer Prices but for individual countries) and hence an additional shock is unnecessary.

Analogically, the uncovered interest parity in real terms looks as follows:

$$\Delta q_{t+1}^{tnd} = \delta_t \Delta q_t^{tnd} + (1 - \delta_t)(r_t - r_t^* - prem_t) \tag{11}$$

Policy reaction function takes form of the so-called Taylor rule that links the interest rate to its lag, as well as to the interest rate trend i_t^{tnd}, year-on-year inflation gap $\pi_{t,4}^{gap}$ and the output gap y_t^{gap}. Moreover, the short-term interest rate is also assumed to be influenced by its value in the previous period and its persistence is projected into η_1 and $\varepsilon_{i,t}$ represents a policy shock. Rewriting formally, we get the policy reaction function in the following form:

$$i_t = \eta_1 i_{t-1} + (1 - \eta_1)\left[i_t^{tnd} + \eta_2 \pi_{t,4}^{gap} + \eta_3 y_t^{gap}\right] + \varepsilon_{i,t} \tag{12}$$

The nominal interest rate trend is defined as the real interest rate trend r_t^{tnd} plus the forward-looking year-on-year inflation target $\pi_{t+1,4}^{tar}$:

$$i_t^{tnd} = r_t^{tnd} + \pi_{t+1,4}^{tar} \tag{13}$$

The year-on-year inflation gap is formed by the differential between the model-consistent expected year-on-year inflation in the upcoming period $E\pi_{t+1,4}$ and its deviation from the target rate of inflation $\pi_{t+1,4}^{tar}$:

$$\pi_{t,4}^{gap} = E_t \pi_{t+1,4} - \pi_{t+1,4}^{tar} \tag{14}$$

Moreover, the year-on-year inflation expectations of the upcoming period $E_t\pi_{t+1,4}$ are formed analogically as the quarter-on-quarter inflation expectations that are partially forward-looking and partially backward-looking:

$$E_t\pi_{t+1,4} = \gamma_2\pi^e_{t+1,4} + (1-\gamma_2)\pi_{t-1,4} \quad (15)$$

Where $\pi_{t+1,4}{}^e$ are model-consistent expectations of year-on-year inflation in the next period encompassing all currently available information and $\pi_{t-1,4}$ is year-on-year inflation.

3.2. Observed Variables

In modeling the individual economies, the following variables were taken as observed: real gross domestic product, foreign output gap, nominal exchange rate, domestic nominal interest rate, foreign nominal interest rate, domestic consumer price index and foreign consumer price index. Moreover, for explicitly inflation-targeting economies, the inflation target was also taken as observed. Data for all observed variables were taken from Eurostat in order to ensure consistency in calculation methods across countries, the only exception being the inflation targets that were taken from the respective National Central Banks applying inflation-targeting regime.

The real GDP was calculated using the seasonally unadjusted nominal GDP level in national currency and the seasonally unadjusted GDP deflator price index with the base 2000=100. Once calculated, the real GDP series was adjusted for seasonality using the X12.

The foreign output gap was also derived from calculating first the real GDP of the EU27 using the series of seasonally unadjusted aggregate nominal GDP level and the corresponding GDP deflator price index 2000=100. Subsequently, seasonal adjustment was made and the output gap was obtained with the use of Hodrick-Prescott filter.

It can be argued that including the foreign output gap for the EU27 along with the lagged domestic output gap aggregate demand equation is not ideal, especially for the largest economies of Germany, France, Great Britain or Italy that have a high weight in the aggregate GDP of EU27 (as of 2011 20.5%, 15.8%, 13.8% and 12.5%, respectively). Some

could object that the rest of the world should be also modeled with respect to China, US or Russia. However, considering that in 2011 the imports from extra-EU27 partners represented only 16% of EU27 aggregate GDP and the exports towards these countries accounted for 14% of the same, disregarding the influence of extra-EU27 trade partners into the domestic economy is not an exaggerated simplification.[34]

The nominal exchange rate is expressed as the average cost of 1 euro[35] in terms of domestic currency. This implies that for the euro area countries, the nominal exchange rate was fixed once the euro replaced the individual currencies in its role of the country's official currency. However, the real exchange rates remain variable due to the inflation discrepancies across the euro area member states. The nominal exchange rate was fixed against the euro on January 1, 1999 for all original members of the euro area, i.e. Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. Subsequently, Greece fixed its currency against the euro as of January 1, 2001, Slovenia in 2007, followed by Malta and Cyprus in 2008 and Slovakia in 2009. While the euro has not officially replaced the Estonian Kroon until 2011, its nominal exchange rate was fixed against the euro already since the beginning of 1999 applying a monetary policy based on the fixed-exchange rate system.

The reference interest rates on the interbank deposit market with 3-month maturity in each country were taken as the short-term nominal interest rates. Analogously to taking an aggregate EU27 output gap as representation of foreign economy, the benchmark rate for euro money market, the Euro Inter Bank Offered Rate (EURIBOR), is used as a proxy for foreign nominal interest rate. Among the contributors to EURIBOR, there are not only banks with their headquarters within the euro area countries but all large banks with the largest volume of business in the euro area money markets both from the EU countries and large international banks from non-EU countries that have important euro area operations.

[34] Exports from the extra-EU27 countries accounted in 2011 for 17%of domestic GDP in case of Germany, 8% for France, 10% for Italy, and 10% for the Great Britain, whereas imports towards these countries equaled 13% of domestic GDP, 8% for France, 12% for Italy and 14% for the Great Britain.
[35] Or the European Currency Unit (ECU) until it was replaced by the euro on January 1, 1999.

The EURIBOR rate serves at the same time as the domestic nominal interest rate for the euro area countries and hence in their case, the interest rate differential between the domestic and foreign interest rate is equal to zero. For the countries outside of the euro area, a comparable 3m Interbank Offered Rate or "IBOR" was used. The IBORs are the benchmark or reference rates for the short-term interest rates and they reflect the average rate at which interbank term deposits are offered from one prime bank to another in a given money market. These are London Interbank Offered Rate (LIBOR) in case of Great Britain, Prague Interbank Offered Rate (PRIBOR) for the Czech Republic or Copenhagen Interbank Offered Rate (CIBOR) for Denmark, etc.

One can object that it would be preferable to use the monetary policy rate instead of the interbank benchmark interest rate. Nevertheless, as the Central Banks do not use exactly the same instruments to implement their monetary policy and the key instruments even change over the course of time,[36] the author chose to use a more comparable rate such as the interbank interest rate. Moreover, almost the majority of theories on the monetary transmission mechanism agree that the Central Banks can control the money market real interest rates[37] and hence they reflect to a certain degree, besides the demand and supply conditions on the interbank market, also the stance of monetary policy.

Both domestic and foreign consumer price index was taken from Eurostat as the so-called Harmonized Index of Consumer Prices (HICP) with the year 2005 as a base. The HICPs reported give a comparable measure of inflation in the individual countries, as well as in the EU27 as a whole. Both domestic and foreign consumer price indices were adjusted for seasonality with the use of X12 ARIMA.

[36] For example, the Bank of England reported the so-called Minimum Band 1 Dealing Rate in the period 1981-1996 as its base rate, since 1997, it switched to reporting the Repo Rate but only until 2006 when once again, the base rate changed its definition as the so-called Official Bank Rate began to serve as the monetary policy key interest rate. While Minimum Band 1 Dealing Rate was the minimum published rate at which the Bank of England discounted bills to relieve money market shortages, the Repo Rate is the interest rate set on the refinancing operations and the Official Bank Rate is the interest rate paid on commercial bank reserves.

[37] Nevertheless, there is a disagreement on the process through which a change in the monetary policy can alter the behavior of the economic agents – households and firms.

Even though the real exchange rate is not directly observable, it is linked to the nominal exchange rate via the following identity where all the right-hand side variables are observable and hence the real exchange rate is observed as well:

$$q_t = s_t + cpi_t^* - cpi_t \tag{16}$$

The inflation target is also taken as an observable variable for those countries where the inflation-targeting is applied, in other words where the Central Bank explicitly sets a quantitative inflation target. These countries include the Czech Republic (since 1998), Hungary (since 2001), Poland (since 1999), Sweden (since 1993), United Kingdom and also the countries within the euro area where the European Central Bank sets a common inflation target for all member states. The data on inflation target were collected from the corresponding Central Banks.[38]

3.3. Unobserved Variables

Most of the unobserved variables are modeled using an AR process. The time series covering the domestic economy's domestic output, real exchange rate and real interest rate are decomposed into a trend and a gap as follows:

$$y_t = y_t^{tnd} + y_t^{gap} \tag{17}$$

$$q_t = q_t^{tnd} + q_t^{gap} \tag{18}$$

$$r_t = r_t^{tnd} + r_t^{gap} \tag{19}$$

The trend in output growth, the real depreciation trend and the real interest rate trend are modeled using the AR process around a constant steady state that is based on the historical average of the output growth and real depreciation and in the case of real interest rate its steady state is derived mainly from the last observed values.

[38] Česká národní banka (Czech Republic), Magyar Nemzeti Bank (Hungary), Narodowy Bank Polski (Poland), Bank of England (Great Britain), Sveriges Riksbank (Sweden) and European Central Bank (euro area), respectively.

The AR processes thus can be written in the following way:

$$\Delta y_t^{tnd} = \theta_1 \Delta y_{t-1}^{tnd} + (1-\theta_1) ss_{\Delta y^{tnd}} + \varepsilon_{t,\Delta y^{tnd}} \quad (20)$$

$$\Delta q_t^{tnd} = \theta_2 \Delta q_{t-1}^{tnd} + (1-\theta_2) ss_{\Delta q^{tnd}} + \varepsilon_{t,\Delta q^{tnd}} \quad (21)$$

$$r_t^{tnd} = \theta_3 r_{t-1}^{tnd} + (1-\theta_3) ss_{r^{tnd}} + \varepsilon_{t,r^{tnd}} \quad (22)$$

Apart from the variables mentioned above, the AR process with a constant is also used to model the inflation target for those countries, where it is not directly observable, i.e. the countries that do not have the inflation-targeting monetary policy. These countries are Bulgaria, Denmark, Latvia, Lithuania and Romania. Moreover, the AR process is also used to model the inflation target for those countries that have joined the euro area later on and were not among the original members. The period prior to its accession to the euro area is modeled for Greece (until 2000), Slovenia (until 2006), Cyprus (until 2007), Malta (until 2007), Slovakia (until 2008) and Estonia (until 2010) as follows:

$$\pi_{t,4}^{tar} = \theta_4 \pi_{t-1,4}^{tar} + (1-\theta_4) ss_{\pi^{tar}} + \varepsilon_{t,\pi^{tar}} \quad (23)$$

Similarly to the domestic economy, the necessary variables of the foreign block, represented by foreign inflation, foreign nominal interest rate, foreign real interest rate trend and the foreign output gap, are modeled using the following AR processes:

$$\pi_t^* = \theta_5 \pi_{t-1}^* + (1-\theta_5) ss_{\pi^*} + \varepsilon_{t,\pi^*} \quad (24)$$

$$i_t^* = \theta_6 i_{t-1}^* + (1-\theta_6) ss_{i^*} + \varepsilon_{t,i^*} \quad (25)$$

$$r_t^{*\,tnd} = \theta_7 r_{t-1}^{*\,tnd} + (1-\theta_7) ss_{r^{*}\,tnd} + \varepsilon_{t,r^{*}\,tnd} \quad (26)$$

$$y_t^{*\,gap} = \theta_8 y_{t-1}^{*\,gap} + (1-\theta_8) ss_{y^{*}gap} + \varepsilon_{t,\Delta y^{*}gap} \quad (27)$$

The following Chapter will provide a methodology overview applied on this model and Appendix A provides the model specification for Matlab.

4. Methodology

This Section provides a brief overview of methodology used for both the Kalman filtration applied to the model described in Chapter 3 and the calculation of the OCA index.

4.1. Model calibration

Prior to the application of the Kalman filter, the parameters of the model were calibrated to be country-specific with the use of the maximum penalized (regularized) likelihood estimation method.

The advantage of using this method of parameter estimation is that it permits the use of information carried by the data even in cases when the model lacks identification which results into a log-normal distribution of the likelihood function being so flat that its extremes cannot be found or the estimate is not robust. Regularizing the likelihood function with the use of quadratic penalty function can solve such issue.[39] The penalty is imposed once a parameter estimate deviates from a set prior.

Compared to similar Bayesian estimates, the implementation of the maximum penalized likelihood estimation method is much simpler and more intuitive but on the other hand, it does not allow us to work with other than normal distributions of the parameters. Nevertheless, the major pitfall of this technique is that both the prior selection and the definition of parameter bands are to a large degree arbitrary and it can influence the results quite significantly.

[39] Beneš and Fukač (2008)

4.2. Kalman Filtering

The Kalman filter is a recursive predictive filter that provides a means for inferring information from measurements disturbed by some noise, generally assumed as white noise. To improve the estimated state of a linear dynamic system, the Kalman filter uses measurements that are related to the state but disturbed as well.[40]

Since its formulation in 1960 by R.E.Kalman, the Kalman filter has been widely used in a broad range of fields from navigation and weather science to manufacturing and others due to its ability to estimate the past, present and even future states without knowing the precise nature of the modeled system.[41]

The main advantages related to the Kalman filtering are its ability to solve a structural model, since it is a multivariate filter, the ease of application and the possibility to estimate even unobserved states. On the other hand, the process of a model specification and its calibration makes the implementation of this method more difficult when compared to univariate filters.

The Kalman filter comprises two steps:

1. The prediction
2. The correction

While in the first step the state is predicted with the use of a dynamic model, the correction step consists of minimization of the error covariance of the estimator using the observation model.[42] Once these two steps are done for the whole series, the output is smoothed.

[40] Kleinbauer (2004)
[41] Welch and Bishop (2006)
[42] Kleinbauer (2004)

Let us assume a general problem of trying to estimate the state $x \in \Re^n$ of a controlled process determined by the following linear stochastic difference equation:

$$x_k = Ax_{k-1} + Bu_{k-1} + \varepsilon_{x,k-1} \tag{28}$$

where A is (n x n) matrix relating the state at time k-1 to the state at current time k, B is a (n x l) matrix relating the control input $u_{k-1} \in \Re^l$ to the state x_k.

Moreover, let us define the measurement $z_k \in \Re^m$ as follows:

$$z_k = Hx_k + \varepsilon_{z,k} \tag{29}$$

where H is a (m x n) matrix relating the state x_k to the measurement z_k at current time k.[43]

The disturbances $\varepsilon_{x,t}$ and $\varepsilon_{z,k}$ are random variables where $\varepsilon_{x,t}$ represents the process noise and $\varepsilon_{z,k}$ represents the measurement noise. They are assumed to be independent and identically distributed with the following normal probability distributions:

$$p(\varepsilon_{x,t}) \sim N(0, Q) \tag{30}$$

$$p(\varepsilon_{z,t}) \sim N(0, R) \tag{31}$$

where Q is the covariance matrix of process noise in the system state dynamics and Q is the covariance matrix of measurement uncertainty.[44]

Since the certainty of the measurements is often difficult to assess with precision, it is common to discuss the filter's behavior in terms of so-called Kalman gain, a function of relative certainty of the measurement compared to the current state estimate:

$$K_k = P_k H^T (HP_k H^T + R)^{-1} \tag{32}$$

The higher the Kalman gain is, the more weight is placed on the measurement and vice versa.

[43] Welch and Bishop (2006)
[44] Andrews and Grewal (2008)

The measurement vector z_k contains all observed variables as defined in Section 3.2., i.e. real gross domestic product, foreign output gap, nominal exchange rate, domestic nominal interest rate, foreign nominal interest rate, domestic consumer price index, foreign consumer price index and inflation target. The state vector includes all the variables specified in Appendix A: Transition Variables.

A schematic representation of how the Kalman filter works is depicted in Figure 6:

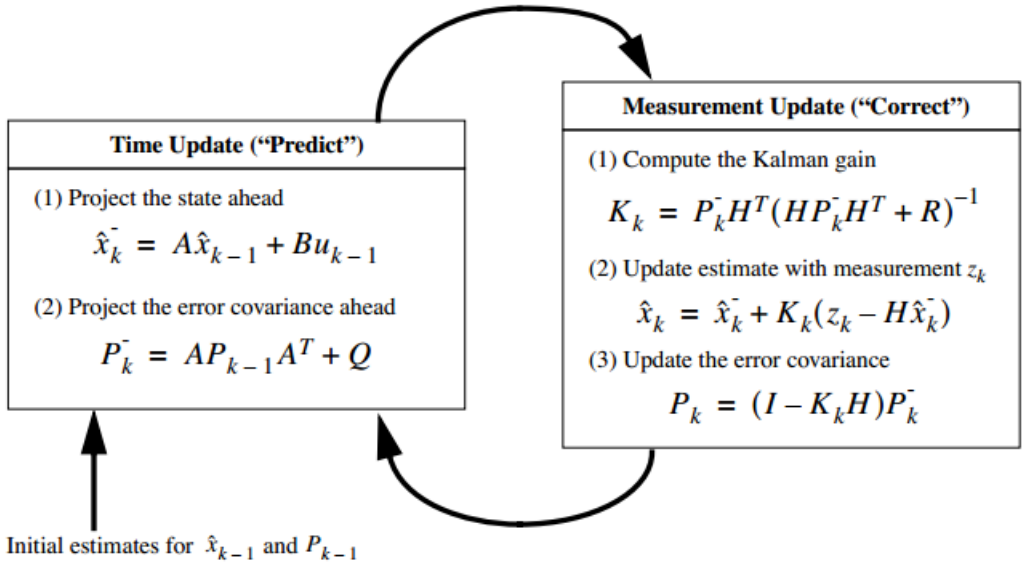

Figure 6: Schematic Representation of the Kalman Filter Operation, Source: Welch and Bishop (2006)

The filtration range goes from 1998Q1 to 2012Q2 and the software used for both the parameter estimation and the Kalman filtration was Matlab R2010a along with IRIS Toolbox. For codes please refer to Appendix E and the enclosed CD-ROM. The Kalman filtration results of individual countries are presented in Appendix C.

4.3. Optimum Currency Area Index

The theoretical foundations of currency unions mostly engage in trying to specify the common characteristics that the prospective members of monetary union should share in order to create a well-functioning union. The broad array of literature on this topic mostly covers the so-called Optimum Currency Area (OCA) pioneered by Mundel (1961) and amplified by the seminal contributions of McKinnon (1963) and Kenen (1969). While subsequently to these works, there has been a slowdown in research on this topic, the interest in OCA theory was restored in 1990s when steps towards the formation of EMU

were taken. At this time, Tavlas (1993) and Bayoumi and Eichengreen (1997) helped shape up the theory and make it operational not only in qualitative but also in a quantifiable way.

Traditionally, the theory is based on factor mobility, price and wage flexibility, diversification in tradable sector, degree of economy's openness, effectiveness of monetary policy, inflation differentials and the character (symmetric or asymmetric) of shocks that the economy is exposed to, all with respect to other prospective members of a currency union. Moreover, many contributors have added other variables they found appropriate as well.

Following the methodology proposed by Bayoumi and Eichengreen (1997), the OCA index will be calculated as the estimated value of the standard deviation of the change in the logarithm of the bilateral exchange rate based on the following equation:

$$\mathrm{SD}(\mathrm{e_{ij}}) = \alpha + \beta_1 \mathrm{SDY} + \beta_2 \mathrm{DISSIM_{ij}} + \beta_3 \mathrm{TRADE_{ij}} + \beta_4 \mathrm{SIZE_{ij}} \quad (33)$$

The individual variables used are defined in Table 1, along with specification of the data source:

Variable	Data Source	Definition
$\boldsymbol{SD(e_{ij})}$	-	Standard deviation of the change in the logarithm of the bilateral exchange rate between i and j
$\boldsymbol{SDY}$	Eurostat	Standard deviation of the difference of the change in the logarithm of real GDP between i and j
$\boldsymbol{DISSIM_{ij}}$	Eurostat	Sum of the absolute differences in the shares of agricultural, mineral and manufacturing trade in total trade
$\boldsymbol{TRADE_{ij}}$	Direction of Trade Statistics (DOTS, IMF)	Mean of the ratio of bilateral exports to domestic GDP for i and j
$\boldsymbol{SIZE_{ij}}$	IMF World Economic Outlook Database (April 2012)	Mean of logarithm of the two GDPs in USD

Table 1: Overview of OCA Index Variables, Source: Bayoumi and Eichengreen (1997), author's representation

The coefficients originally estimated by Bayoumi and Eichengreen (1997) are as follows:

$$\mathrm{SD}(\mathrm{e_{ij}}) = -0.09 + 1.46 * \mathrm{SD}(\Delta \mathrm{y_i} - \Delta \mathrm{y_j}) + 0.022 * \mathrm{DISIM_{ij}} - 0.054 * \mathrm{TRADE_{ij}} + 0.012 * \mathrm{SIZE_{ij}} \quad (34)$$

As in Cincibuch and Vávra (2000), this relationship will be assumed as stable and it will be used for the calculation of the OCA index, I.e. the appropriateness of common currency between a pair of countries. For this purpose, two benchmark countries will be established: Germany and Italy.

According to Frankel and Rose (1997), some of the OCA criteria are endogenous and hence if a country enters a monetary union, the increased integration between its members will lead the country to meeting the OCA criteria ex post even if it wasn't fulfilling them in ex ante analysis. Given that prior to the creation of monetary union, Bayoumi and Eichengreen (1997) evaluated several countries as unfit to form a monetary union with Germany and yet they were included in the newly emerged union, it seems to be a good opportunity to revisit the OCA criteria for the ex post analysis and assess whether the suggestions of Frankel and Rose (1997) hold.

5. Discussion of the Results

In this Chapter, the results obtained from the Kalman filtration will be discussed along with the conclusions that can be drawn from calculation of the Optimum Currency Area index. Both the Kalman filtration and the OCA Index calculation will be first presented for the euro area member states with the aim to identify countries that are not optimally harmonized with the remainder of monetary union and subsequently for the non-euro area member states of EU27 with the goal to assess which countries could, in return, function well with the euro area. Furthermore, it will be assessed whether the euro area outlier countries could form a successful monetary union with some of the non-euro area member states.

For methodology description please refer to Chapter 3 and for decomposed results of the Kalman filtration by country see Appendix C. Throughout this Chapter, the discussion of results will focus on the following three time periods: 1998Q2-2002Q4 (denoted P1), 2003Q1-2007Q3 (denoted P2) and 2007Q4-2012Q2 (denoted P3), in order to be able to assess their evolution over time and especially, analyze the effects that the sovereign crisis has had on the individual member states.

5.1. Alignment of Business Cycles

Although a vast array of criteria, that need to be fulfilled in order to attain a successful formation and subsequent functioning of a monetary union, have emerged from the research field, especially since the planning of the EMU had started, probably one of the most important ones is the alignment of business cycles. The alignment of business cycles is the key condition that should be met in order to have the uniform monetary policy functioning efficiently without creating any political and economic unrest.

The evolution in the output gap harmonization since the first quarter of 1999 until the second quarter of 2012, both for the real-time composition of the euro area[45] and for the original 11 member states throughout the whole sample, is depicted in Figure 7. Moreover, the series of standard deviation of output gaps across the euro area original member states

[45] Since 1999 it was Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. In 2001 Greece was added, followed by Slovenia in 2007, Cyprus and Malta in 2008, Slovakia in 2009 and finally Estonia in 2011.

along with Greece, called the euro area 12 (EA12), is added since 2007Q1. This provides for a comparison of how the alignment of business cycles was affected by the accession of new member states and moreover, it will let us assess the impact of Greek economy that was hit very hard by the financial crisis subsequently resulting into the sovereign debt crisis.

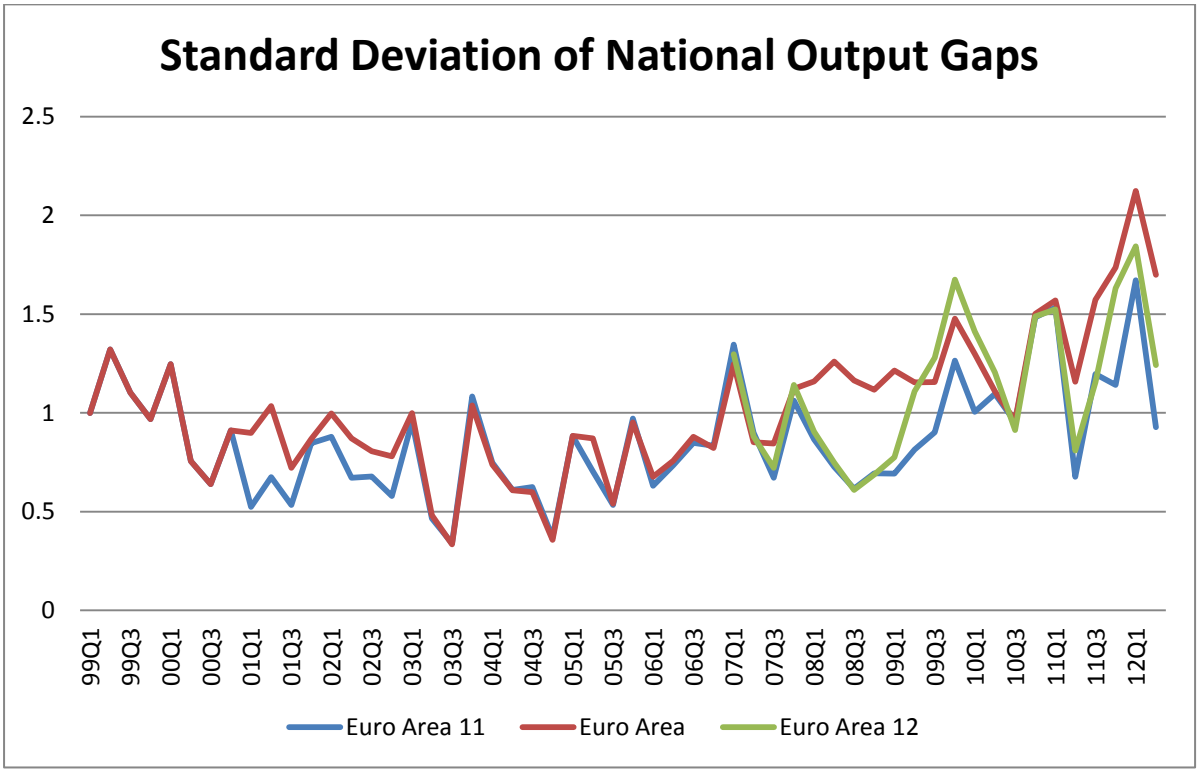

Figure 7: Standard Deviation of Output Gaps, Source: Author's Calculations

It can be noted that the accession waves have almost always led to an increase in the dispersion of business cycles across countries, measured as the standard deviation across the national output gaps, the increase being the most marked for the period 2008-2009 when the total of three countries (Cyprus, Malta and Slovakia) have entered the euro area. It can also be noted that Greece's accession to the monetary union had only a temporary deteriorating effect on the business cycle alignment as in the period 2003-2007, that is prior to Slovenia's accession, the two aggregates behaved almost in unison.

This supports the argumentation of Frankel and Rose (1997) that the membership in a monetary union alone can lead to business cycles synchronization among the participating countries. Nevertheless, as the crisis unleashed, the aggregate euro area 12 became associated with higher dispersion of the output gaps than the euro area 11 aggregate,

meaning that there has been an asymmetric impact of the crisis on Greece compared to the remainder of the original euro area member states and hence, the membership in a monetary union does not mean that periods of business cycle misalignment would seize to exist as suggested by Frankel and Rose.

As far as the overall output gap dispersion is concerned, it can be noted that starting after the period 2003-2004 that was associated with the lowest average business cycle disharmony since the launch of the monetary union, there has been a clear increasing trend of business cycle misalignment across all three aggregates.

Seeing how Greece was exposed to the asymmetric impact of the crisis raises question about what other countries of the euro area were influenced differently than the euro area average. Figure 8 helps answering this question since it provides the correlation coefficient of the business cycles between the individual euro area member states and the euro area average output gap for three different periods of the same length of 19 quarters.

The three periods covered are 1998Q2-2002Q4, 2003Q1-2007Q3 and 2007Q4-2012Q2. The period of 1998Q2-2002Q4 represents a transition period when the exchange rates were irrevocably fixed, Greece joined the monetary union and the physical launch of euro coins and banknotes took place. The second period represents a phase of already stable functioning of the monetary union, only with Slovenia joining the union in 2007Q1 which, according to Figure 7, did not cause much of a shock to alignment of the euro area business cycles. Contrarily, the last period of 2007Q4-2012Q2 is mainly characterized by four new members joining the monetary union, spreading of the economic and financial crisis, resulting into the sovereign debt crisis in some of the countries, namely Greece, Ireland, Italy, Spain and Portugal.[46]

[46] However, other countries have also passed fiscal stabilization packages (France for example).

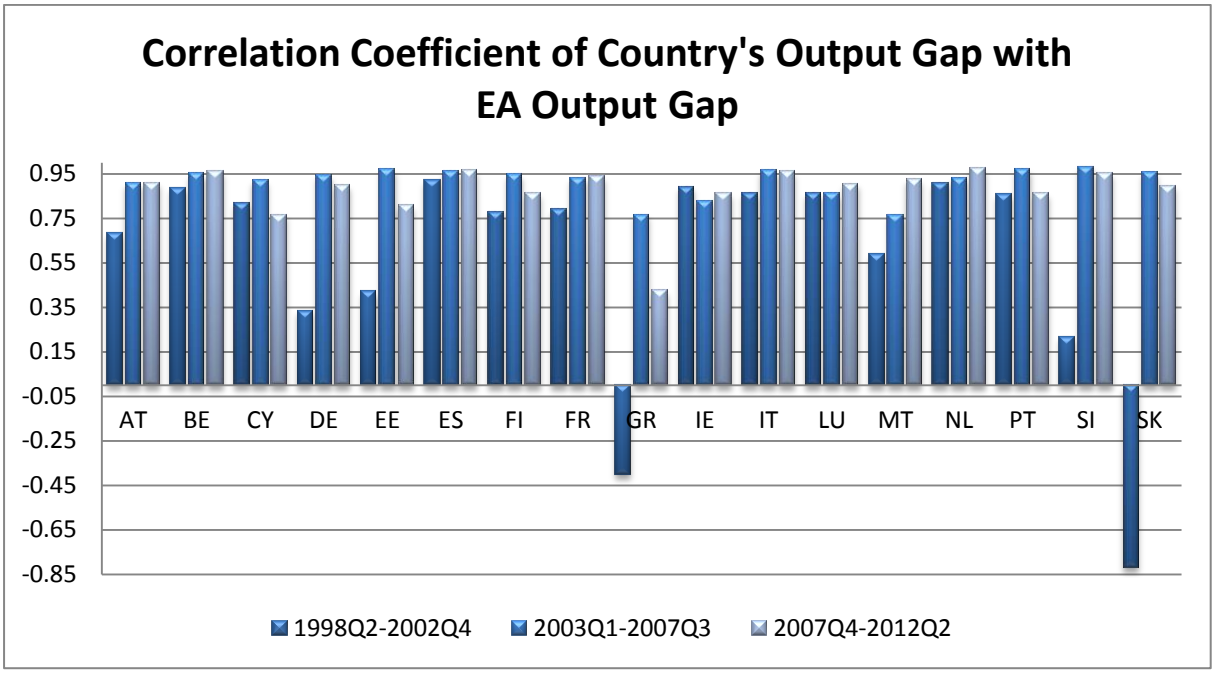

Figure 8: Correlation Coefficient of Country's Output Gap with EA Output Gap, Source: Author's Calculations

Given the simplifications of the model used and the calibrated values of individual parameters, Figure 8 shows that while all countries except for Ireland, Luxembourg and Netherlands, (that have shown a high degree of output gap alignment with the EA average already in the first period) have experienced a rather significant increase in harmonization of the business cycles in the period 2003Q1-2007Q3 when compared to the period 1998Q2-2002Q4[47], the financial crisis and subsequent sovereign debt crisis led to a drop in the output gap correlation coefficients of some countries as they were affected by the turmoil in a different way than the euro area average. These countries are Cyprus, Germany, Estonia, Finland, Greece, Portugal, Slovenia and Slovakia.

In order to find the two or more groups of countries that could function well together even in the turmoil period without showing signs of the output gap misalignments, let us assess the correlation coefficients of the national output gaps and two large but rather different economies: Germany and Italy. While Germany has been always considered as a benchmark economy not only due its size but also thanks to its macroeconomic stability, low unemployment levels and low inflation rates, Italy will be taken as its antipole since it is also a large economy but with similarities to other Southern, often called peripheral,

[47] Slovakia's correlation coefficient is negative for the period of 1998Q2-2002Q4 due to a banking system crisis that unleashed in 1999.

economies and hence can represent a good alternative benchmark. Figure 9 groups the countries with higher correlation coefficient with Germany's output gap than with the Italian one and Figure 10 includes countries that have it vice versa.

It is not too surprising that most of the financially distressed countries from the euro area 12[48] are not included in Figure 9. In other words, Greece, Ireland, Portugal and Spain have a better alignment with Italy's output gap. Moreover, Italy is not included as it is taken as the alternative benchmark economy and Belgium, France, Luxembourg and Netherlands have almost the same value of correlation coefficient with respect to Germany and Italy in the last period. As far as the period of stability (2003Q1-2007Q3) is concerned, both countries show higher degree of business cycles alignment with Italy rather than Germany and hence could possibly belong to the alternative monetary union.

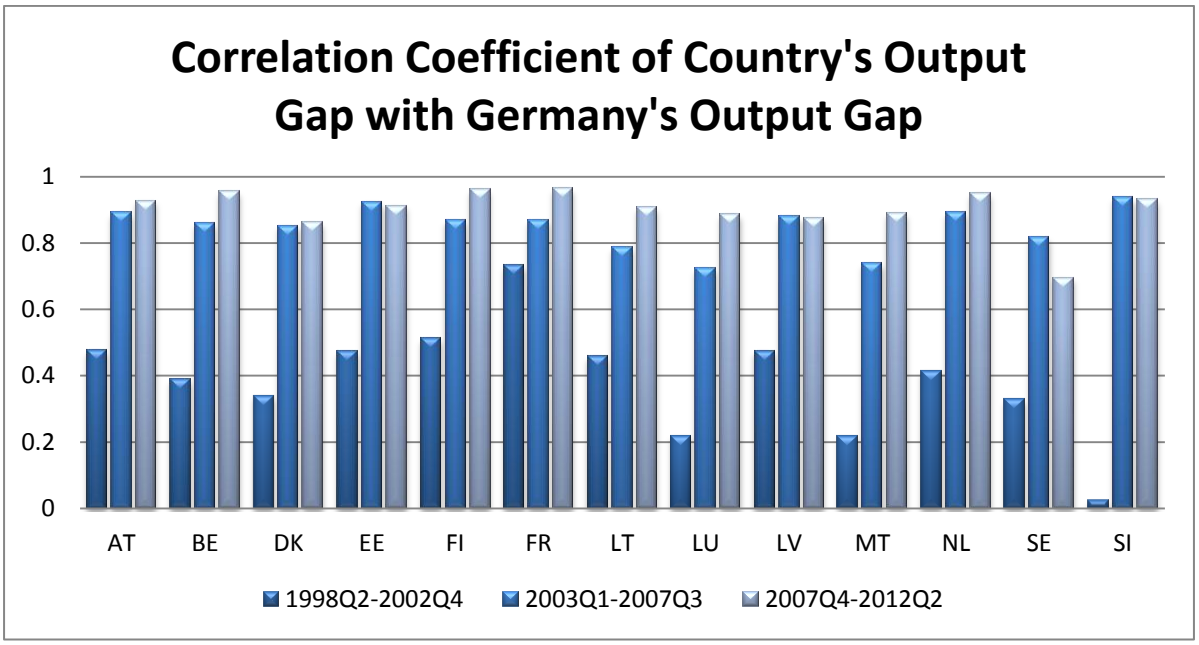

Figure 9: Correlation Coefficient of Country's Output Gap with Germany's Output Gap, Source: Author's Calculations

Out of the euro area newcomers, Cyprus and Slovakia have a better alignment with Italy, whereas Estonia and Slovenia show a larger harmonization with German economy. Malta, on the other hand, could function well in either monetary union as the harmonization pattern towards Italy is almost the same as towards Germany.

[48] That is original member states along with Greece.

As far as the non-euro area EU members are concerned, Latvia and Lithuania seem to be improving their output gap harmonization sufficiently in order to join their Baltic neighbor Estonia in the Germany-based monetary union and so could Denmark, if it were to withdraw its opt-out, along with Sweden. Overall, it can be concluded that almost all of the countries depicted in Figure 9 have demonstrated a process of the output gap harmonization with respect to Germany over the three periods and most importantly, the built-up business cycles alignment remains stable or even increases further in a period of downturn, meaning that there really could be a uniform monetary policy applied without creating unwanted political and economic pressures stemming from different national economies' needs.

The alternative group of countries that could form a monetary union centered on the Italian economy is depicted in Figure 10, including those countries that were identified as possibly functioning in either of the unions (Belgium, France, Luxembourg, Malta and Netherlands).

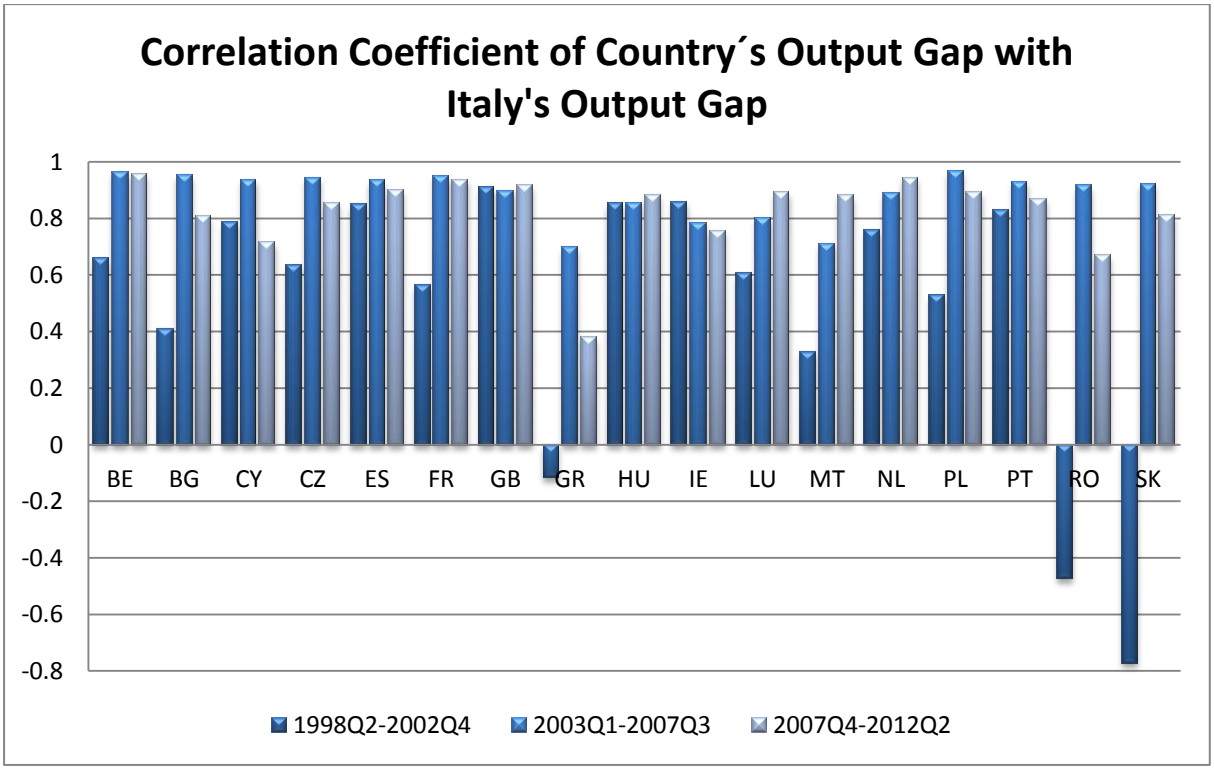

Figure 10: Correlation Coefficient of Country's Output Gap with Italy's Output Gap, Source: Author's Calculations

As can be seen in Figure 10, the output gap alignment with Italy is not as profound and increasing as in case of Germany. Nevertheless, if an arbitrary rule is applied on the

average of correlation coefficients in the last two periods, then the decision-making is made much easier. Assuming that an average correlation coefficient of 0.85 represents a sufficient alignment of output gaps over the three periods, then the Italy-bound monetary union could include Belgium, Bulgaria, Czech Republic, France, Great Britain (once again, if it would be willing to opt in), Hungary, Luxembourg, Poland, Portugal, Spain and Slovakia.

Applying the same criterion on the first group of countries, the German-based monetary union would include Austria, Denmark, Estonia, Finland, Latvia, Lithuania, Netherlands and Slovenia. This means that Cyprus, Greece, Ireland, Malta, Romania and Sweden would not form a monetary union with either benchmark economies if such arbitrary rule is applied.

Nevertheless, apart from alignment of business cycles, alternative criteria of inflation differentials and the OCA index will be assessed in the following Sections. The results will be summed up in Section 5.4.

5.2. Inflation Differentials

One of the key characteristics of a currency union is that the level of nominal exchange rates of participating currencies becomes fixed at a certain point of time with respect to the common currency introduced. A higher inflation in one member state then leads to a real exchange rate appreciation in the individual state and that can lead to a drop in its competitiveness and increase its external deficit.[49] Moreover, significant inflation differentials and especially, different inflation expectations, across member states of a monetary union may result in the uniform monetary policy functioning sub-optimally for individual member states and hence creating political and economic pressures.

As discussed in Chapter 2, the Maastricht criteria included an inflation criterion targeted at avoiding the adverse effects of inflation differentials by harmonization of inflation rates prior to the formation of the currency union and the introduction of common monetary policy. As many studies point out, there has been a sharp convergence in the national

[49] Courdert, V., Couharde, C., Mignon, V. (2012)

inflation rates across the prospective euro area member states in the 1990s, reaching their all-time low inflation dispersion already in 1999[50] when the monetary union formally came to life. Since then, the remaining disparities in inflation rates seem to be quite persistent. As can be seen in Figure 11, the inflation dispersion across the euro area member states has a constant trend on the whole time range of 1991Q1-2012Q2, showing neither significant harmonization in inflation rates nor the opposite tendency.

Nevertheless, the events of new member states' accession of to the monetary union,[51] the outbreak of the financial crisis in 2008 and subsequent sovereign debt crisis have led to an increase in the unweighted standard deviation of y-o-y inflation across the euro area. While the accession of new members to the euro area has led to higher inflation dispersion across the new aggregate than across the original member states (difference between red and blue line in Figure 11), the commencement of the financial crisis and subsequent unleashing of the sovereign debt crisis have resulted in higher inflation differentials in both of them, falling back to their pre-crisis levels after reaching their peak in 2010Q2.

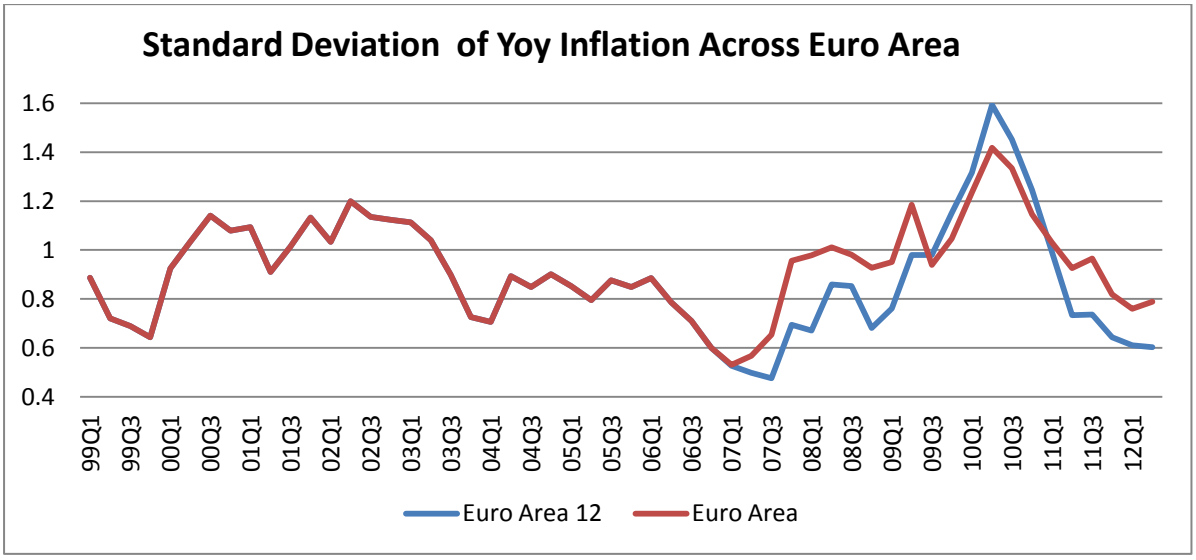

Figure 11: Standard Deviation of Yoy Inflation Across Euro Area, Source: Eurostat, Author's Calculations

Figure 12 provides an overview of the evolution in inflation differentials from the euro area unweighted average across individual countries and across the same three time periods specified in the previous Section. These periods are 1998Q2-2002Q4 denoted in Figure 12

[50] The unweighted standard deviation of national inflation rates were brought to 1% in 1999, down from 6% in 1991. See: Angeloni, I., Ehrmann, M. (2004)
[51] In 2007, 2008, 2009 and 2011.

as P1, period P2 covering 2003Q1-2007Q3 and the period of 2007Q4-2012Q2 denoted P3. While the points represent the average value of inflation differential for a given country and time period, the connecting lines run from its minimum to its maximum value.

Analyzing Figure 12 more closely, it can be seen that many of the countries have either systematically positive or negative inflation differential vis-à-vis the euro area average. Austria, Germany and France can be characterized by very stable prices as their inflation differentials with respect to EA average remained negative on average throughout the three time periods. On the contrary, the newcomers Cyprus, Estonia, Slovenia and Slovakia have had a persistent positive inflation differential on average in all three periods. Nevertheless, in case of Slovenia and Slovakia, there has been a significant stabilization of prices and the subsequent reduction in the size of their inflation differential with respect to the euro area average, dropping from more than 5 percentage points in the first period to less than 0.5 of a percentage point in the last period.

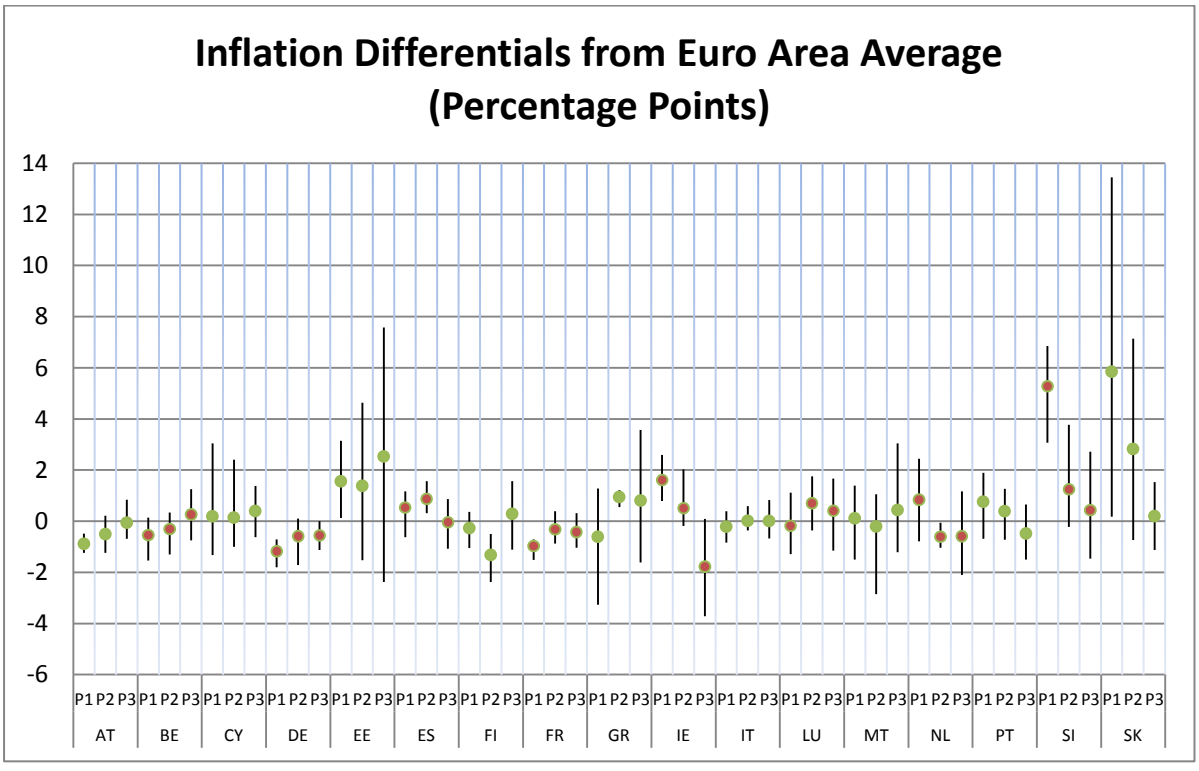

Figure 12: Evolution of Inflation Differentials from Euro Area Average, Source: Eurostat, Author's Calculations

While the remainder of the countries did not have a systematically positive or negative inflation differential in all three periods, Italy, Luxembourg, Malta, Netherlands, Portugal and Spain at least did not recede too much from the euro area average, keeping their

inflation differentials within a band of ±1 percentage point. On the other hand, even this 1 percentage point above the euro area average inflation in each quarter will cause significant pressures on real appreciation with respect to the remainder member states.

The real exchange rate appreciation (downward direction) and depreciation (upward direction) pressures of individual euro area countries since their accession to the monetary union are summed up in Figure 13.

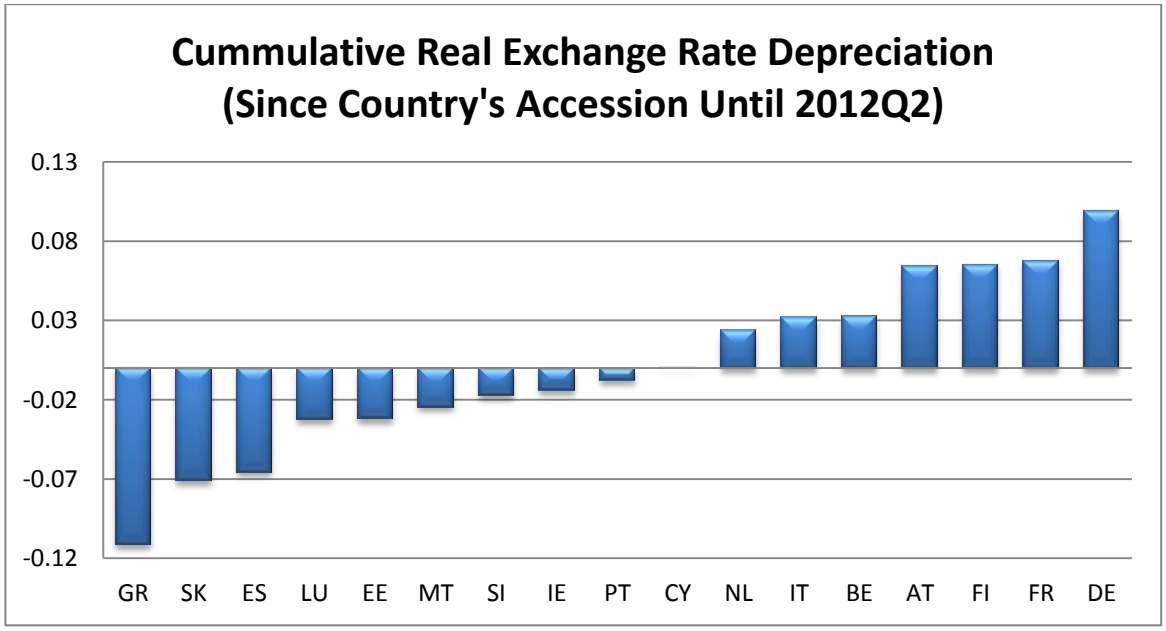

Figure 13: Real Exchange Rate Depreciation (Since Country's Accession Until 2012Q2), Source: Eurostat, Author's Calculations

Figure 13 clearly shows the two different tendencies in real exchange rate movements that are based on the inflation differentials discussed earlier. On the right-hand sight of the graph, there are countries that have experienced a period of price stability throughout the three periods Germany, France and Austria, along with Finland, Belgium, Italy and Netherlands. On the other side lie countries that are either newcomers or the ones hit the most by the sovereign debt crisis with Luxembourg being an exception..

Apart from the EA outliers identified already on the basis of output gap misalignments, Figures 12 and 13 suggest that Estonia may not be such a suitable Germany-based monetary union member. Figure 12 shows that while the average inflation differential has been kept quite stably around 2 percentage points, the volatility of its inflation differential has been increasing substantially over time. Although it can be objected that it has

experienced the same appreciation pressure as for example Luxembourg, it needs to be kept in mind that Figure 13 shows the evolution over the individual country's membership in the euro area. This means that while Luxembourg has experienced a cumulative real exchange rate appreciation of approximately 3% since 1999, Estonia has done so only since 2011. Similarly, Slovakia has appreciated by some 7% since its accession to the currency union in 2009 which is also calling for attention. The evidence of such strong appreciation pressures in the newcomer countries is most probably driven by insufficient convergence process prior to their accession and the effect of the transition itself.

Turning the attention back to analyzing the alternative monetary unions, Figures 14 and 15 summarize the inflation differentials with respect to Germany and Italy in the two groups of countries identified in the previous Section.

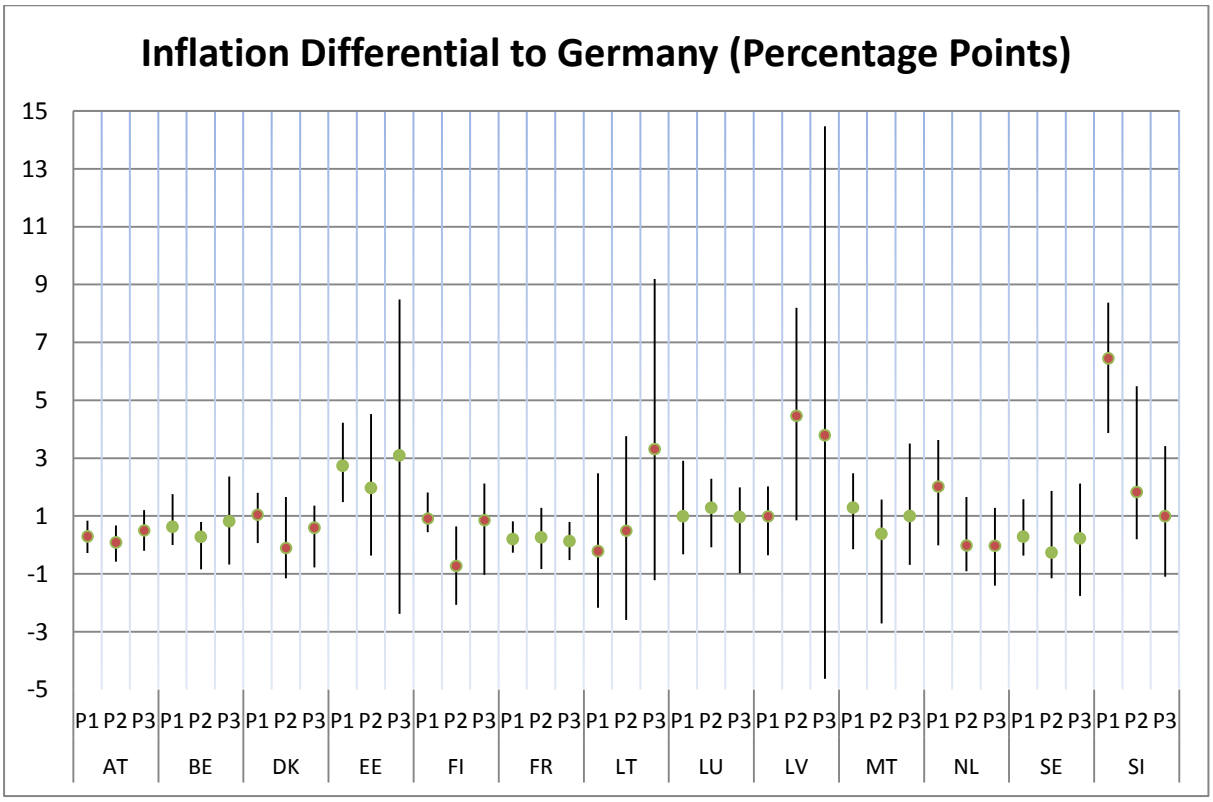

Figure 14: Inflation Differential to Germany (Percentage Points), Source: Eurostat, Author's Calculations

Apart from confirming what has been said already about Estonia's inflation and related real appreciation, Figure 14 also indicates that the other two Baltic countries, i.e. Latvia and Lithuania (that showed a substantial alignment of business cycles with respect to Germany) have much higher inflation rates than Germany. Furthermore, the volatility in their

inflation differentials to Germany has been increasing substantially over time and hence it can be concluded that the Baltic countries in general do not represent good candidates to form a monetary union with, or at least not with price-moderate Germany.

The inflation differentials with respect to Italy are summed up in Figure 15. While Belgium, Czech Republic, France, Great Britain, Luxembourg, Portugal and Spain have demonstrated quite low and stable inflation differentials with respect to Italy, there are several countries that do not seem to be ready to form a monetary union with it. Bulgaria, Hungary and Slovakia all show a trend of approaching Italy's inflation rate, but only Slovakia has already finalized the process and at the same time indicates a substantial decrease in the inflation differential's volatility. Poland, on the other hand, does not show any clear trend in the convergence of inflation rate towards the Italian one and hence should not join it in a monetary union.

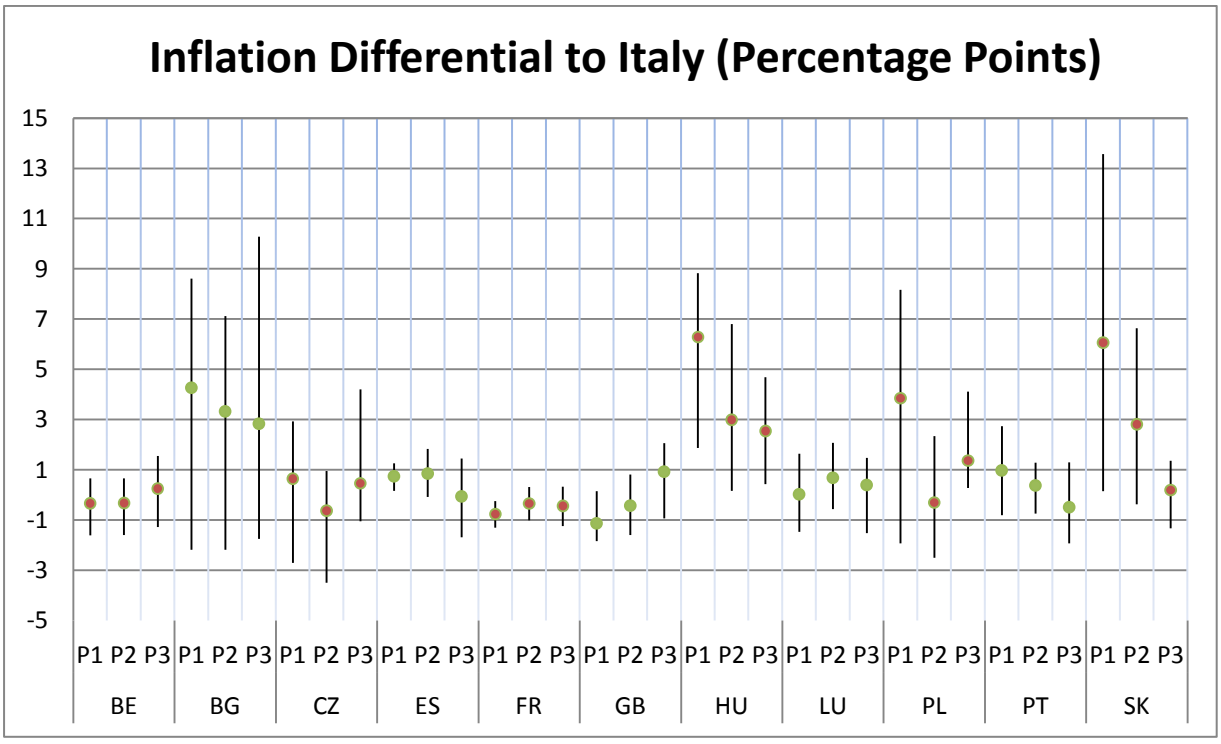

Figure 15: Inflation Differentials to Italy (Percentage Points), Source: Eurostat, Author's Calculations

Coming back to the groups of countries identified based on the output gap correlation coefficients and drawing another arbitrary limit of inflation differential average being within the range $\langle -1{,}1 \rangle$ percentage points for the P2 and P3 average, then the groups would have the following composition:

- German group – Austria, Denmark, Finland and Netherlands,
- Italian group – Belgium, Czech Republic, France, Great Britain, Luxembourg, Poland, Portugal and Spain,
- Neither group – Bulgaria, Cyprus, Estonia, Greece, Hungary, Ireland, Latvia, Lithuania, Malta, Romania, Sweden, Slovenia and Slovakia.

5.3. OCA Index

The OCA Index is traditionally calculated in yearly frequency and hence it is necessary to modify slightly the time periods that are analyzed throughout this thesis. With respect to the data availability, the time horizon will be split into three five-year-long periods: P1 will now cover 1997-2001 (instead of 1998Q2-2002Q4), P2 will represent 2002-2006 (instead of 2003Q1-2007Q3) and P3 will stand for the time period of 2007-2011 (instead of 2007Q4-2012Q2). As the OCA index was calculated both with respect to Germany and with respect to Italy, it will serve as the last criterion for the optimal composition of two alternative monetary unions. For OCA index methodology, please refer to Section 4.3.

Analyzing the contributions of the change in the individual variables to the change of overall OCA index, it can be concluded that TRADE variable does not yield a significant contribution to the overall index. Given that it is calculated as the mean of the ratios of bilateral exports to GDP, it provides information on the evolution of bilateral trade linkages over time.

As the changes on the bilateral basis are not that substantial and moreover, the trade variable is assumed to have quite a small weight in the overall index,[52] the TRADE contribution to the change in OCA index is negligible. This, by no means, implies that there hasn't been deepening of trade linkages within the euro area or European Union on the aggregate level over the last 15 years. Just to make it clear, Germany's exports towards the remaining EU27 member states accounted for 14% of its GDP in 1997, whereas in 2011 it reached more than 24%, i.e. more than 80% increase.

[52] Some authors suggest that the weight of TRADE variable should be higher, however even if the weight proposed by Viera and Viera (2010) is used, the change in overall OCA index does not change significantly and so the authors come to similar conclusions.

Figures 16 and 17 provide a summary of the contributions of individual variables to the change of the overall OCA index between the first and last period vis-à-vis Germany and Italy, respectively. Nevertheless, in both cases the same conclusion can be drawn from these two Figures: in terms of the overall OCA criteria, there has been a general tendency of divergence rather than convergence. Basically, the only variable that has had a negative, i.e. convergent, tendency was the variable DISSIM that represents the dissimilarity of export structure. If countries relatively specialize in a certain industry and hence increase its weight in their export production, they become increasingly prone to asymmetric shocks[53] and their economies become more vulnerable. Therefore, countries within a monetary union should have the structure of their tradable sector as similar, as possible. This increasing unification of the structure of export production was somewhat more pronounced with respect to Germany, as can be seen in Figures 16 and 17.

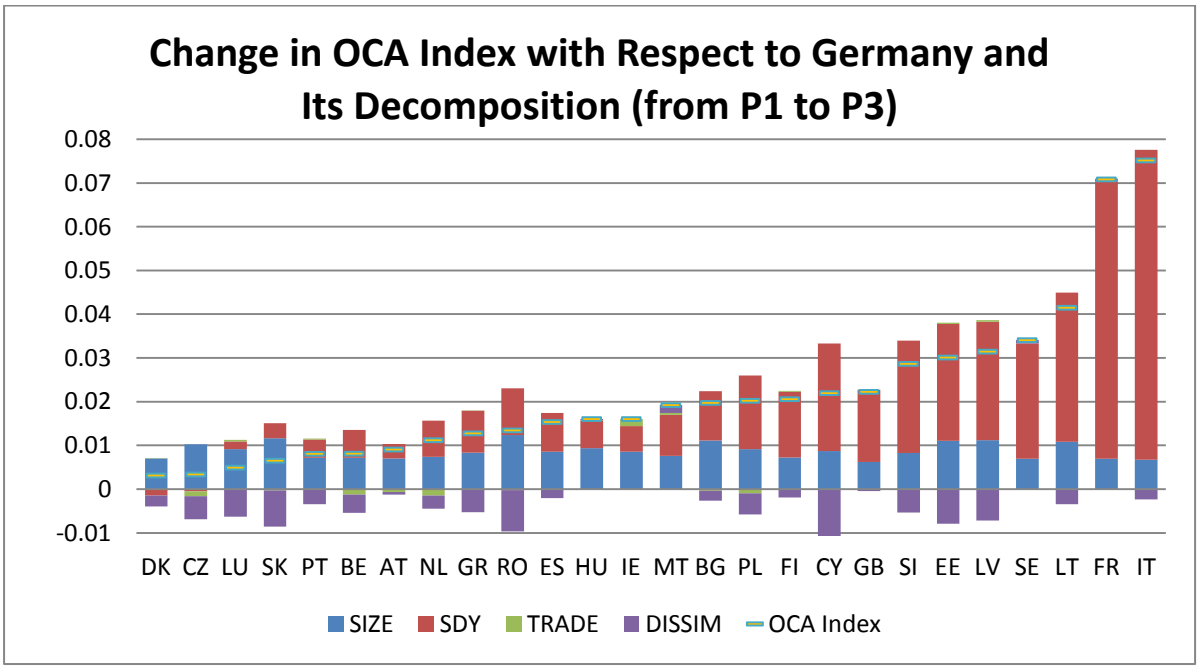

Figure 16: Change in OCA Index with Respect to Germany and Its Decomposition, Source: Author's Calculations

Moreover, it can be concluded that the variable SIZE, defined as the average of logarithmic approximation of the GDP of a given country and the respective benchmark country, has had a similar contribution across countries both with respect to Germany and Italy. Even

[53] Cincibuch and Vávra (2000)

though its contribution tends to be somewhat lower for larger economies such as France or Great Britain than for smaller ones such as the Czech and Slovak Republic or the Baltic countries, as is logical given its definition, it is clearly not the main driver of the different change of OCA index across countries.

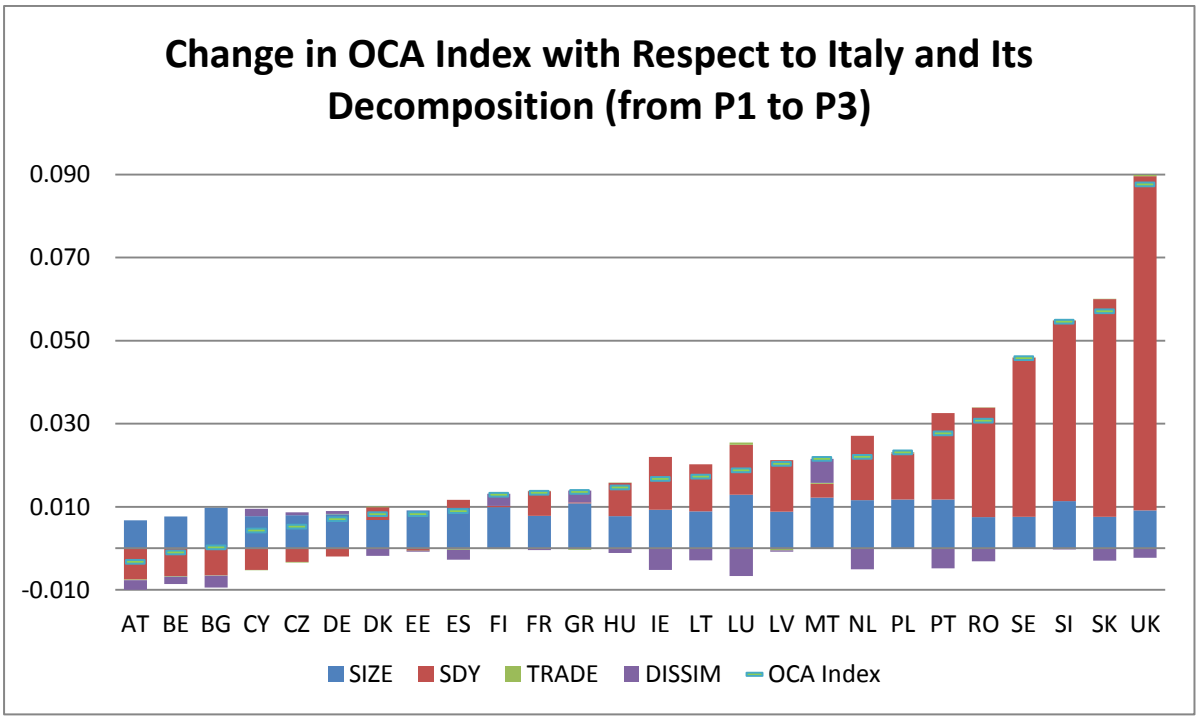

Figure 17: Change in OCA Index with Respect to Italy and Its Decomposition, Source: Author's Calculations

The majority of differences in the change of overall OCA index across countries stems from the variable SDY which is an approximation of business cycle correlation, defined as the standard deviation of percentage changes in the relative output of a given country and the respective benchmark country.

The countries that have demonstrated the highest degree of divergence from the German benchmark in terms of the difference in their relative output changes are Italy and France, followed by Sweden and the Baltic countries. While Italy's strong divergent tendency from Germany confirms its position of a suitable alternative benchmark country, French divergence from Germany and quite stable position towards Italy, on the other hand, is quite a surprise. Although the Baltic countries demonstrated a high degree of alignment in business cycles as derived by the Kalman filter with respect to Germany, the inflation

analysis showed their incompatibility with this benchmark country and hence their overall divergent tendency as showed by the Figure 16 is in line with these results.

Figure 17 suggests that Romania, Sweden, Slovenia, Slovakia and Great Britain have the most divergent tendencies with respect to Italy's output growth. While Romania has been a clear outsider in all aspects of the previous analysis, Slovenia and Great Britain were, until now, considered potential candidates for Italy-based union and hence their divergent tendency calls for caution.

Apart from the analysis of the evolution of OCA index in time, it is also useful for a static cross-country comparison. In Bayoumi and Eichengreen (1997), the authors regroup the countries according to the value of the OCA index into three categories: converged, converging and other countries. Converged countries are those that have the OCA index lower than 0.025, corresponding to less than one standard error for the overall regression. Since the analysis provided by Bayoumi and Eichengreen (1997) was only until the year 1995, let us apply the same arbitrary level for the average value of last two periods covered, i.e. excluding the transition period but including the crisis years.

As can be seen from Figures 16 and 17, when comparing the average of period 2007-2011 to the average of 1997-2001, except for almost negligible convergent tendency towards Italy in case of Austria and Belgium, the overall trend is divergent and hence, the countries will be assigned either as "converged" denoted C (with OCA index below 0.025 in each period) or "diverging," denoted D.

The resulting groups of countries are presented in the following Table 2:

Benchmark	AT	BE	BG	CY	CZ	DK	EE	ES	FI	FR	GB	GR	HU	IE	IT/DE	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK
Germany	C	C	C	C	C	C	D	C	C	D	D	D	C	C	D	D	C	C	C	C	C	D	C	C	C	C
Italy	C	C	C	C	C	C	D	C	C	C	C	D	C	C	D	D	C	C	C	C	C	D	C	C	C	C

Table 2: Converged and Diverging Countries, Source: Bayoumi and Eichengreen (1997), Author

Summarizing the results provided by Table 2, the countries can be actually split into three groups: one that includes countries converged both towards Germany and Italy, one with countries that diverge from Germany but remain in the converged category with respect to Italy and finally, one group containing countries that diverge with respect to both benchmark countries.

Apart from Austria, Belgium and Ireland that were already considered as converged to Germany by Bayoumi and Eichengreen (1997), the most recent results show that the vast majority of the countries have also reached a very high degree of convergence, as measured by the OCA criteria, and moreover, they were able to sustain it in spite of the general divergent pressures that arose in the crisis years. These countries include Bulgaria, Cyprus, Czech Republic, Denmark, Finland, Luxembourg, Latvia, Hungary, Malta, Netherlands, Poland, Romania, Slovenia, Slovakia, Spain and Sweden.

The second group of countries, those with divergent tendency from both benchmarks but that were able to attain and keep a converged status towards Italy; includes France, United Kingdom and, in the sense of diverging from Germany, Italy as well. Once again, these results are pretty much in line with those suggested by Bayoumi and Eichengreen (1997) except for the fact that Spain has gained a converged status since then and in the period of the original study, 1987-1995, all of these countries were presenting at least a slight tendency of convergence, whereas now there has been a rather divergent tendency. The fact that the United Kingdom's OCA index indicates a diverging trend from Germany suggests that its choice of opting out was wise. The third group of countries, i.e. those that diverge from both benchmark economies, includes Estonia, Greece, Latvia and Portugal.

Given that France, Greece, Italy and Portugal have spent more than a decade in a monetary union along with Germany and their structural and cyclical characteristics, as measured by the OCA index, have not improved towards the EA benchmark economy is striking and it provides a strong argument against the suggestions of Frankel and Rose (1997) about the endogeneity of the OCA criteria and the EMU becoming more justifiable in the ex-post analysis.

5.4. Summary of Results

Tables 3 and 4 provide an overview of the three evaluative criteria and summarize the results by assigning each country to a suitable monetary union. Let us consider that a country is fit to form a union with Germany (denoted G), Italy (denoted I) or either of the two countries (denoted G/I) if and only if it complies with all three criteria introduced. That is, it has to demonstrate a high degree of business cycle alignment (average correlation coefficient of 0.85 or higher) both in the period of relative stability P2, as well as in the crisis period P3. Moreover, the inflation differential with respect to the benchmark country should not, on average, surpass the level of 1 percentage point in either direction and the country should have a converged status as defined by Bayoumi and Eichengreen (1997), i.e. the OCA criterion should not surpass the 0.025 for periods P2 and P3.

Based on these criteria, Table 3 regroups the countries that can potentially form a monetary union with one or both benchmark countries.

Germany	**AT**	**BE**	**CY**	**CZ**	**DK**	**ES**	**FI**	**FR**	**GB**	**LU**	**NL**	**PL**	**SI**
Cycles Alignment	1	1	0	0	1	0	1	1	0	0	1	0	1
Inflation	1	1	0	1	1	1	1	1	1	0	1	0	0
OCA Converged	1	1	1	1	1	0	1	0	0	1	1	0	1
TOTAL SCORE	3	3	1	2	3	1	3	2	1	1	3	0	2
Italy	**AT**	**BE**	**CY**	**CZ**	**DK**	**ES**	**FI**	**FR**	**GB**	**LU**	**NL**	**PL**	**SI**
Cycles Alignment	1	1	1	1	0	1	1	1	1	1	1	1	1
Inflation	1	1	1	1	1	1	1	1	1	1	1	1	1
OCA Converged	1	1	1	1	1	1	1	1	1	1	1	1	1
TOTAL SCORE	3	3	3	3	2	3	3	3	3	3	3	3	3
Monetary Union	G/I	G/I	I	I	G	I	G/I	I	I	I	G/I	I	I

Table 3: Possible Candidates for Formation of Monetary Union, Source: Author

Comparing these results to the actual composition of the euro area, it can be concluded that it might be beneficial to its functioning to split the union into two subgroups that would incorporate only those countries that have more common features and exclude several outliers. While the German-based subgroup could include Austria, Belgium, Denmark, Finland and Netherlands, Italy's economy could benefit from being grouped with Cyprus, Czech Republic, France, Great Britain, Luxembourg, Poland, Slovenia and Spain.

On the other hand, several euro area countries appear to be unfit to form a monetary union with either of the benchmark economies, such as the euro area newcomers Estonia, Malta and Slovakia, along with the countries whose diverging tendencies were mainly the result of the asymmetric effect of the sovereign debt crisis, i.e. Greece, Ireland and Portugal. These results are summarized in Table 4.

Germany	**BG**	**EE**	**GR**	**HU**	**IE**	**LT**	**LV**	**MT**	**PT**	**RO**	**SE**	**SK**
Cycles Alignment	0	1	0	0	0	1	1	0	0	0	0	0
Inflation	0	0	0	0	1	0	0	1	1	0	1	0
OCA Converged	1	0	0	1	1	0	1	1	0	0	1	1
TOTAL SCORE	1	1	0	1	2	1	2	2	1	0	2	1
Italy	**BG**	**EE**	**GR**	**HU**	**IE**	**LT**	**LV**	**MT**	**PT**	**RO**	**SE**	**SK**
Cycles Alignment	1	0	0	1	0	0	0	0	1	0	0	1
Inflation	0	0	1	0	1	0	0	1	1	0	1	0
OCA Converged	1	0	0	1	1	0	1	1	0	0	1	1
TOTAL SCORE	2	0	1	2	2	0	1	2	2	0	2	2
Monetary Union	N	N	N	N	N	N	N	N	N	N	N	N

Table 4: Countries Not Ready for Formation of Monetary Union, Source: Author

The remainder of the countries, that are not ready for the formation of a monetary union with either Germany or Italy, are the catching-up countries of Bulgaria, Hungary, Romania and the Baltic countries of Estonia, Latvia and Lithuania.

To sum up, it may be beneficial to reorganize the composition of the euro area monetary union in order to contain only economies that demonstrate a higher level of structural and cyclical similarities and hence help mitigate the pressures arising from the impacts of sovereign debt crisis.

6. Conclusion

It can be concluded that the sovereign debt crisis has had an asymmetric effect on several euro area countries and has led to a notable increase in the business cycle dispersion within the Economic and Monetary Union, making the tendency of business cycle harmonization, that the participating countries have been experiencing since the formation of the monetary union, either disappear or even revert in some cases.

Without taking the ultimate responsibility off the euro area member states' shoulders for their actions in the fiscal field, the one-time nature of the Maastricht criteria and the weak institutional framework of its follow-up Stability and Growth Pact should carry a part of the blame for the current sovereign debt crisis. Moreover, as the accession of new member states led to an increase in the dispersion of both output gap and inflation differential, it suggests that the Maastricht criteria did not guarantee a sufficient degree of convergence between the prospective and original member states prior to their accession.

Furthermore, deprived of the right to implement their own monetary policy and possibility to devaluate their currency in order to revive their economy, the individual member states were unlikely to resist the temptation of fiscal spending, given that the cost of borrowing has dropped substantially since the formation of the EMU as a result of positive credibility spillovers.

The revision of an alternative set of criteria for a country's readiness to form a monetary union, the Optimum Currency Area criteria, suggests that even after more than a decade of the functioning of the EMU, there are several member countries, namely France, Greece, Italy and Portugal, which have not significantly improved their degree of convergence with Germany's economy. This finding undermines the suggestions of Frankel and Rose (1997) about the self-fulfilling convergence that should have taken place once the EMU was launched. Moreover, in the light of the recent events related to the sovereign debt crisis, the economies of Greece and Portugal that were, as provided by the ex-ante analysis of Bayoumi and Eichengreen (1997), considered converging towards Germany, the ex-post analysis shows the contrary.

While the current composition of the EMU does not form the Optimum Currency Area, two alternative monetary unions could do so. The search for structural and cyclical similarities with the use of business cycles alignment, inflation differentials and the OCA index yielded the alternative compositions of one currency union based on German economy and a second one centered in Italy. While the Germany-based union could include Austria, Belgium, Denmark, Finland and the Netherlands, the one based on Italian economy could consist of Cyprus, Czech Republic, France, Great Britain, Luxembourg, Poland, Slovenia and Spain.

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Hungarian Central Bank (Magyar Nemzeti Bank)
(http://www.mnb.hu/)

Polish Central Bank (Narodowy Bank Polski)
(http://www.nbp.pl/)

Bank of England (Great Britain)
(http://www.bankofengland.co.uk/Pages/home.aspx)

Swedish Central Bank (Sveriges Riksbank)
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Databases and Archives

ECB Statistical Data Warehouse
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Appendix A: Model Specification for MATLAB

Transition Variables

```
'Real GDP, millions of national currency'           y
'Potential output, millions of national currency'   y_tnd
'Real GDP (100*log)'                                l_y
'Potential output (100*log)'                        l_y_tnd
'Output gap, percent'                               l_y_gap
'Annualized q-o-q growth of real GDP  (log)'        dl_y
'Annualized q-o-q growth of potential output (log)' dl_y_tnd
'y-o-y growth of real GDP (log)'                    d4l_y
'Output gap EU27, percent'                          l_y_for_gap
'Real monetary conditions index'                    rmci
'Consumer price index, 2005=100'                    cpi
'Consumer price index (100*log)'                    l_cpi
'Annualized q-o-q inflation (log)'                  dl_cpi
'Annualized y-o-y inflation (log)'                  d4l_cpi
'y-o-y inflation target (log)'                      d4l_cpi_tar
'Import price index'                                cpi_imp
'Import price index (log)'                          l_cpi_imp
'Annualized q-o-q imported inflation (log)'         dl_cpi_imp
'y-o-y imported inflation (log)'                    d4l_cpi_imp
'Real marginal cost'                                rmc
'Annualized q-o-q inflation expectations (log)'     e_dl_cpi
'y-o-y inflation expectations (log)'                e_d4l_cpi
'Nominal exchange rate, national currency/1EUR'     s
'Nominal exchange rate, national currency/1EUR (log'l_s
'Annualized q-o-q nominal depreciation (log)'       dl_s
'Short-term nominal interest rate'                  i
'Short-term equilibrium nominal interest rate'      i_tnd
'Short-term nominal interest rate (log)'            l_i
'Short-term equilibrium nominal interest rate (log)' l_i_tnd
'y-o-y inflation gap (log)'                         d4l_cpi_gap
'Long-term foreign nominal interest rate'           i_for
'Long-term foreign nominal interest rate (log)'     l_i_for
'Long-term nominal interest rate country premium (log)' l_prem
'Long-term UIP country premium'                     prem
'Long-term domestic real interest rate'             r
'Long-term domestic equilibrium real interest rate' r_tnd
'Long-term domestic real interest rate (log)'       l_r
'Long-term domestic equilibrium real interest rate (log)' l_r_tnd
'Long-term domestic real interest rate gap, percent' l_r_gap
'Real exchange rate'                                q
'Equilibrium real exchange rate'                    q_tnd
'Real exchange rate (log)'                          l_q
'Annualized q-o-q real exchange rate depreciation (log)' dl_q
'Real exchange rate gap, percent'                   l_q_gap
'Equilibrium real exchange rate (log)'              l_q_tnd
'Annualized q-o-q equilibriun real exchange rate depreciation (log)'l_q_tnd
'Harmonized index pf consumer prices for EU27 (log)' l_cpi_for
'Annualized q-o-q foreign inflation, EU27 (log)'    dl_cpi_for
'Harmonized index of consumer prices for EU27, 2005=100' cpi_for
'Long-term foreign equilibrium real interest rate (log)' l_r_for_tnd
'Long-term foreign equilibrium real interest rate'  r_for_tnd
```

Measurement Variables

obs_cpi
obs_d4l_cpi_tar
obs_y
obs_l_y_for_gap
obs_s
obs_i_for
obs_r_for_tnd
obs_i
obs_cpi_for

Variables in Logarithmic Approximation

cpi
cpi_imp
y
y_tnd
r
r_tnd
q
q_tnd
s
i_for
r_for_tnd
prem
i
i_tnd
cpi_for
obs_cpi
obs_y
obs_s
obs_i_for
obs_r_for_tnd
obs_i
obs_cpi_for

Transitions Shocks

shock_l_y_gap
shock_l_y_for_gap
shock_dl_cpi
shock_d4l_cpi_tar
shock_dl_s
shock_l_i
shock_dl_y_tnd
shock_dl_q_tnd
shock_l_r_tnd
shock_dl_cpi_for
shock_l_i_for
shock_l_r_for_tnd

Parameters

```
a1_l_y_gap, a2_rmci, a3_l_q_gap, a4_l_y_for_gap
b1_dl_cpi, b2_dl_cpi, b3_dl_cpi, b4_dl_cpi, b5_rmc
c1_dl_s, c3_dl_q_tnd
d1_l_i, d2_l_i, d3_l_i
e1_dl_cpi, e2_d4l_cpi
f1_dl_y_tnd, f2_dl_q_tnd, f3_l_r_tnd, f4_d4l_cpi_tar, f5_dl_cpi_for,
f6_l_i_for, f7_l_r_for_tnd, f8_l_y_for_gap
ss_d4l_cpi_tar
ss_dl_y_tnd
ss_dl_q_tnd
ss_l_r_tnd
ss_dl_cpi_for
ss_l_i_for
ss_l_r_for_tnd
```

Transition Equations

```
'Real Economy' %(r=real intereste rate, q=real exchange rate)
l_y_gap = a1_l_y_gap*l_y_gap{-1} - a2_rmci*rmci{-1} +
a4_l_y_for_gap*l_y_for_gap{-1}+shock_l_y_gap;
rmci    = a3_l_q_gap*(-l_q_gap) +(1-a3_l_q_gap)*(l_r_gap);

'Phillips Curve'
dl_cpi     = b1_dl_cpi*(b2_dl_cpi*dl_cpi{-1}+(1-b2_dl_cpi)*e_dl_cpi)+(1-
b1_dl_cpi)*dl_cpi_imp{-1}+b3_dl_cpi*rmc{-1}+shock_dl_cpi;
dl_cpi_imp = b4_dl_cpi*dl_cpi_imp{-1}+(1-b4_dl_cpi)*(dl_s{-1} +
dl_cpi_for{-1} - dl_q_tnd{-1});
rmc        = b5_rmc*l_y_gap + (1-b5_rmc)*l_q_gap;

'Expectations'
e_dl_cpi  = e1_dl_cpi*dl_cpi{+1}+(1-e1_dl_cpi)*dl_cpi{-1};
e_d4l_cpi = e2_d4l_cpi*d4l_cpi{+1}+(1-e2_d4l_cpi)*d4l_cpi{-1};

'Uncovered interest rate parity'
dl_s{+1}     = c1_dl_s*dl_s + (1-c1_dl_s)*(l_i - l_i_for - l_prem) +
shock_dl_s;
dl_q_tnd{+1} = c3_dl_q_tnd*dl_q_tnd + (1-c3_dl_q_tnd)*(l_r_tnd -
l_r_for_tnd - l_prem);

dl_s = (l_s-l_s{-1})*4;

'Taylor rule'
l_i         = d1_l_i*l_i{-1} + (1-d1_l_i)*(l_i_tnd + d2_l_i*d4l_cpi_gap +
d3_l_i*l_y_gap) + shock_l_i;
l_i_tnd     = l_r_tnd + d4l_cpi_tar{+1};
d4l_cpi_gap = e_d4l_cpi - d4l_cpi_tar{+1};

'Fisher equation'
l_r = l_i - e_d4l_cpi;

'Real exchange rate formation'
l_q  = l_s + l_cpi_for - l_cpi;
dl_q = (l_q - l_q{-1})*4;

'Identities and trends'
l_y=l_y_tnd+l_y_gap;
dl_y=(l_y-l_y{-1})*4;
d4l_y=(dl_y+dl_y{-1}+dl_y{-2}+dl_y{-3})/4;
```

```
dl_y_tnd=(l_y_tnd-l_y_tnd{-1})*4;
dl_y_tnd=f1_dl_y_tnd*dl_y_tnd{-1}+(1-
f1_dl_y_tnd)*ss_dl_y_tnd+shock_dl_y_tnd;

l_y_for_gap=f8_l_y_for_gap*l_y_for_gap{-1}+shock_l_y_for_gap;

l_q=l_q_tnd+l_q_gap;
dl_q_tnd=(l_q_tnd-l_q_tnd{-1})*4;
dl_q_tnd=f2_dl_q_tnd*dl_q_tnd{-1}+(1-
f2_dl_q_tnd)*ss_dl_q_tnd+shock_dl_q_tnd;

l_r = l_r_tnd+l_r_gap;
l_r_tnd = f3_l_r_tnd*l_r_tnd{-1} + (1-f3_l_r_tnd)*ss_l_r_tnd +
shock_l_r_tnd;

dl_cpi=(l_cpi-l_cpi{-1})*4;
d4l_cpi=(dl_cpi+dl_cpi{-1}+dl_cpi{-2}+dl_cpi{-3})/4;

dl_cpi_imp=(l_cpi_imp-l_cpi_imp{-1})*4;
d4l_cpi_imp=(dl_cpi_imp+dl_cpi_imp{-1}+dl_cpi_imp{-2}+dl_cpi_imp{-3})/4;

d4l_cpi_tar = f4_d4l_cpi_tar*d4l_cpi_tar{-1} + (1-
f4_d4l_cpi_tar)*ss_d4l_cpi_tar + shock_d4l_cpi_tar;

'Foreign block'
dl_cpi_for = (l_cpi_for - l_cpi_for{-1})*4;
dl_cpi_for = f5_dl_cpi_for*dl_cpi_for{-1}+(1-f5_dl_cpi_for)*ss_dl_cpi_for +
shock_dl_cpi_for;

l_i_for = f6_l_i_for*l_i_for{-1} + (1-f6_l_i_for)*ss_l_i_for +
shock_l_i_for;

l_r_for_tnd = f7_l_r_for_tnd*l_r_for_tnd{-1} + (1-
f7_l_r_for_tnd)*ss_l_r_for_tnd + shock_l_r_for_tnd;
```

Transformations

```
100*log(cpi)         = l_cpi;
100*log(cpi_imp)     = l_cpi_imp;
100*log(y)           = l_y;
100*log(y_tnd)       = l_y_tnd;
100*log(r)           = l_r;
100*log(r_tnd)       = l_r_tnd;
100*log(q)           = l_q;
100*log(q_tnd)       = l_q_tnd;
100*log(s)           = l_s;
100*log(i_for)       = l_i_for;
100*log(r_for_tnd)   = l_r_for_tnd;
100*log(prem)        = l_prem;
100*log(i)           = l_i;
100*log(i_tnd)       = l_i_tnd;
100*log(cpi_for)     = l_cpi_for;
```

Measurement Equations

```
obs_cpi         = cpi;
obs_d4l_cpi_tar = d4l_cpi_tar;
obs_y           = y;
```

```
obs_l_y_for_gap         = l_y_for_gap;
obs_s           = s;
obs_i_for       = i_for;
obs_r_for_tnd   = r_for_tnd;
obs_i           = i;
obs_cpi_for     = cpi_for;
```

Appendix B: Estimated Parameters

1. Structural Parameters

Structural Parameters	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK
p.a1_l_y_gap	0.60	0.60	0.60	0.60	0.75	0.64	0.60	0.60	0.64	0.60	0.60	0.90	0.73	0.73	0.63	0.67	0.60	0.60	0.62	0.60	0.60	0.58	0.60	0.80	0.70	0.62	0.75
p.a2_rmci	0.40	0.40	0.28	0.36	0.22	0.33	0.27	0.40	0.38	0.40	0.40	0.30	0.40	0.28	0.36	0.38	0.30	0.40	0.20	0.30	0.26	0.30	0.33	0.30	0.30	0.40	0.35
p.a3_l_q_gap	0.61	0.62	0.52	0.57	0.48	0.53	0.53	0.60	0.65	0.67	0.61	0.50	0.70	0.50	0.56	0.58	0.49	0.70	0.49	0.50	0.57	0.46	0.56	0.43	0.52	0.68	0.47
p.a4_l_y_for_gap	0.60	0.59	0.62	0.63	0.79	0.75	0.69	0.74	0.56	0.59	0.50	0.59	0.41	0.80	0.71	0.67	0.74	0.62	0.80	0.64	0.48	0.80	0.52	0.65	0.70	0.52	0.77
p.b1_dl_cpi	0.78	0.80	0.90	0.85	0.85	0.85	0.82	0.78	0.84	0.85	0.74	0.81	0.71	0.86	0.79	0.79	0.83	0.82	0.86	0.78	0.74	0.89	0.83	0.84	0.82	0.90	0.77
p.b2_dl_cpi	0.67	0.59	0.46	0.54	0.60	0.61	0.70	0.55	0.65	0.80	0.69	0.80	0.80	0.61	0.67	0.73	0.63	0.62	0.70	0.51	0.63	0.80	0.62	0.66	0.69	0.60	0.58
p.b3_dl_cpi	0.35	0.37	0.20	0.34	0.40	0.38	0.24	0.30	0.29	0.20	0.28	0.30	0.20	0.40	0.32	0.26	0.38	0.20	0.23	0.38	0.20	0.20	0.35	0.35	0.36	0.40	0.35
p.b4_dl_cpi	0.51	0.50	0.51	0.51	0.50	0.50	0.52	0.50	0.50	0.49	0.52	0.54	0.48	0.50	0.51	0.52	0.51	0.51	0.51	0.52	0.50	0.61	0.50	0.52	0.51	0.50	0.50
p.b5_rmc	0.59	0.58	0.64	0.58	0.58	0.59	0.61	0.51	0.63	0.70	0.64	0.62	0.56	0.59	0.60	0.64	0.58	0.62	0.63	0.54	0.63	0.79	0.61	0.61	0.58	0.60	0.60
p.c1_dl_s	0.50	0.71	0.77	0.68	0.51	0.50	0.50	0.72	0.71	0.52	0.51	0.50	0.68	0.50	0.60	0.57	0.50	0.68	0.50	0.79	0.75	0.50	0.76	0.50	0.50	0.50	0.50
p.c3_dl_q_tnd	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.51	0.56	0.51	0.50	0.50	0.50	0.50	0.50	0.50	0.51	0.50	0.50	0.50	0.50	0.50	0.50	0.50
p.d1_l_i	0.60	0.64	0.90	0.65	0.67	0.64	0.71	0.80	0.68	0.80	0.66	0.75	0.65	0.62	0.80	0.69	0.69	0.80	0.80	0.66	0.75	0.80	0.66	0.50	0.67	0.55	0.57
p.d2_l_i	1.20	1.15	1.20	1.20	1.19	1.22	1.20	1.20	1.20	1.21	1.20	1.20	1.10	1.17	1.10	1.20	1.20	1.30	1.10	1.20	1.20	1.20	1.20	1.20	1.20	1.05	1.20
p.d3_l_i	0.47	0.47	0.50	0.50	0.50	0.47	0.50	0.45	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.44	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.45	0.50
p.e1_dl_cpi	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
p.e2_d4l_cpi	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

2. Persistence of AR process

Persistence	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK
p.f1_dl_y_tnd	0.60	0.61	0.69	0.50	0.60	0.60	0.61	0.84	0.65	0.64	0.50	0.50	0.80	0.60	0.64	0.60	0.80	0.69	0.86	0.59	0.75	0.58	0.62	0.50	0.85	0.65	0.61
p.f2_dl_q_tnd	0.95	0.75	0.65	0.60	0.90	0.75	0.60	0.88	0.85	0.65	0.70	0.60	0.85	0.89	0.60	0.75	0.92	0.50	0.95	0.90	0.85	0.65	0.60	0.50	0.91	0.60	0.90
p.f3_l_r_tnd	0.92	0.99	0.80	0.70	0.75	0.90	0.75	0.93	0.85	0.65	0.85	0.65	0.82	0.75	0.90	0.85	0.91	0.75	0.90	0.75	0.91	0.70	0.70	0.70	0.75	0.75	0.70
p.f4_d4l_cpi_tar	0.99	0.96	0.80	0.65	0.30	0.99	0.60	0.75	0.99	0.99	0.99	0.45	0.40	0.60	0.30	0.30	0.60	0.99	0.60	0.70	0.99	0.45	0.98	0.60	0.40	0.65	0.60
p.f5_dl_cpi_for	0.85	0.86	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
p.f6_l_i_for	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
p.f7_l_r_for_tnd	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
p.f8_l_y_for_gap	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85

3. Steady States for AR process

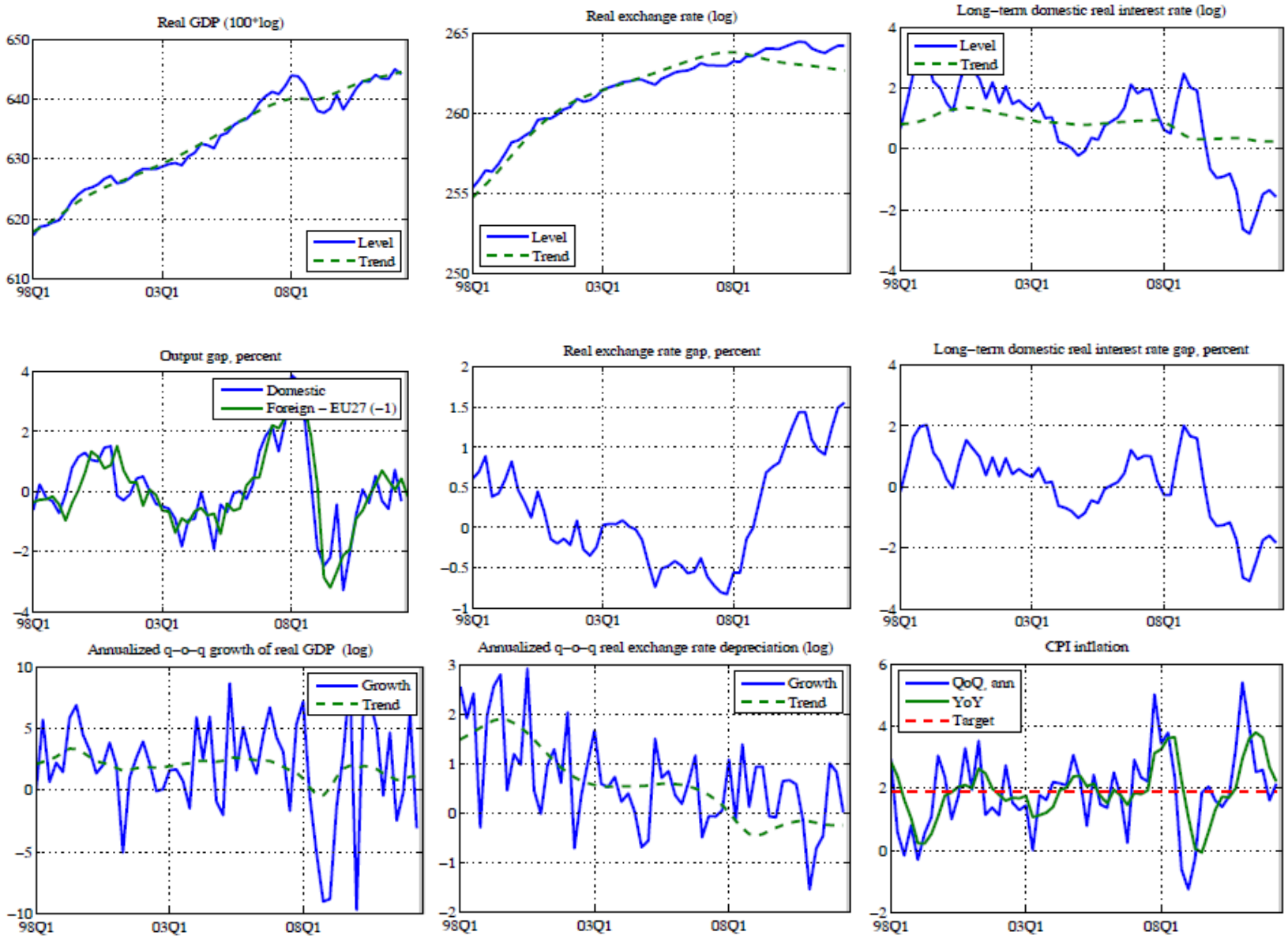
Steady states	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK
p.ss_d4l_cpi_tar	1.93	1.90	4.98	1.90	2.00	1.90	1.80	3.50	1.90	1.90	1.90	1.90	1.90	3.00	1.90	1.90	2.50	1.90	3.50	1.90	1.90	3.50	1.90	5.00	1.80	1.90	1.90
p.ss_dl_y_tnd	1.80	1.50	3.50	2.74	2.90	1.31	1.00	4.30	2.35	2.00	1.50	1.50	1.80	3.20	4.04	0.80	2.50	3.00	1.50	1.72	1.50	4.00	0.70	8.50	2.08	1.50	4.50
p.ss_dl_q_tnd	0.15	0.20	-3.50	0.10	-2.30	0.50	0.50	-2.02	-0.49	0.50	0.50	0.50	-1.00	-0.75	0.05	0.50	-1.50	-0.05	-2.00	0.10	0.20	-1.50	-0.05	-1.50	1.55	-0.15	-3.70
p.ss_l_r_tnd	0.75	0.40	-0.75	-0.50	0.50	0.50	0.75	0.10	0.40	0.50	1.00	1.20	0.05	2.50	0.10	0.50	0.75	0.05	1.20	0.50	0.49	4.50	0.10	4.00	0.75	0.51	0.25
p.ss_dl_cpi_for	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90
p.ss_l_r_for_tnd	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
p.ss_l_i_for	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40

4. Standard Deviation of Shocks

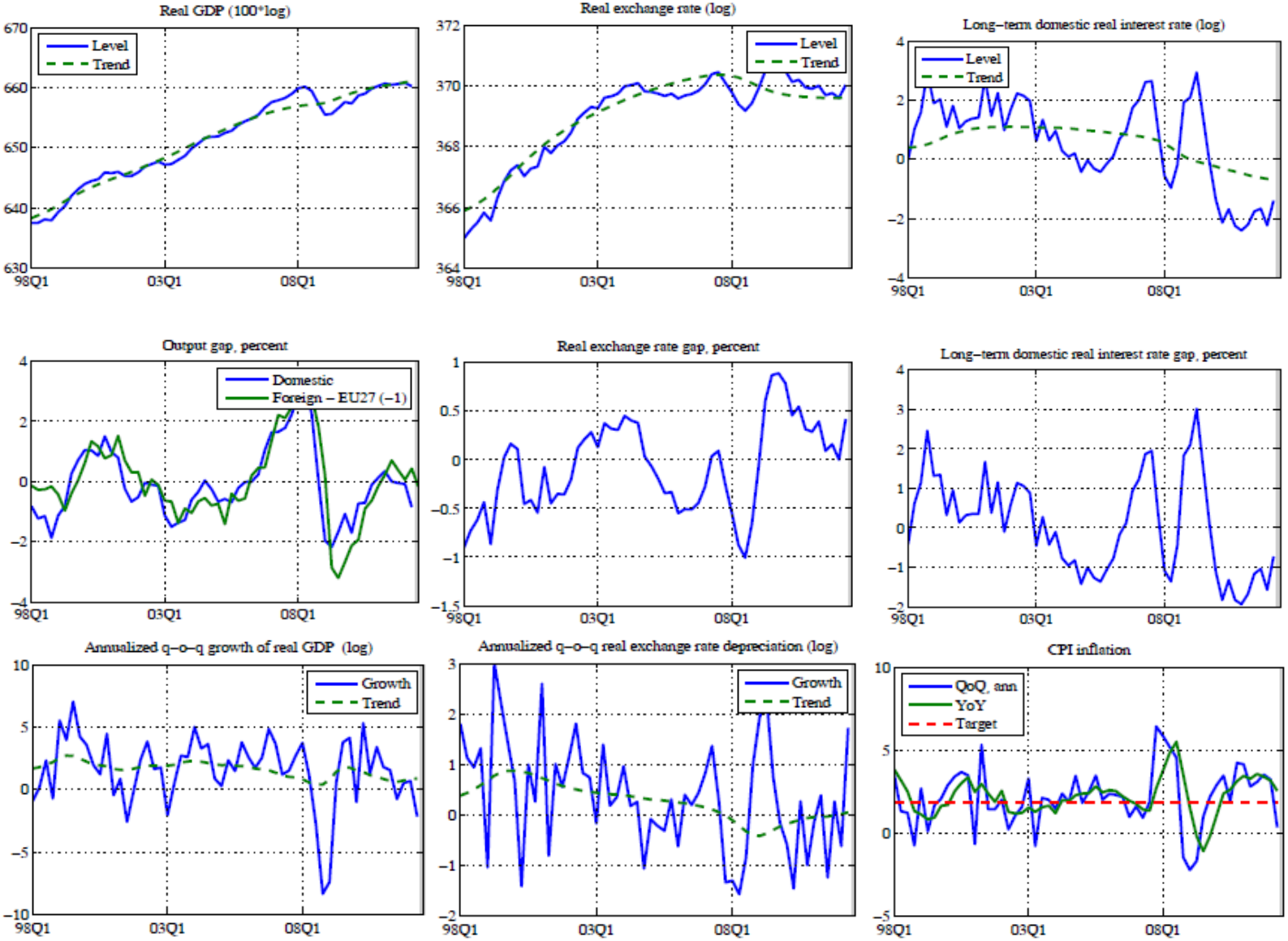
Shocks	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK
p.std_shock_l_y_gap	0.99	0.99	0.99	0.99	0.70	0.99	0.99	0.99	0.99	0.99	0.99	0.30	0.99	0.40	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.30	0.30	0.99	0.99	0.99
p.std_shock_l_y_for_gap	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
p.std_shock_dl_cpi	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	0.10	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
p.std_shock_dl_s	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.10	1.30
p.std_shock_l_i	1.00	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	0.50	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
p.std_shock_dl_y_tnd	0.80	0.80	0.80	0.50	0.35	0.80	0.80	0.80	0.80	0.80	0.80	0.10	0.80	0.20	0.80	0.40	0.80	0.80	0.80	0.80	0.80	0.50	0.16	0.20	0.40	0.80	0.40
p.std_shock_dl_q_tnd	0.10	0.14	0.40	0.05	0.14	0.14	0.10	0.14	0.08	0.10	0.10	0.12	0.14	0.14	0.10	0.05	0.14	0.14	0.14	0.15	0.14	0.14	0.14	0.05	0.14	0.03	0.14
p.std_shock_l_r_tnd	0.15	0.15	0.40	0.30	0.15	0.15	0.10	0.15	0.30	0.13	0.15	0.15	0.30	0.15	0.10	0.15	0.15	0.15	0.15	0.14	0.15	0.15	0.15	0.15	0.10	0.15	0.15
p.std_shock_dl_cpi_for	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
p.std_shock_l_i_for	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
p.std_shock_l_r_for_tnd	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Appendix C: Results of Kalman Filter by Country

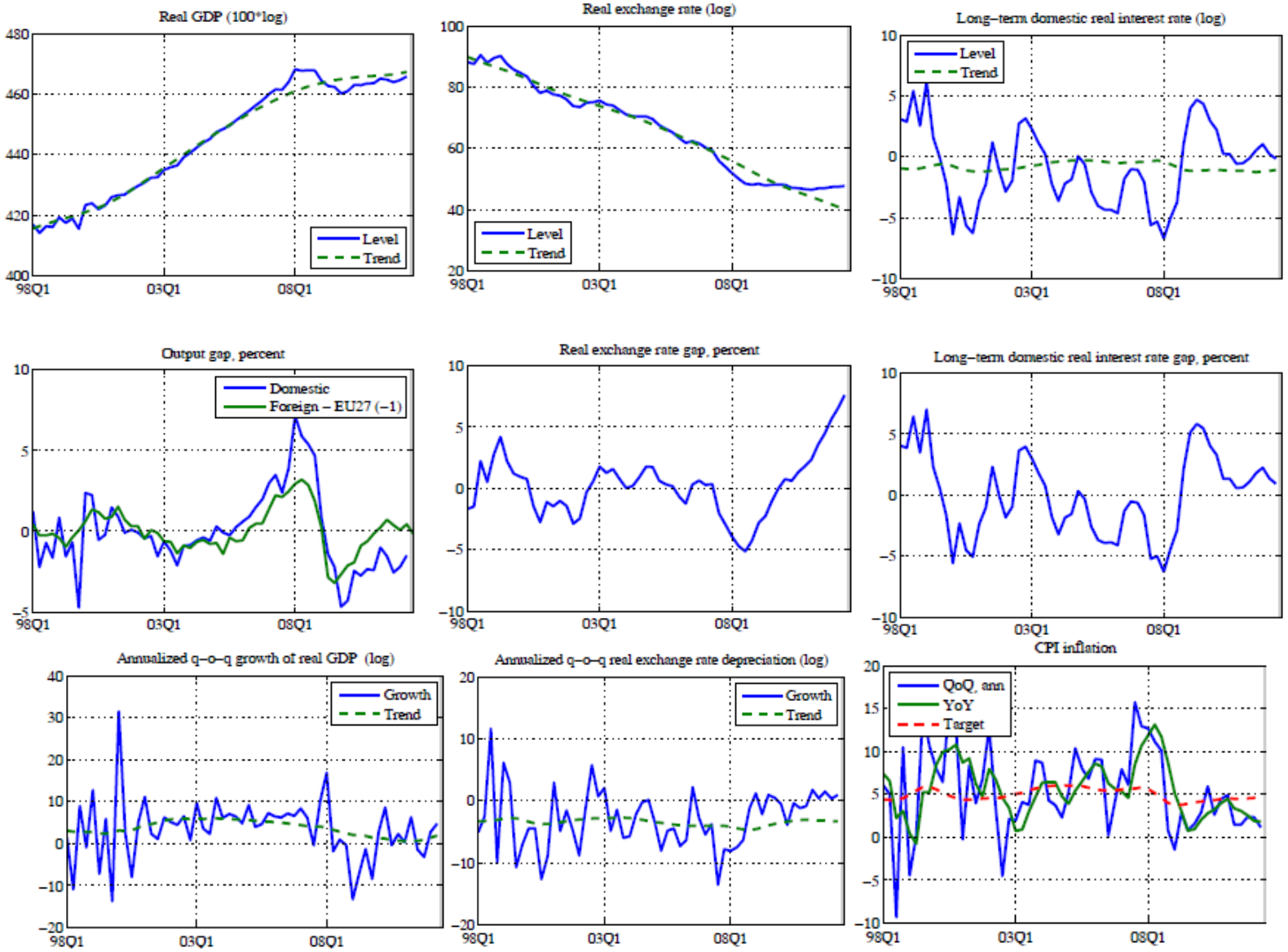
Austria



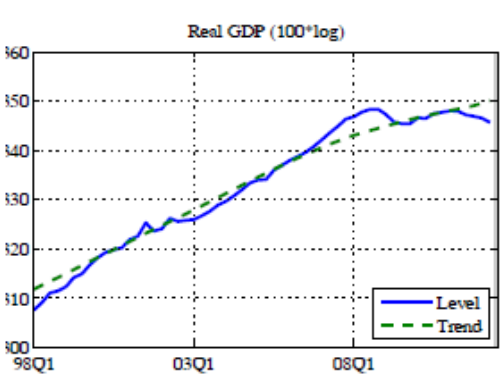
Belgium

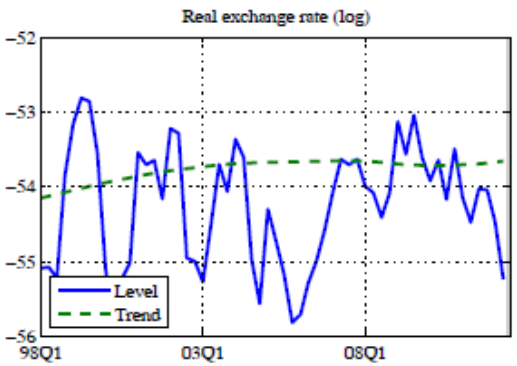

Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long–term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign – EU27 (–1)
Real exchange rate gap, percent
Long–term domestic real interest rate gap, percent
Annualized q–o–q growth of real GDP (log)
Growth
Trend
Annualized q–o–q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

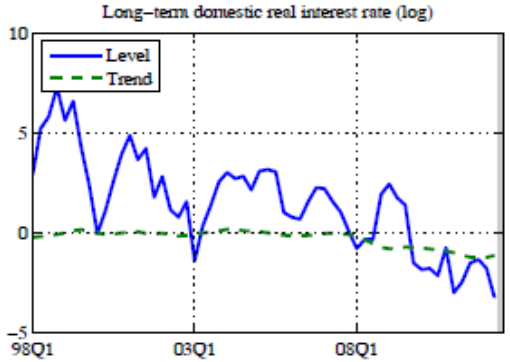
Bulgaria

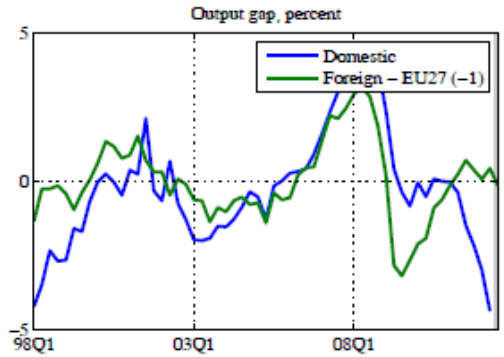

Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long–term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign – EU27 (–1)
Real exchange rate gap, percent
Long–term domestic real interest rate gap, percent
Annualized q–o–q growth of real GDP (log)
Growth
Trend
Annualized q–o–q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

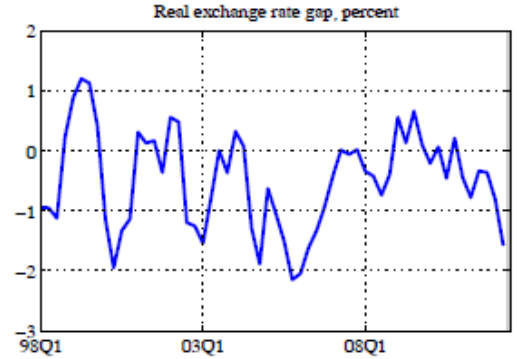
Cyprus

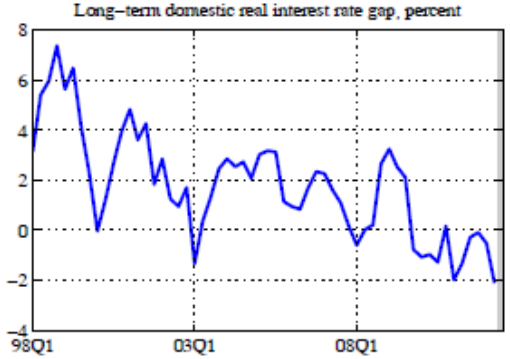

Real GDP (100*log)
Level
Trend
98Q1
03Q1
08Q1

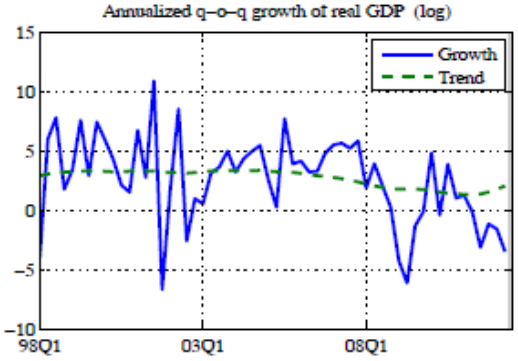

Real exchange rate (log)
Level
Trend
98Q1
03Q1
08Q1

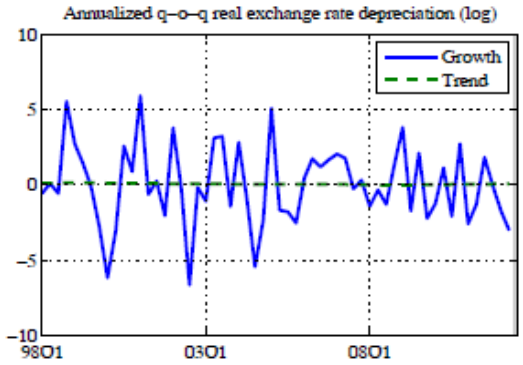

Long−term domestic real interest rate (log)
Level
Trend
98Q1
03Q1
08Q1

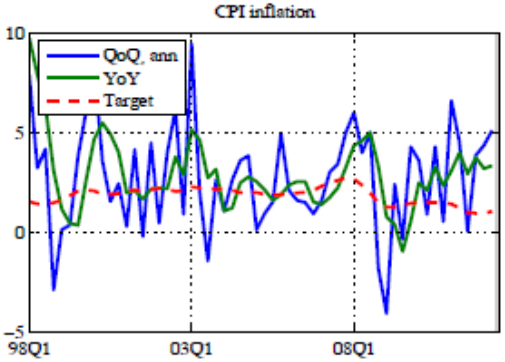

Output gap, percent
Domestic
Foreign − EU27 (−1)
98Q1
03Q1
08Q1


Real exchange rate gap, percent
98Q1
03Q1
08Q1

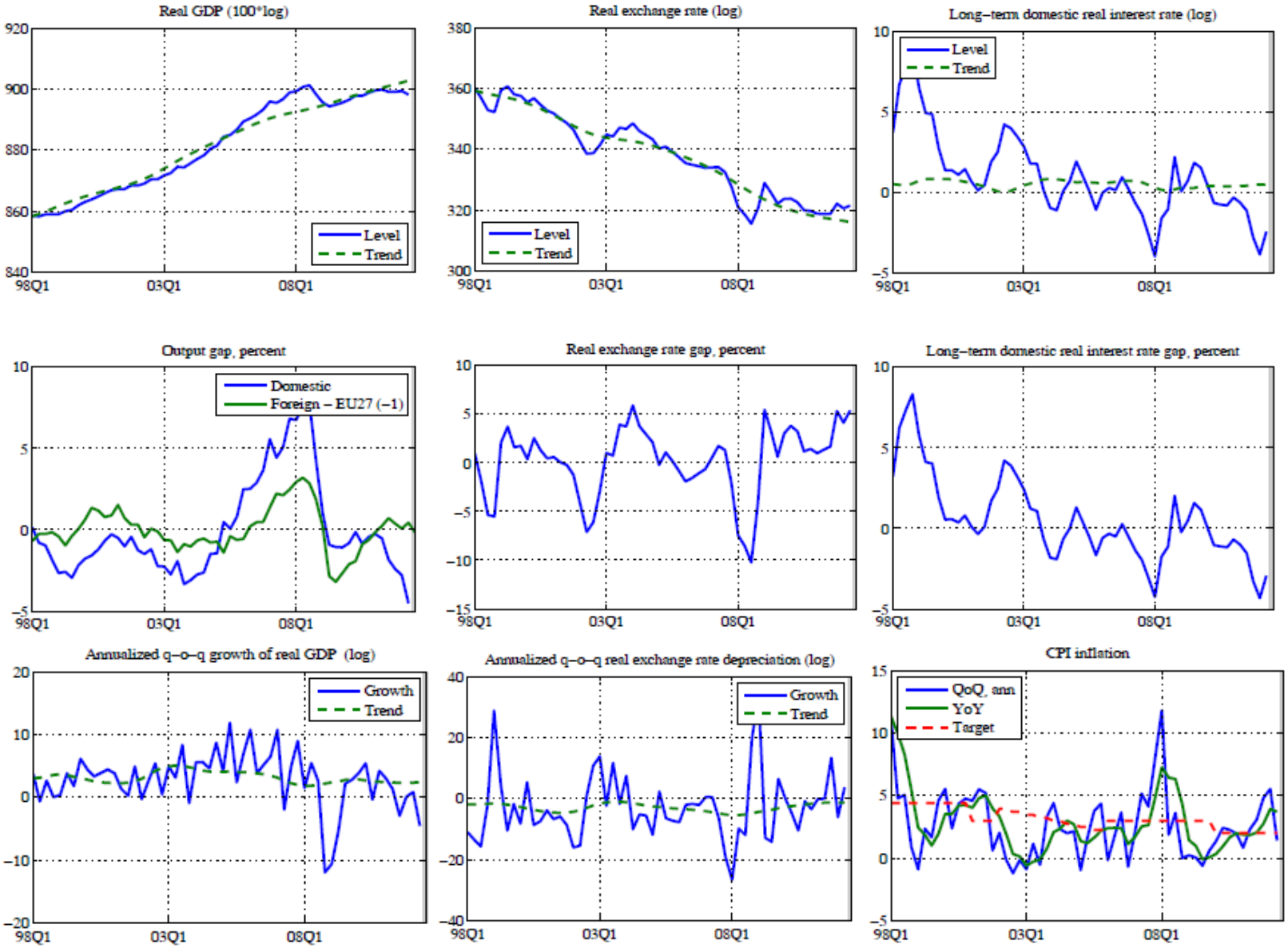

Long−term domestic real interest rate gap, percent
98Q1
03Q1
08Q1


Annualized q−o−q growth of real GDP (log)
Growth
Trend
98Q1
03Q1
08Q1

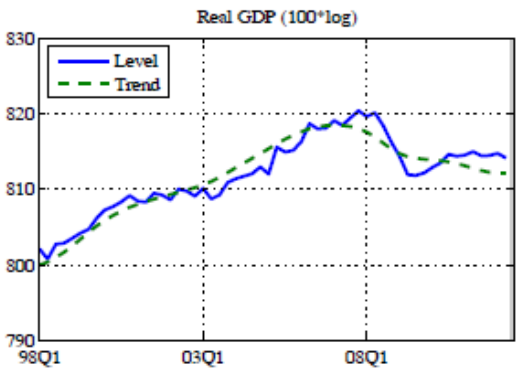

Annualized q−o−q real exchange rate depreciation (log)
Growth
Trend
98Q1
03Q1
08Q1

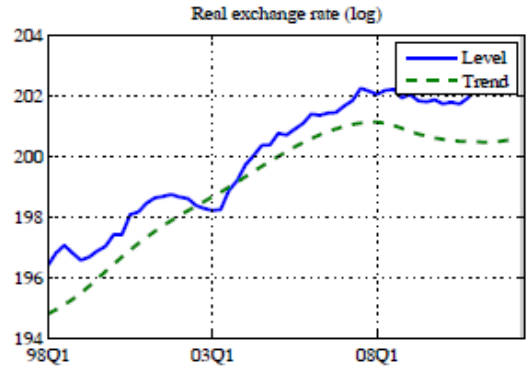

CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

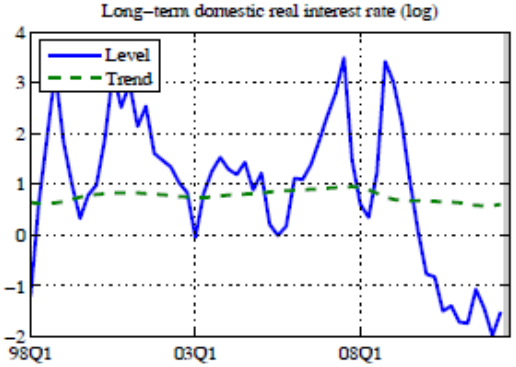
Czech Republic

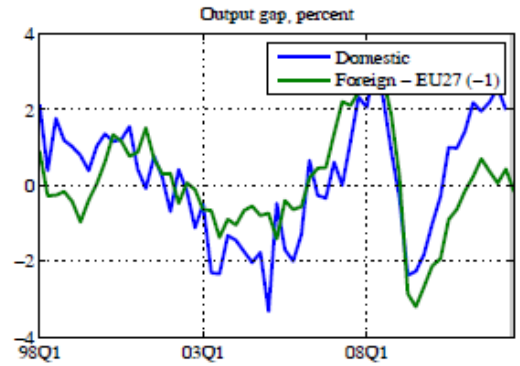


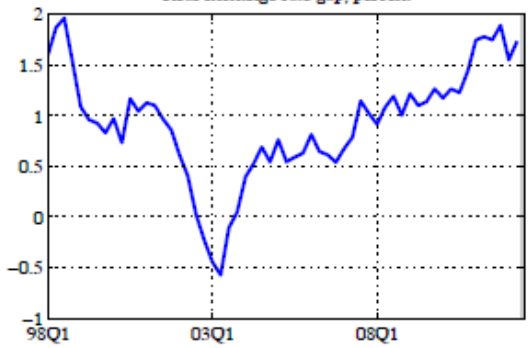
Denmark

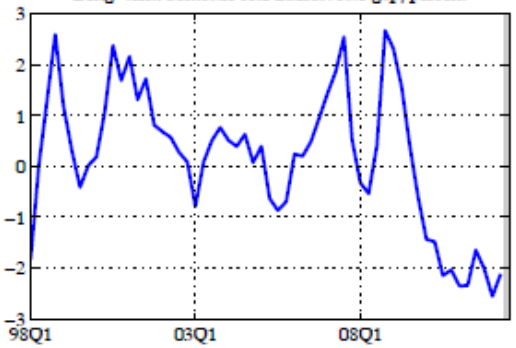

Real GDP (100*log)
Level
Trend
830
820
810
800
790
98Q1
03Q1
08Q1

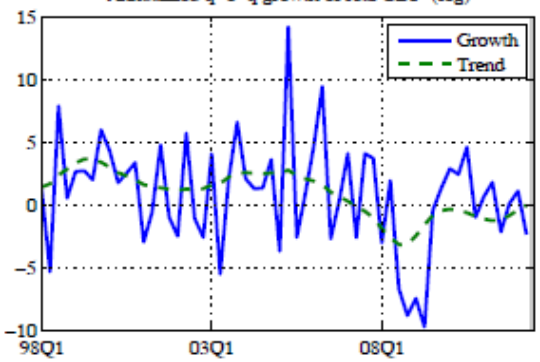

Real exchange rate (log)
Level
Trend
204
202
200
198
196
194
98Q1
03Q1
08Q1

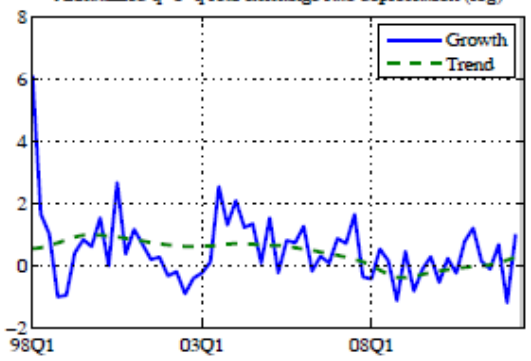

Long−term domestic real interest rate (log)
Level
Trend
4
3
2
1
0
−1
−2
98Q1
03Q1
08Q1

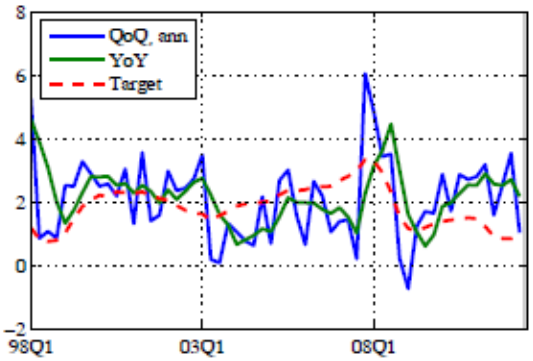

Output gap, percent
Domestic
Foreign − EU27 (−1)
4
2
0
−2
−4
98Q1
03Q1
08Q1


Real exchange rate gap, percent
2
1.5
1
0.5
0
−0.5
−1
98Q1
03Q1
08Q1

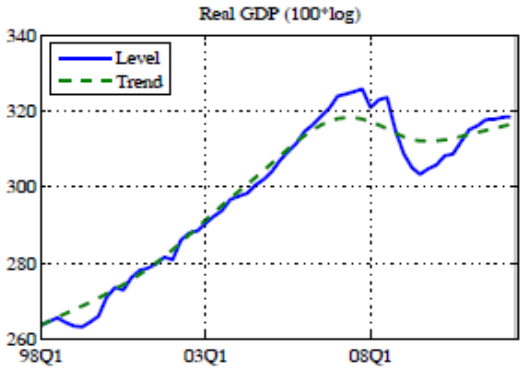

Long−term domestic real interest rate gap, percent
3
2
1
0
−1
−2
−3
98Q1
03Q1
08Q1

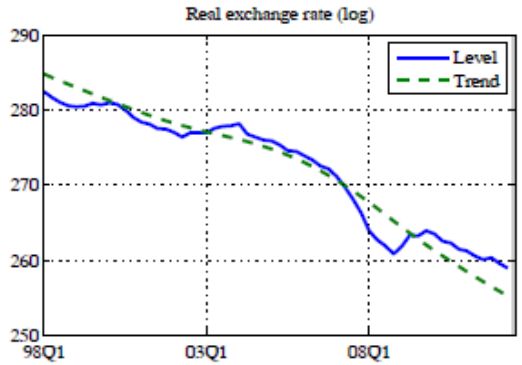

Annualized q−o−q growth of real GDP (log)
Growth
Trend
15
10
5
0
−5
−10
98Q1
03Q1
08Q1

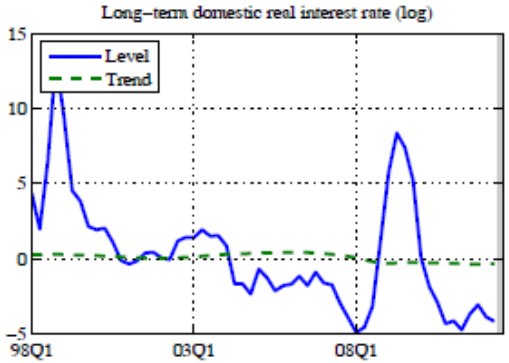

Annualized q−o−q real exchange rate depreciation (log)
Growth
Trend
8
6
4
2
0
−2
98Q1
03Q1
08Q1

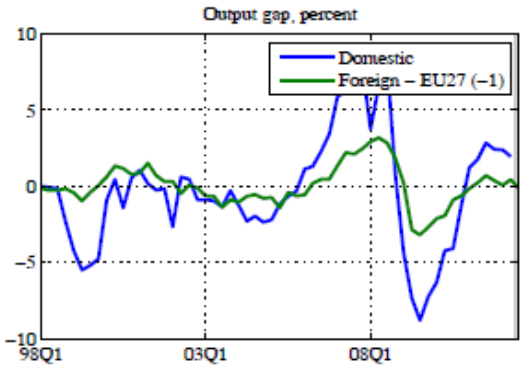

CPI inflation
QoQ, ann
YoY
Target
8
6
4
2
0
−2
98Q1
03Q1
08Q1

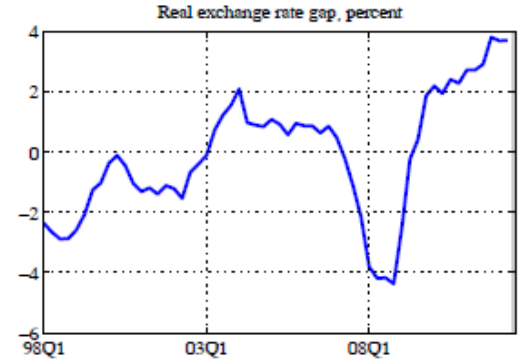
Estonia

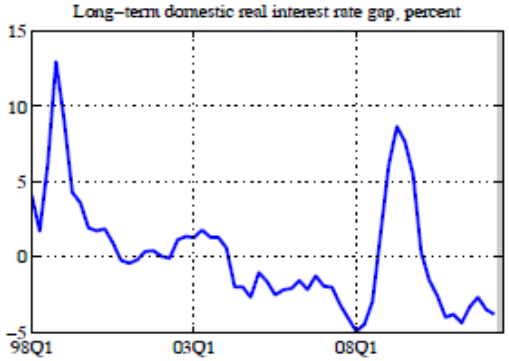

Real GDP (100*log)
Level
Trend
340
320
300
280
260
98Q1
03Q1
08Q1

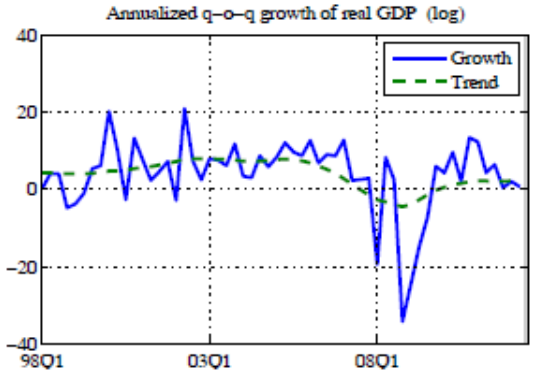

Real exchange rate (log)
Level
Trend
290
280
270
260
250
98Q1
03Q1
08Q1

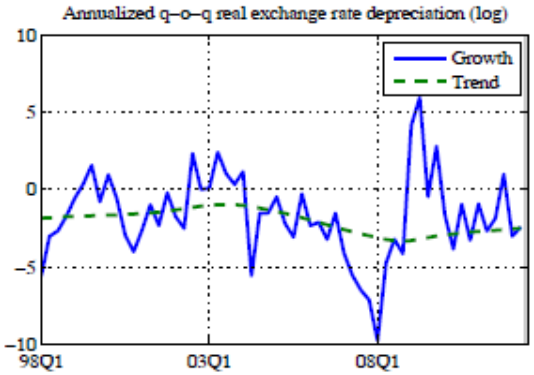

Long−term domestic real interest rate (log)
Level
Trend
15
10
5
0
−5
98Q1
03Q1
08Q1

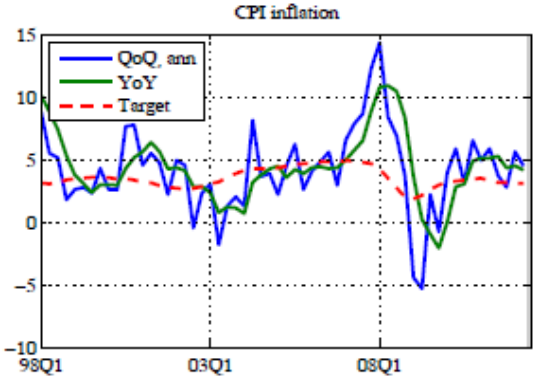

Output gap, percent
Domestic
Foreign − EU27 (−1)
10
5
0
−5
−10
98Q1
03Q1
08Q1


Real exchange rate gap, percent
4
2
0
−2
−4
−6
98Q1
03Q1
08Q1

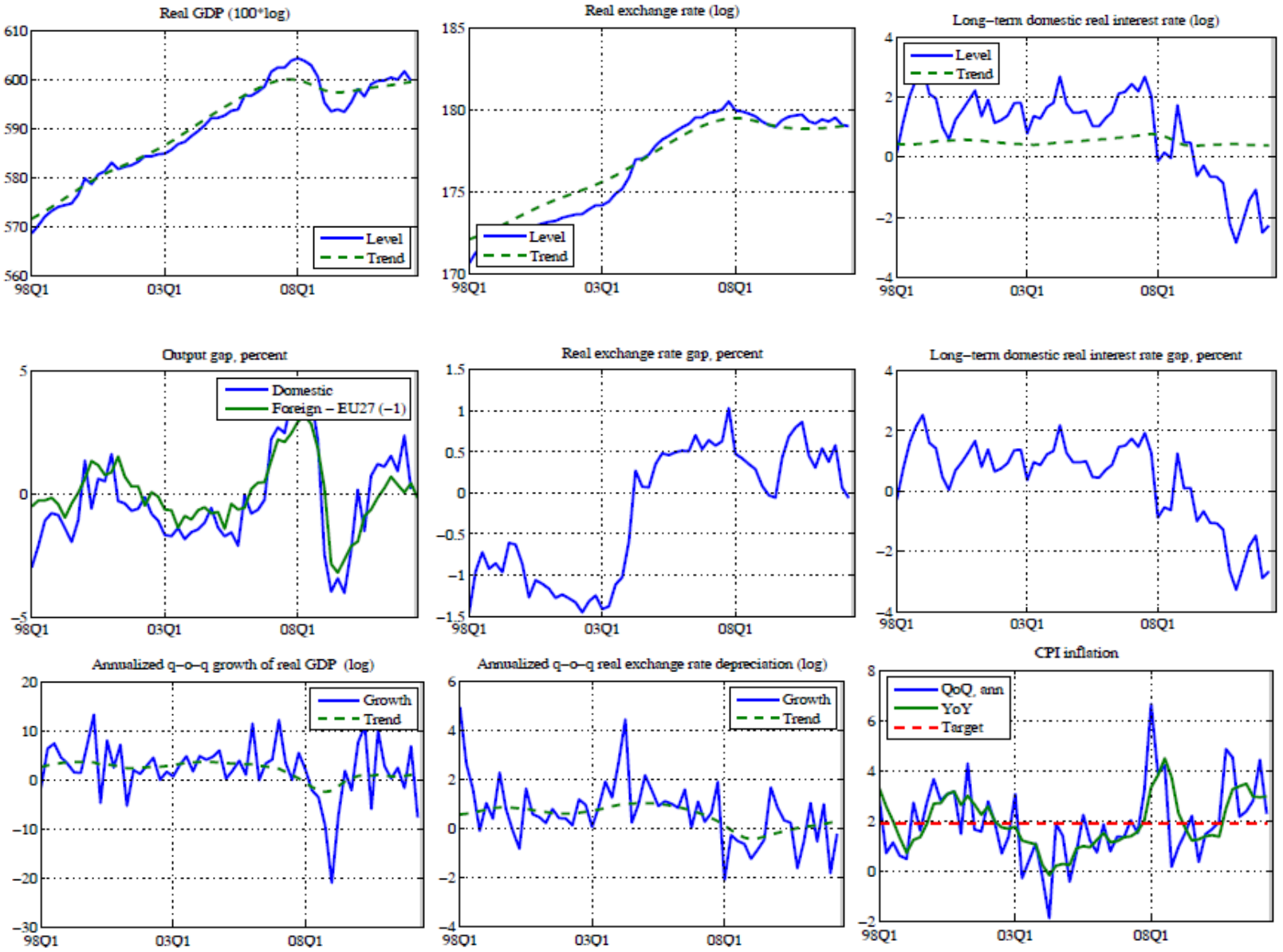

Long−term domestic real interest rate gap, percent
15
10
5
0
−5
98Q1
03Q1
08Q1


Annualized q−o−q growth of real GDP (log)
Growth
Trend
40
20
0
−20
−40
98Q1
03Q1
08Q1

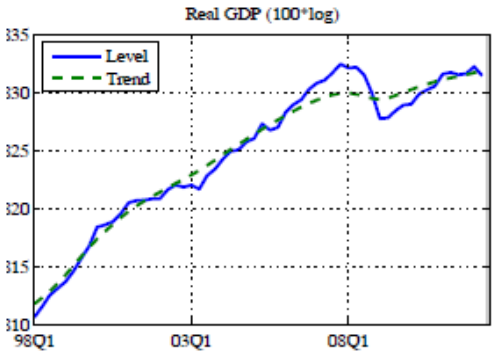

Annualized q−o−q real exchange rate depreciation (log)
Growth
Trend
10
5
0
−5
−10
98Q1
03Q1
08Q1

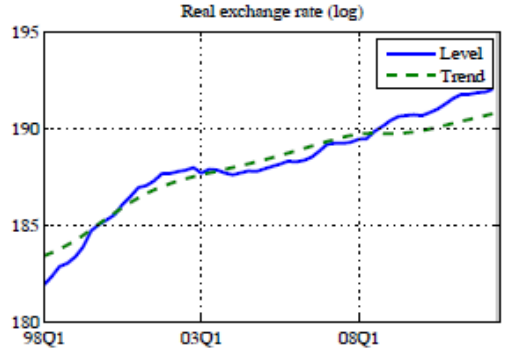

CPI inflation
QoQ, ann
YoY
Target
15
10
5
0
−5
−10
98Q1
03Q1
08Q1

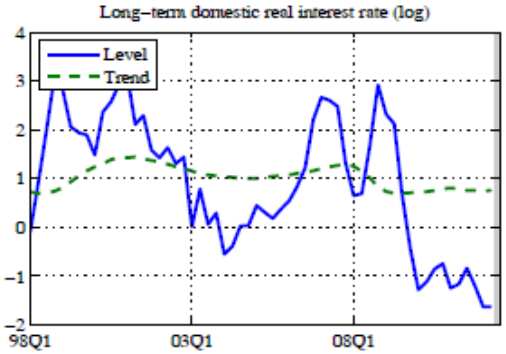
Finland

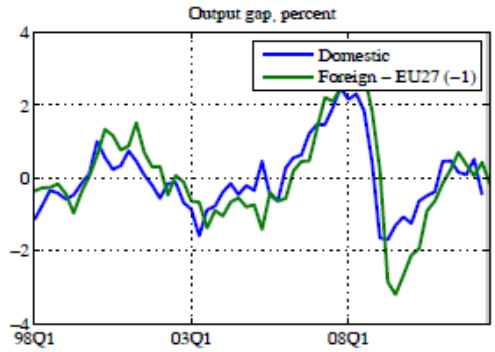

Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long−term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign − EU27 (−1)
Real exchange rate gap, percent
Long−term domestic real interest rate gap, percent
Annualized q−o−q growth of real GDP (log)
Growth
Trend
Annualized q−o−q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

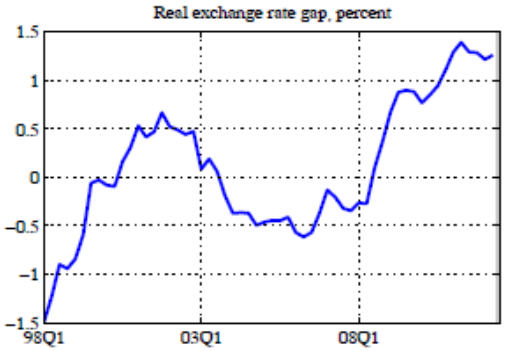
France

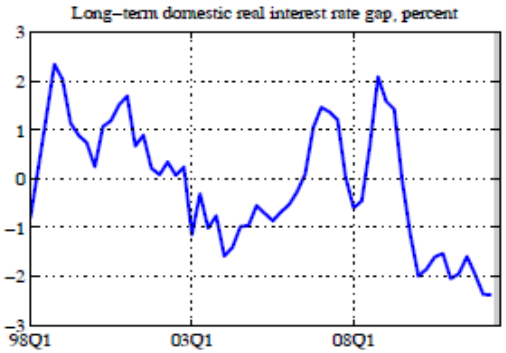

Real GDP (100*log)
Level
Trend
98Q1
03Q1
08Q1

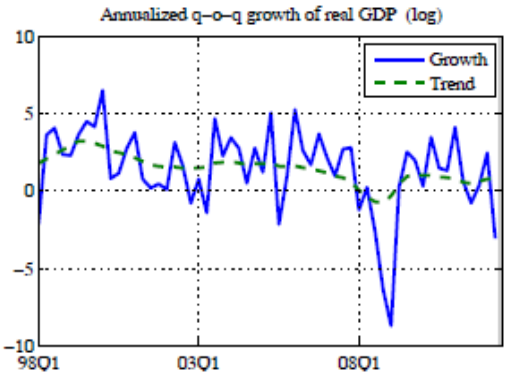

Real exchange rate (log)
Level
Trend
98Q1
03Q1
08Q1

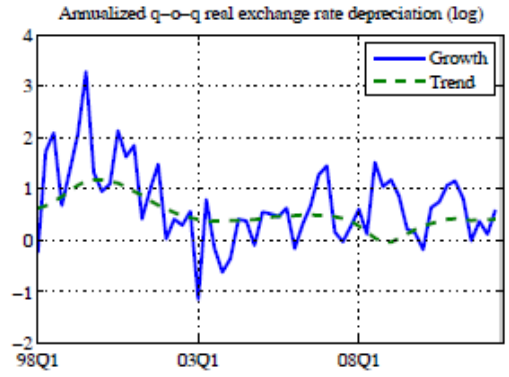

Long−term domestic real interest rate (log)
Level
Trend
98Q1
03Q1
08Q1

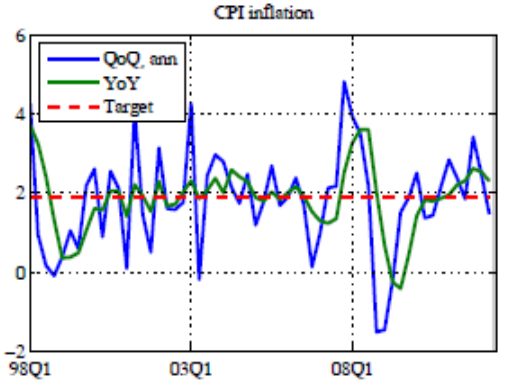

Output gap, percent
Domestic
Foreign − EU27 (−1)
98Q1
03Q1
08Q1


Real exchange rate gap, percent
98Q1
03Q1
08Q1

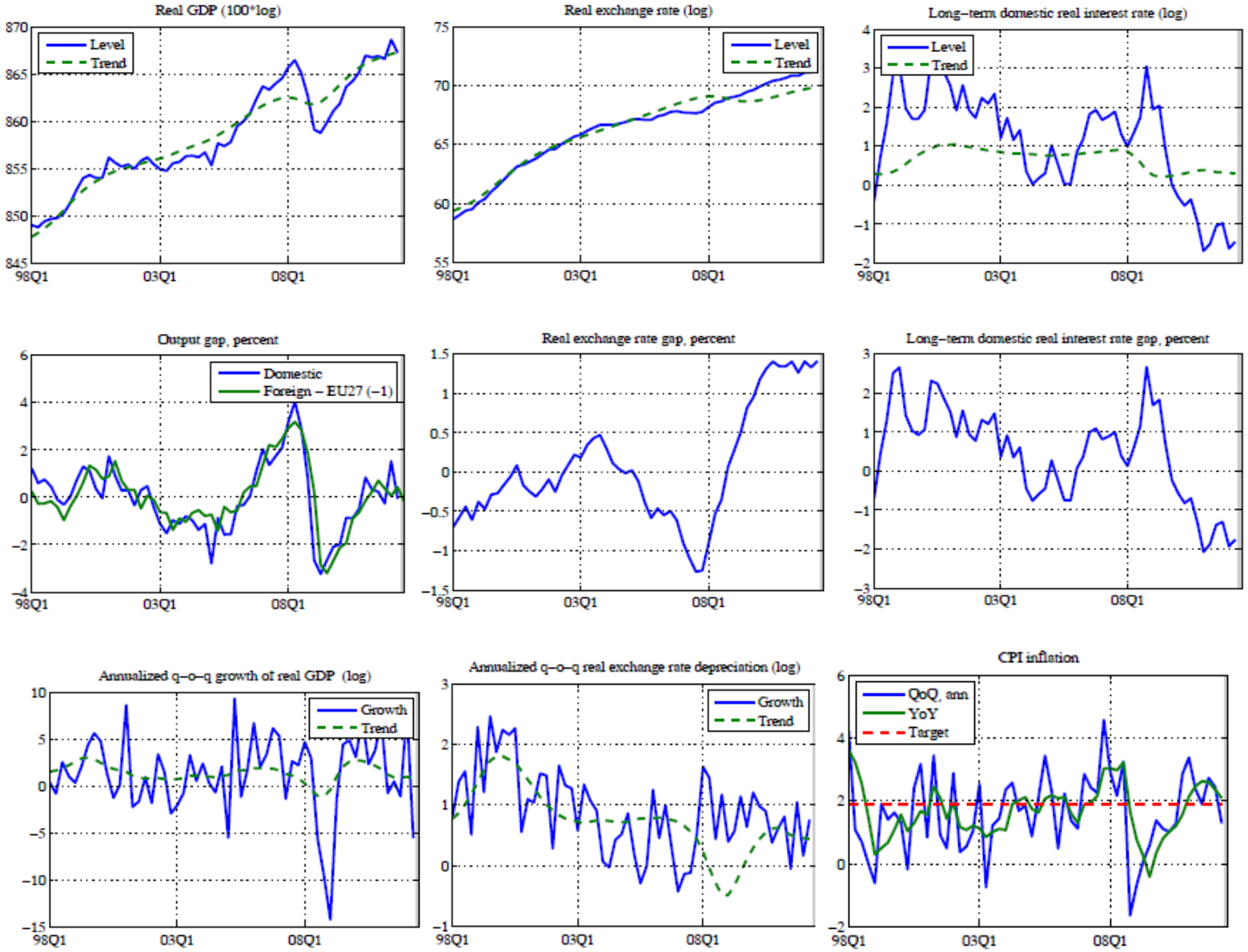

Long−term domestic real interest rate gap, percent
98Q1
03Q1
08Q1


Annualized q−o−q growth of real GDP (log)
Growth
Trend
98Q1
03Q1
08Q1

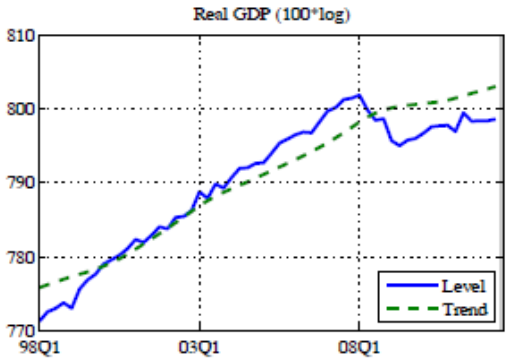

Annualized q−o−q real exchange rate depreciation (log)
Growth
Trend
98Q1
03Q1
08Q1

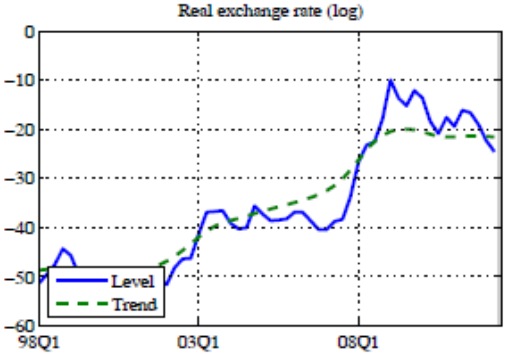

CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

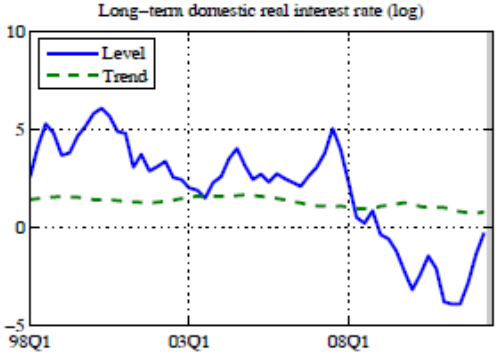
Germany

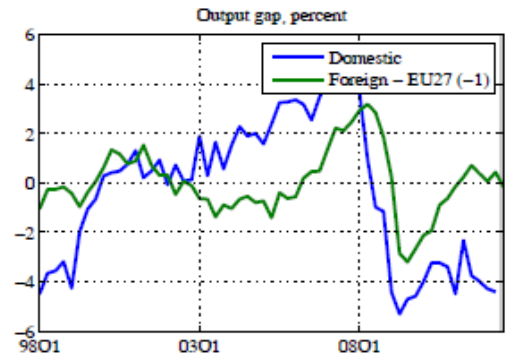

Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long–term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign – EU27 (–1)
Real exchange rate gap, percent
Long–term domestic real interest rate gap, percent
Annualized q–o–q growth of real GDP (log)
Growth
Trend
Annualized q–o–q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

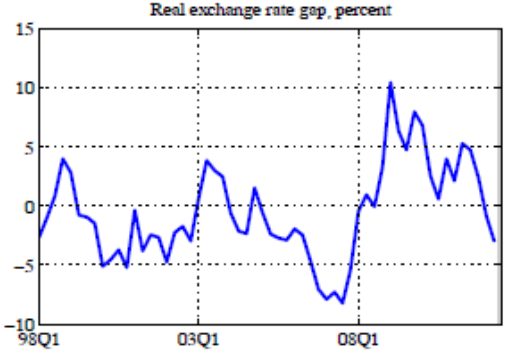
Great Britain

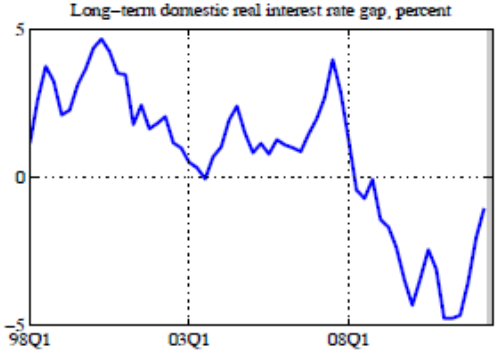


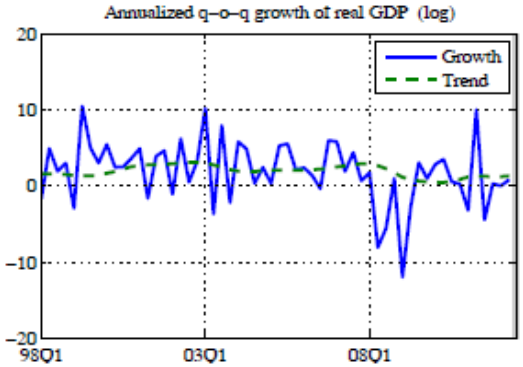


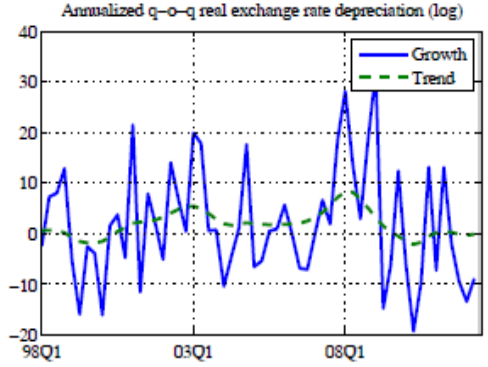


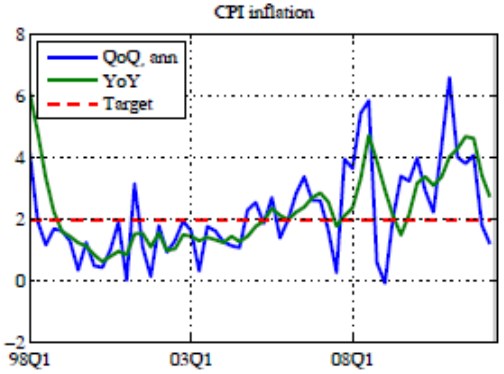




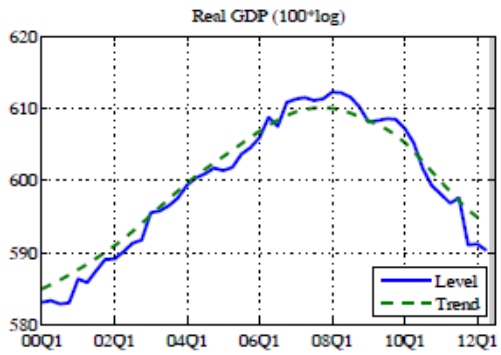


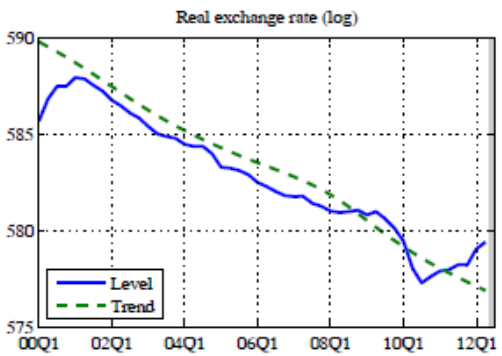


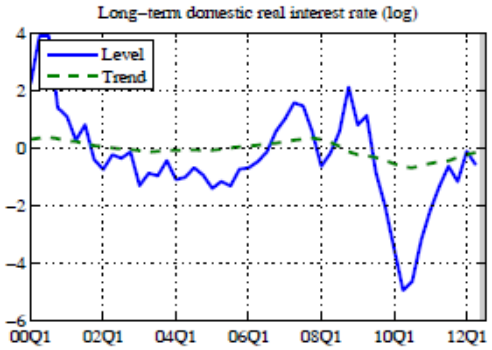


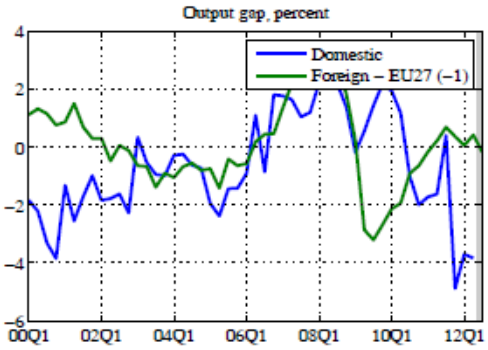


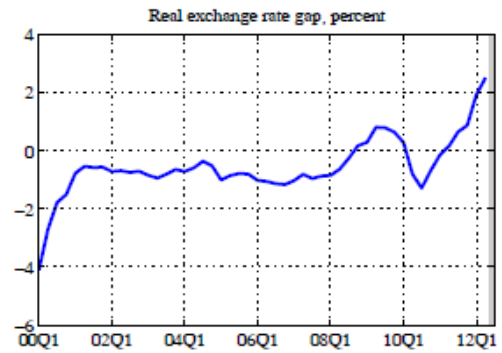
Greece

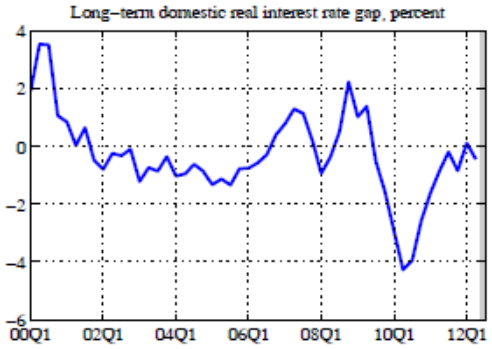

Real GDP (100*log)
Level
Trend

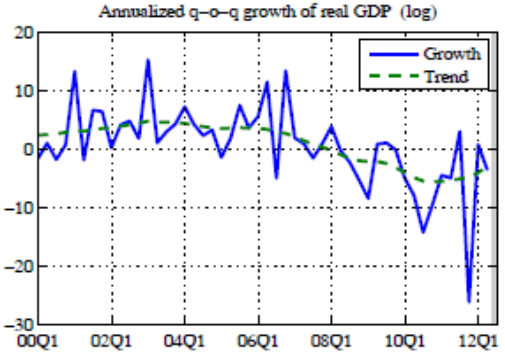

Real exchange rate (log)
Level
Trend

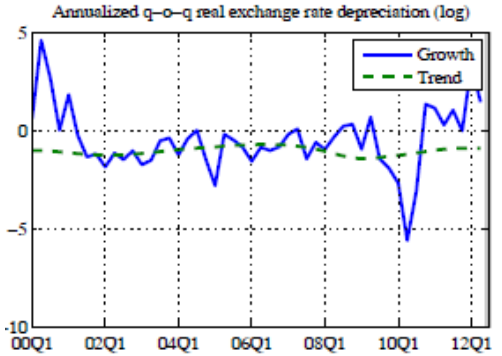

Long−term domestic real interest rate (log)
Level
Trend

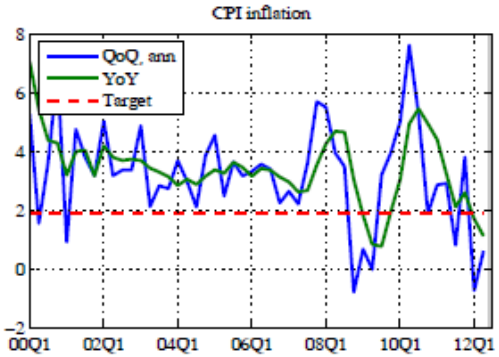

Output gap, percent
Domestic
Foreign − EU27 (−1)


Real exchange rate gap, percent

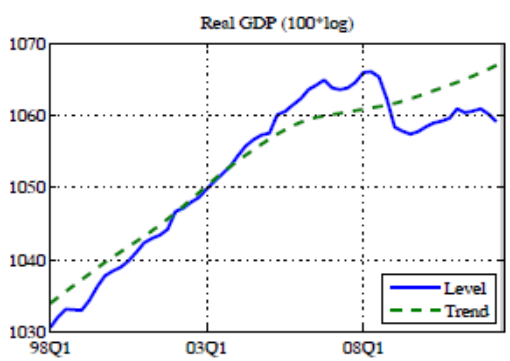

Long−term domestic real interest rate gap, percent

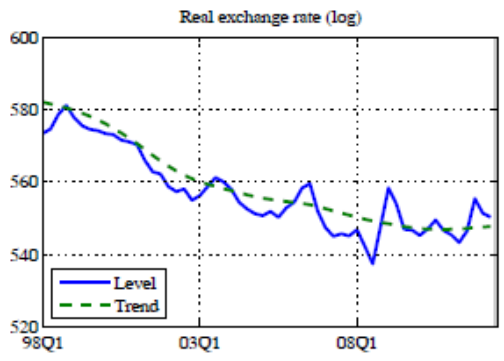

Annualized q−o−q growth of real GDP (log)
Growth
Trend

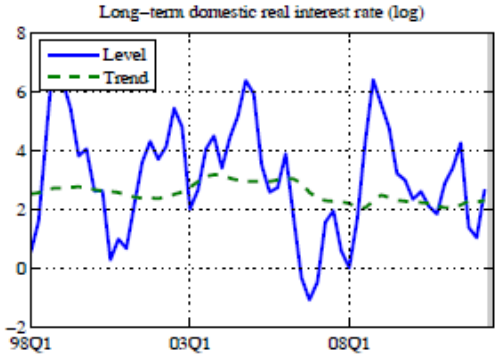

Annualized q−o−q real exchange rate depreciation (log)
Growth
Trend

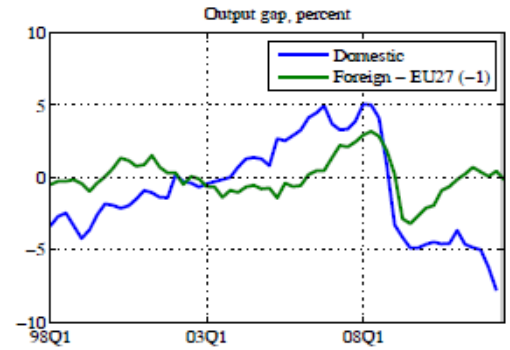

CPI inflation
QoQ, ann
YoY
Target

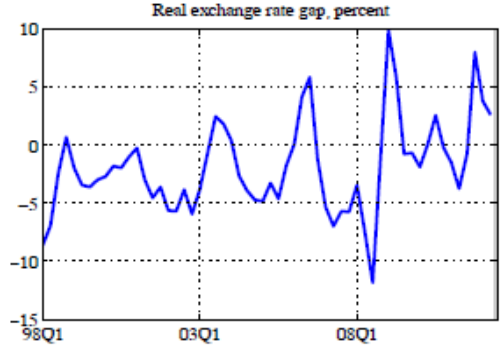
Hungary

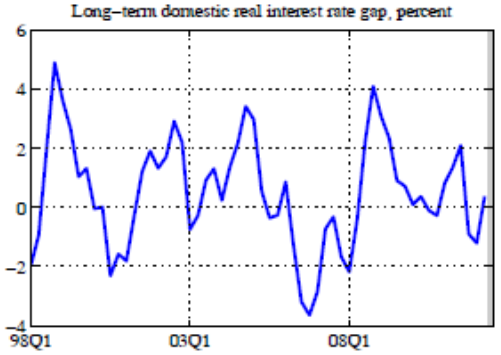

Real GDP (100*log)
Level
Trend
98Q1
03Q1
08Q1

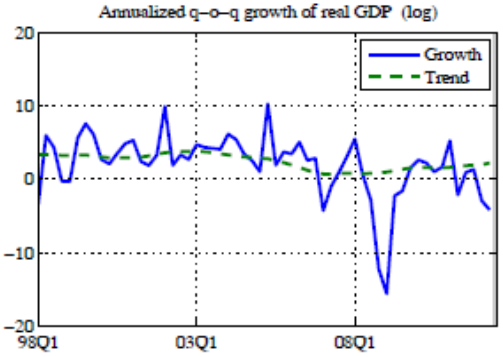

Real exchange rate (log)
Level
Trend
98Q1
03Q1
08Q1

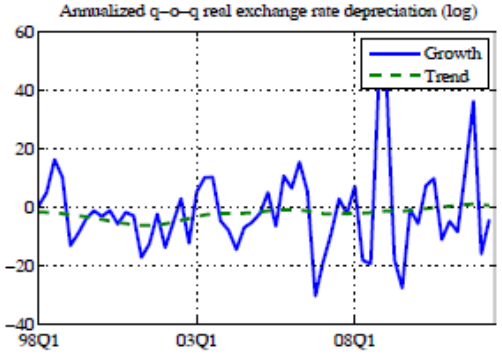

Long−term domestic real interest rate (log)
Level
Trend
98Q1
03Q1
08Q1

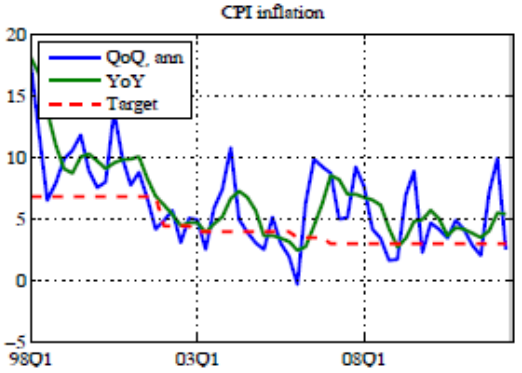

Output gap, percent
Domestic
Foreign − EU27 (−1)
98Q1
03Q1
08Q1


Real exchange rate gap, percent
98Q1
03Q1
08Q1

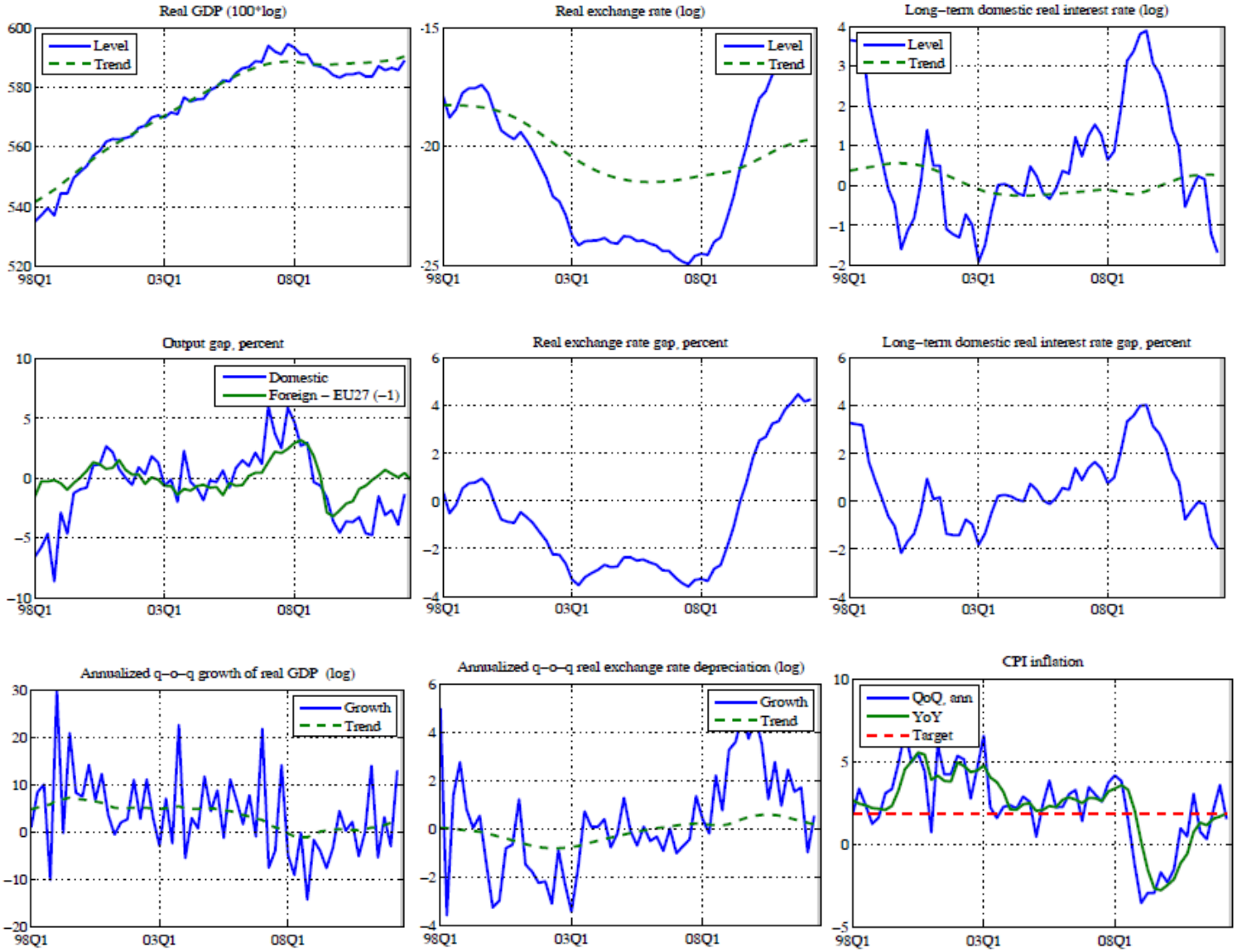

Long−term domestic real interest rate gap, percent
98Q1
03Q1
08Q1


Annualized q−o−q growth of real GDP (log)
Growth
Trend
98Q1
03Q1
08Q1

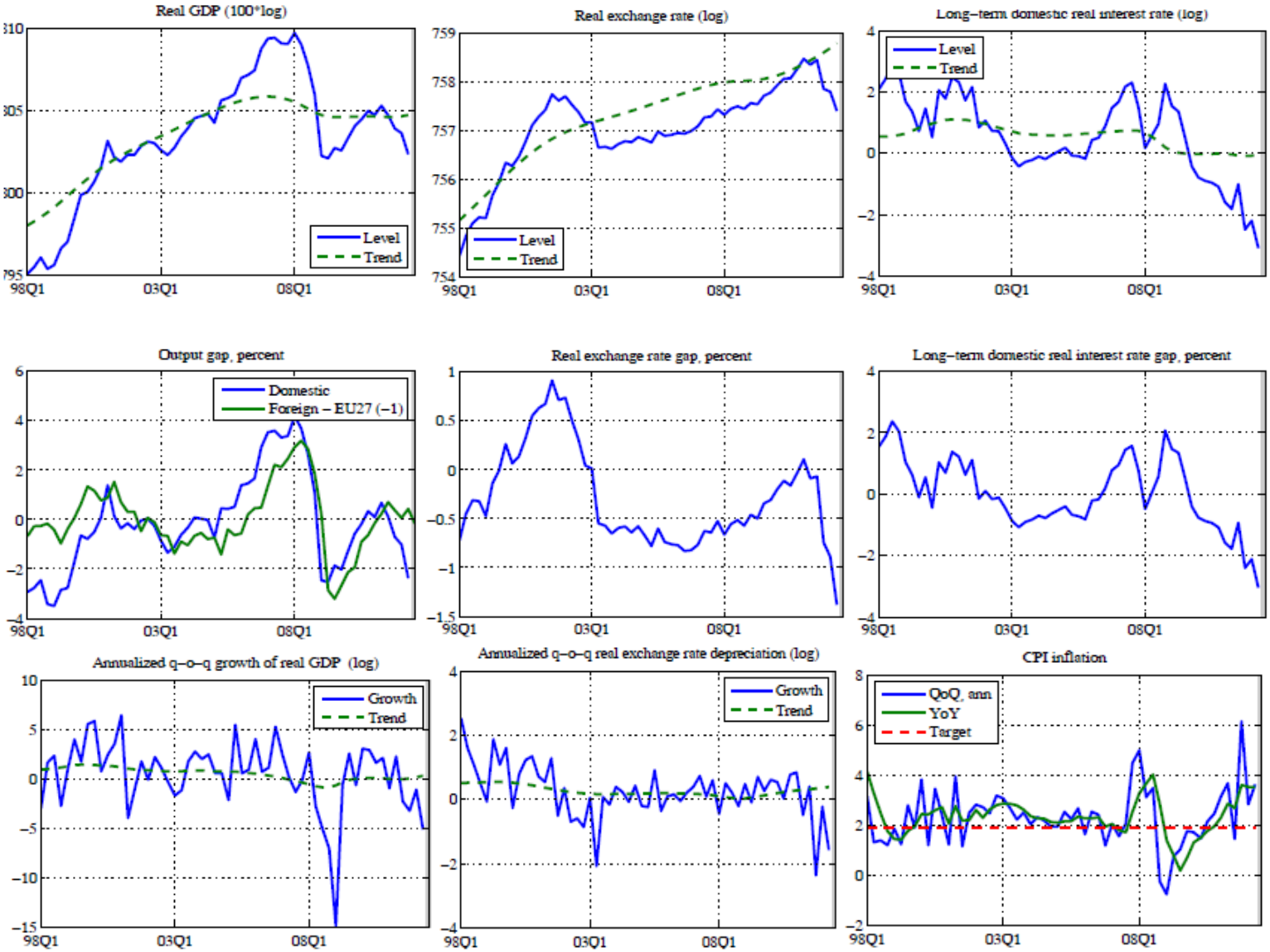

Annualized q−o−q real exchange rate depreciation (log)
Growth
Trend
98Q1
03Q1
08Q1


CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

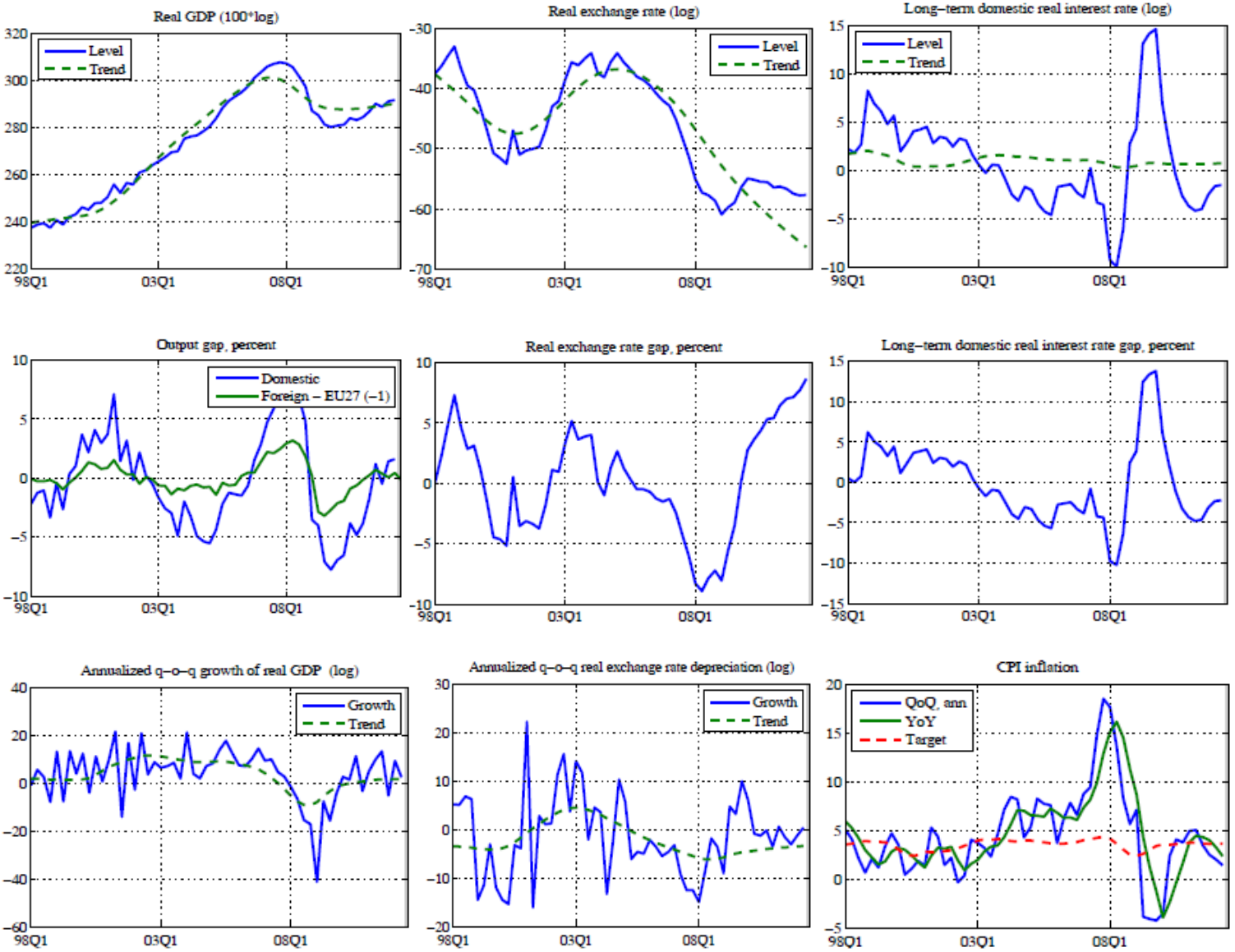
Ireland


Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long−term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign − EU27 (−1)
Real exchange rate gap, percent
Long−term domestic real interest rate gap, percent
Annualized q−o−q growth of real GDP (log)
Growth
Trend
Annualized q−o−q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

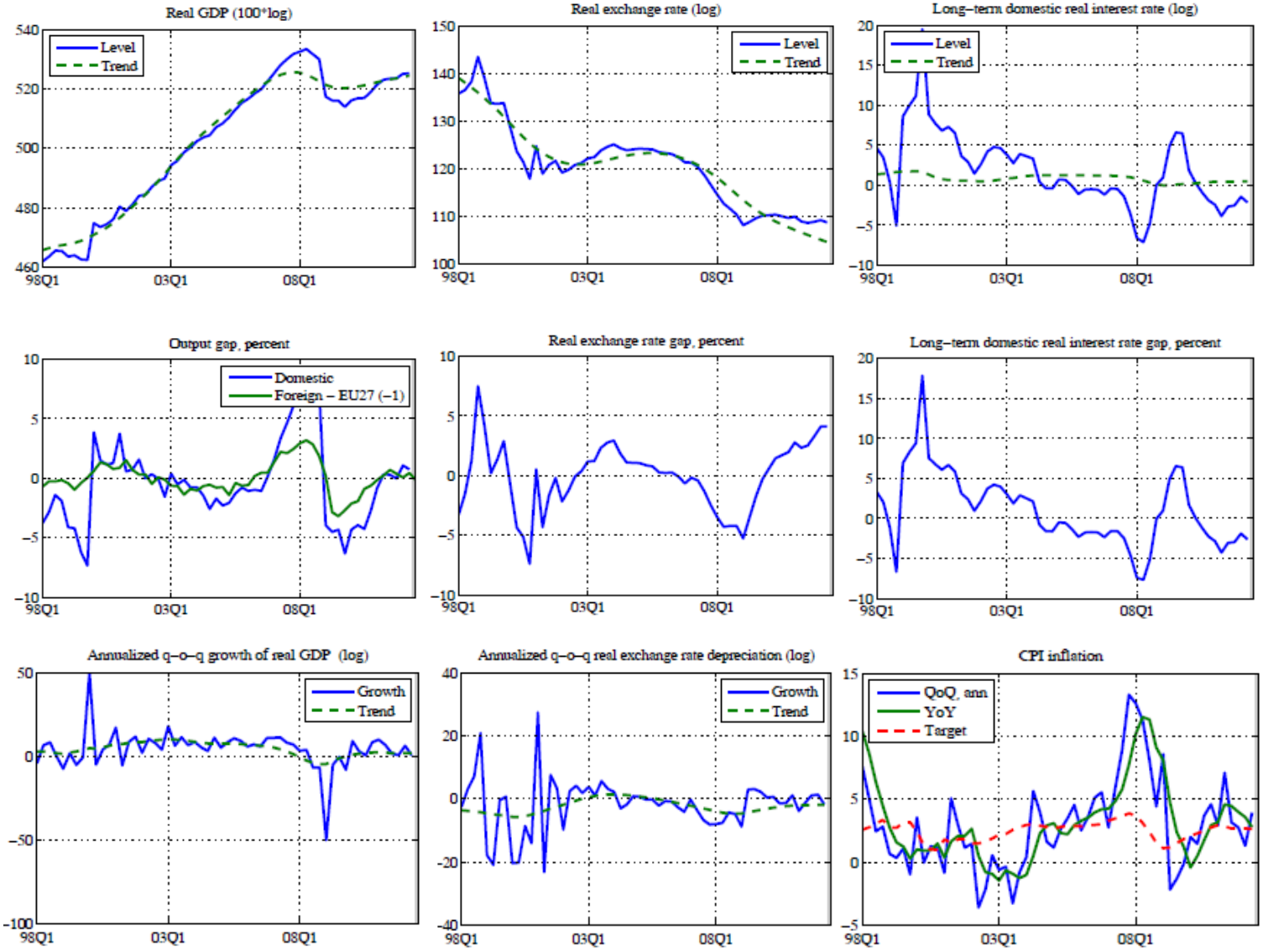
Italy


Real GDP (100*log)
Level
Trend
98Q1
03Q1
08Q1
Real exchange rate (log)
Level
Trend
Long–term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign – EU27 (–1)
Real exchange rate gap, percent
Long–term domestic real interest rate gap, percent
Annualized q–o–q growth of real GDP (log)
Growth
Trend
Annualized q–o–q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target

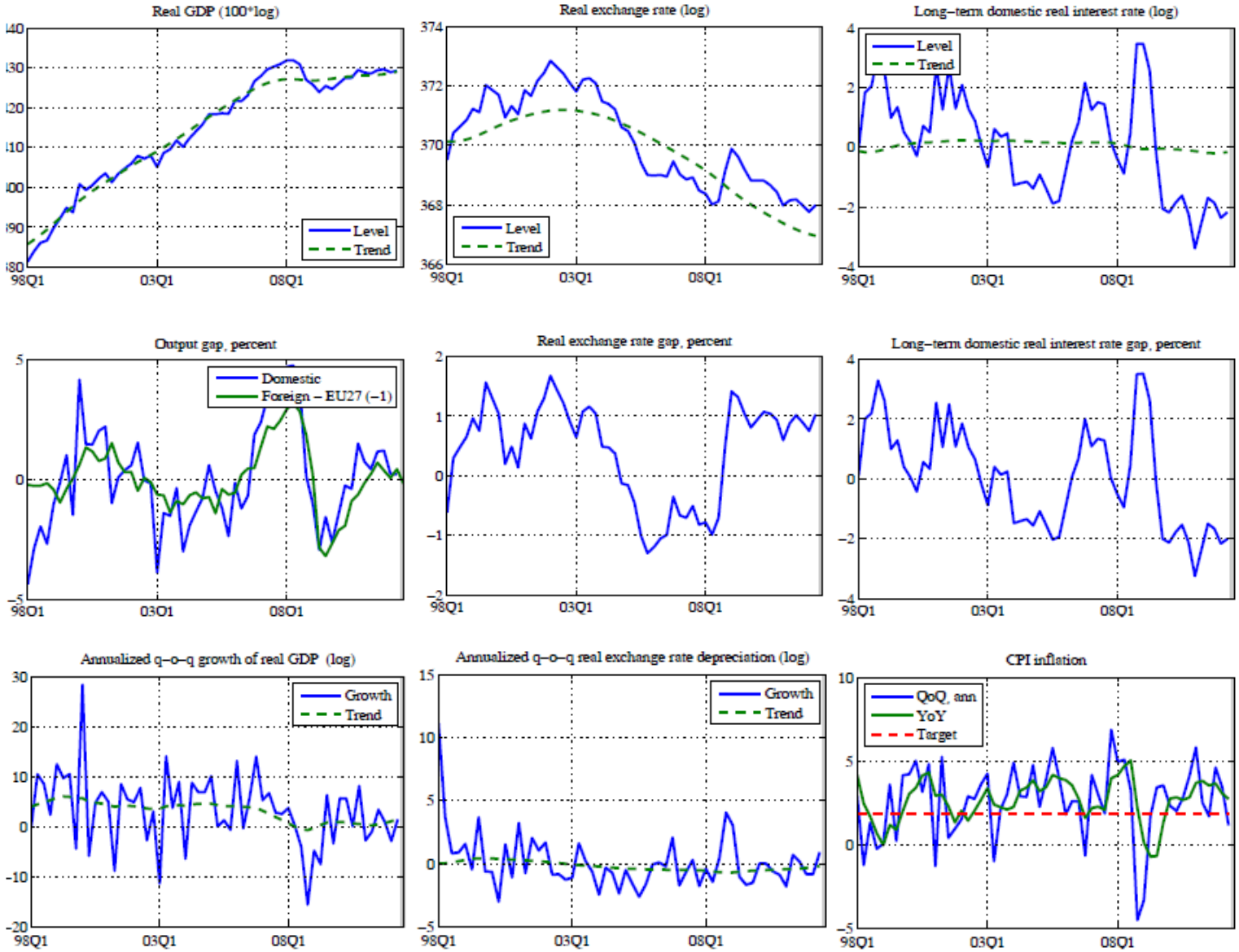
Latvia


Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long–term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign – EU27 (–1)
Real exchange rate gap, percent
Long–term domestic real interest rate gap, percent
Annualized q–o–q growth of real GDP (log)
Growth
Trend
Annualized q–o–q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

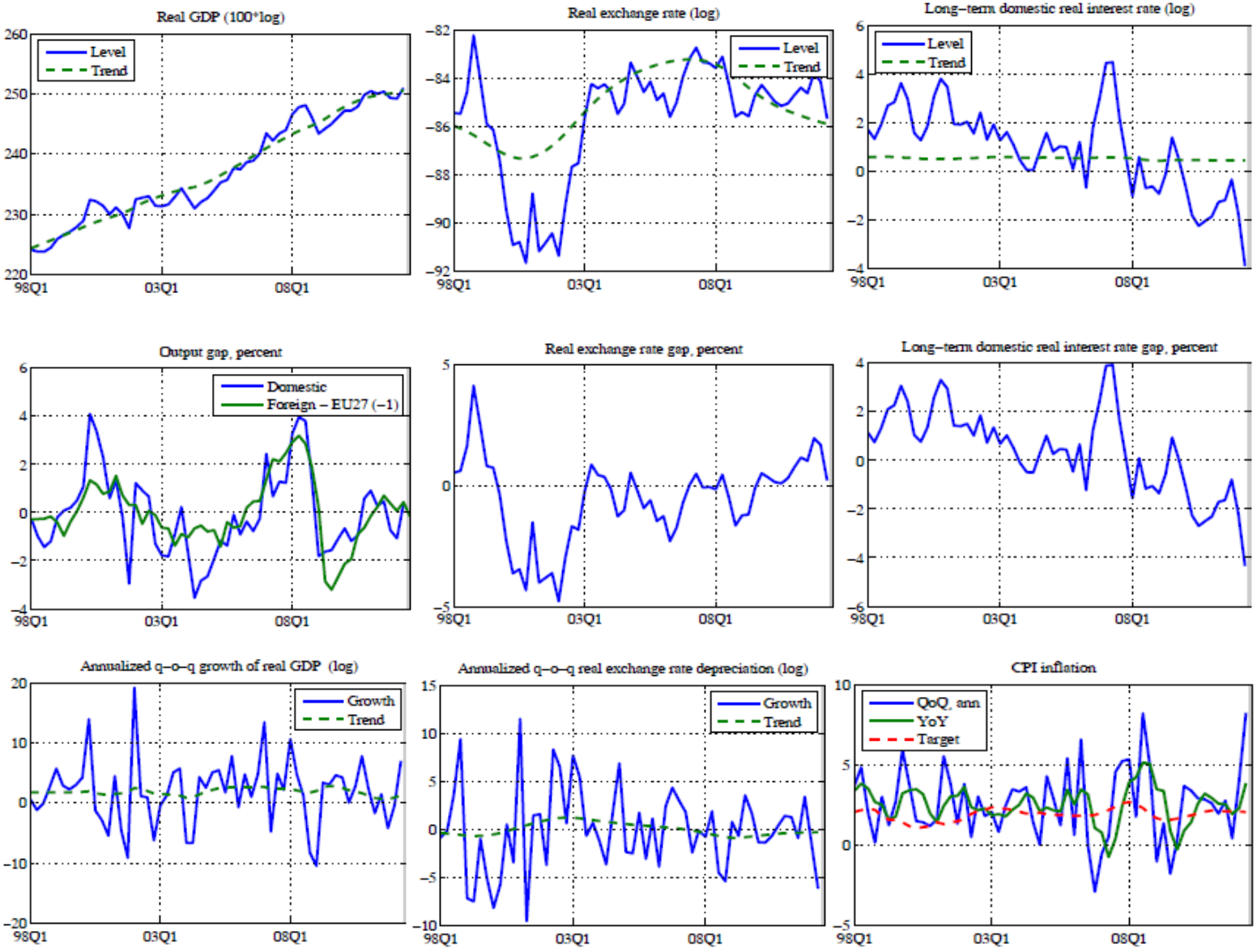
Lithuania


Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long–term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign – EU27 (–1)
Real exchange rate gap, percent
Long–term domestic real interest rate gap, percent
Annualized q–o–q growth of real GDP (log)
Growth
Trend
Annualized q–o–q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

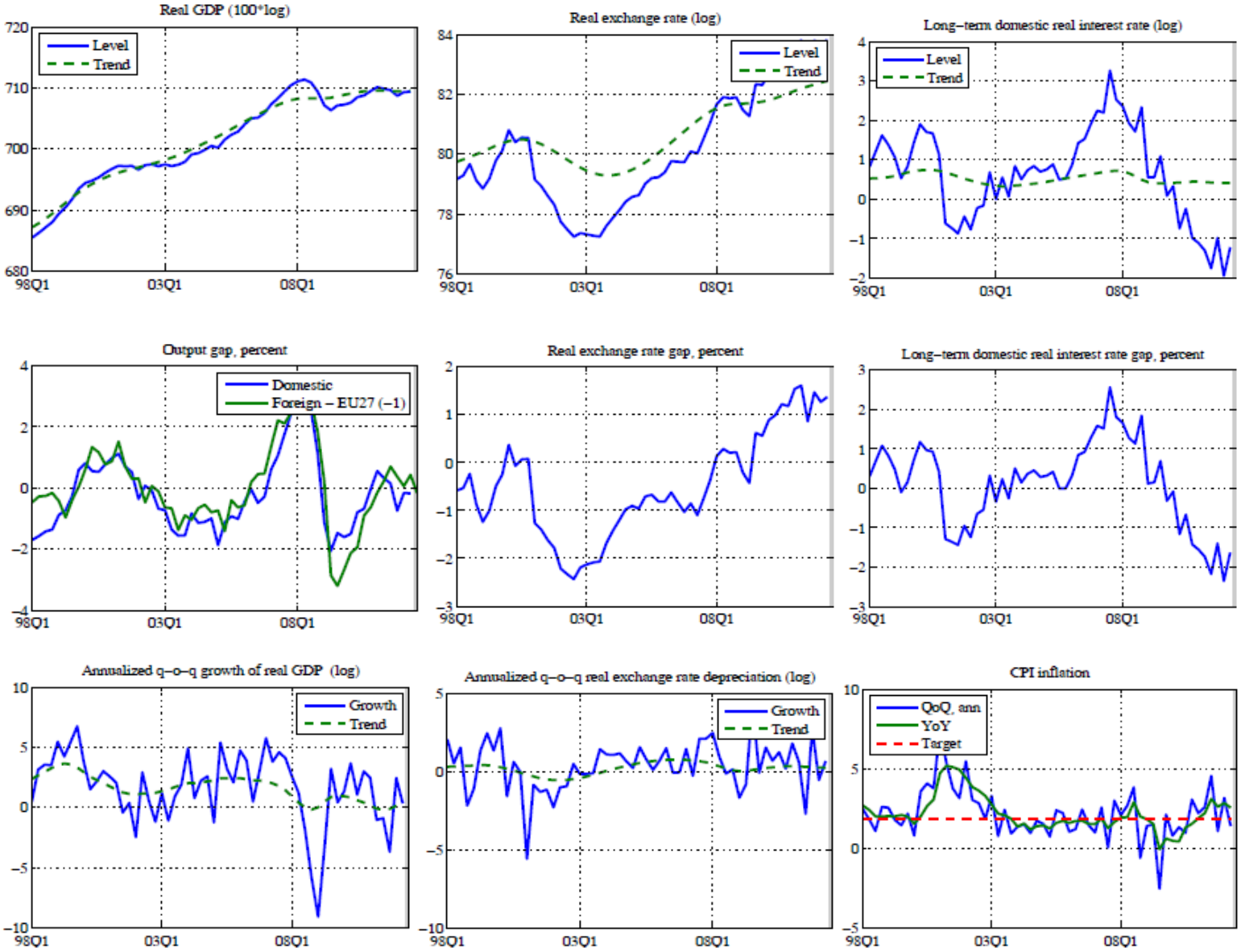
Luxembourg


Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long–term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign – EU27 (–1)
Real exchange rate gap, percent
Long–term domestic real interest rate gap, percent
Annualized q–o–q growth of real GDP (log)
Growth
Trend
Annualized q–o–q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

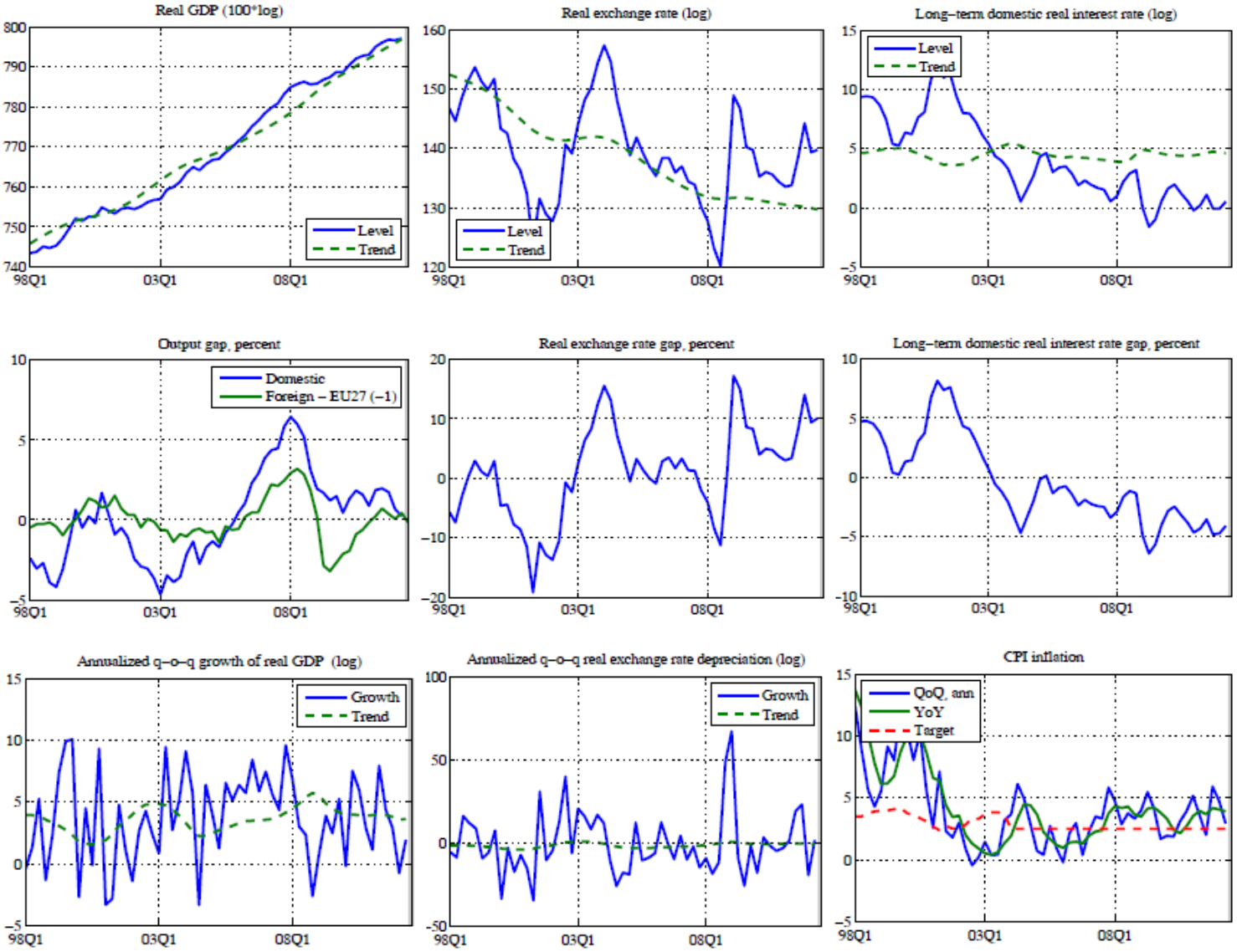
Malta


Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long–term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign – EU27 (–1)
Real exchange rate gap, percent
Long–term domestic real interest rate gap, percent
Annualized q–o–q growth of real GDP (log)
Growth
Trend
Annualized q–o–q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

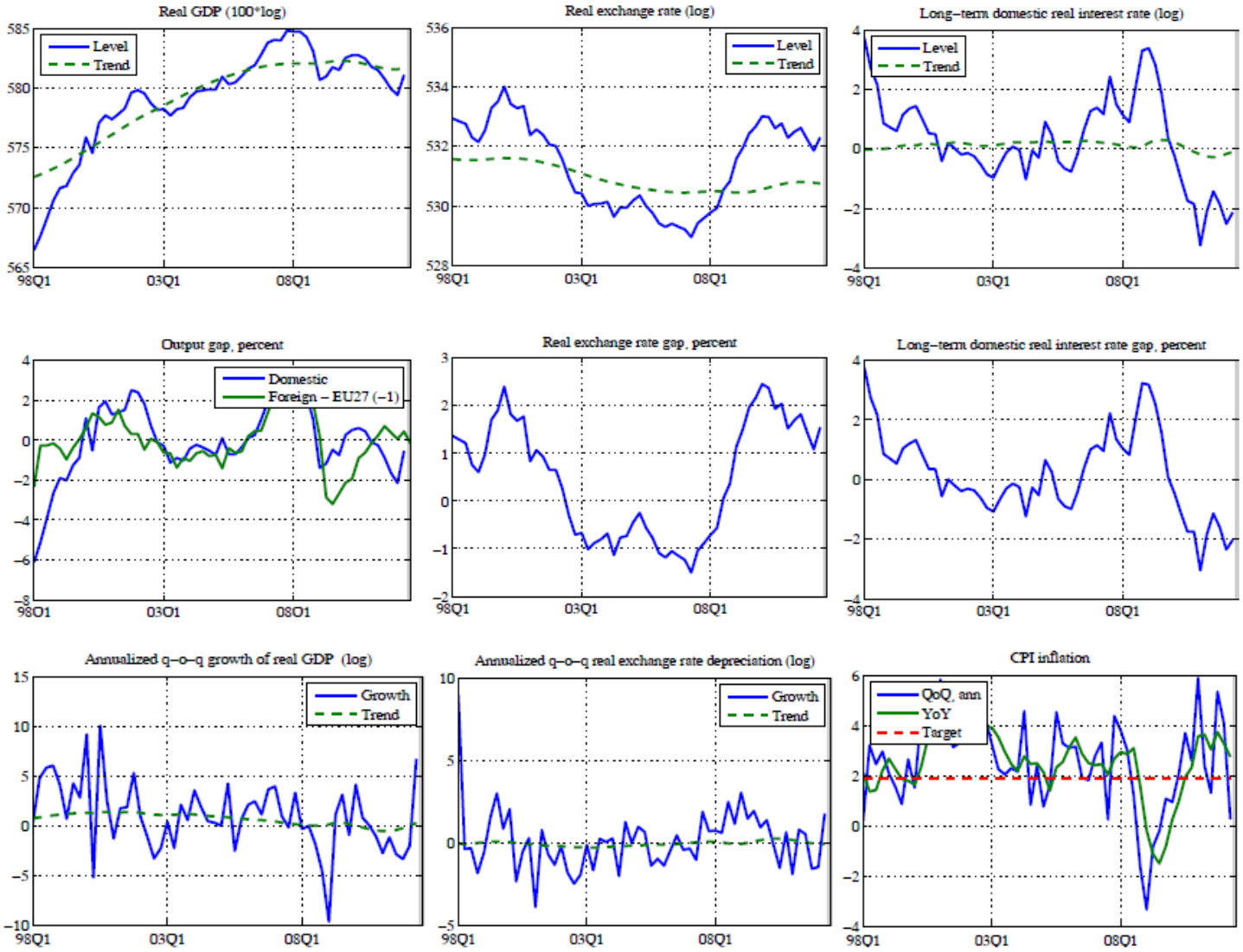
Netherlands



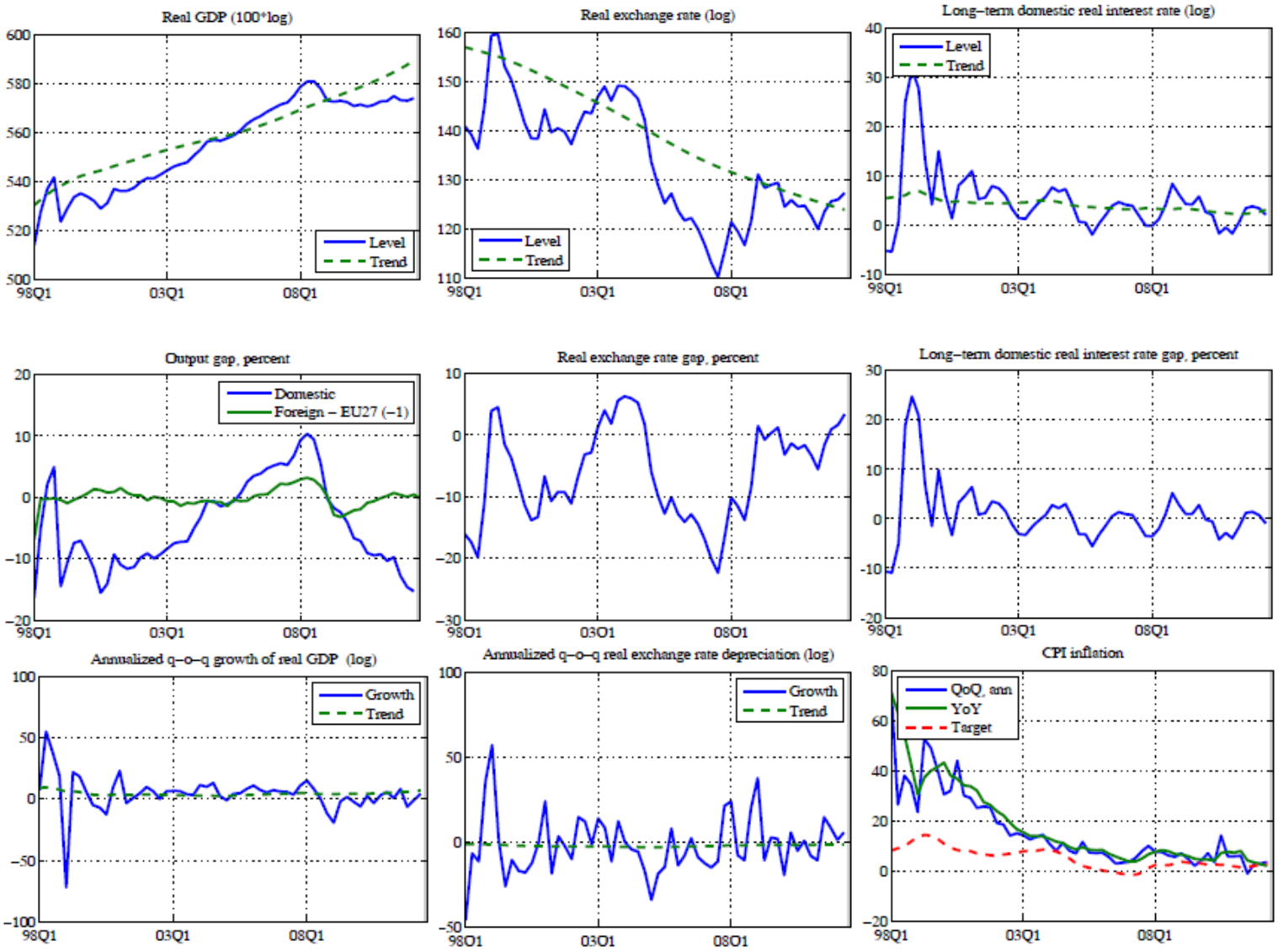
Poland


Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long–term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign – EU27 (–1)
Real exchange rate gap, percent
Long–term domestic real interest rate gap, percent
Annualized q–o–q growth of real GDP (log)
Growth
Trend
Annualized q–o–q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

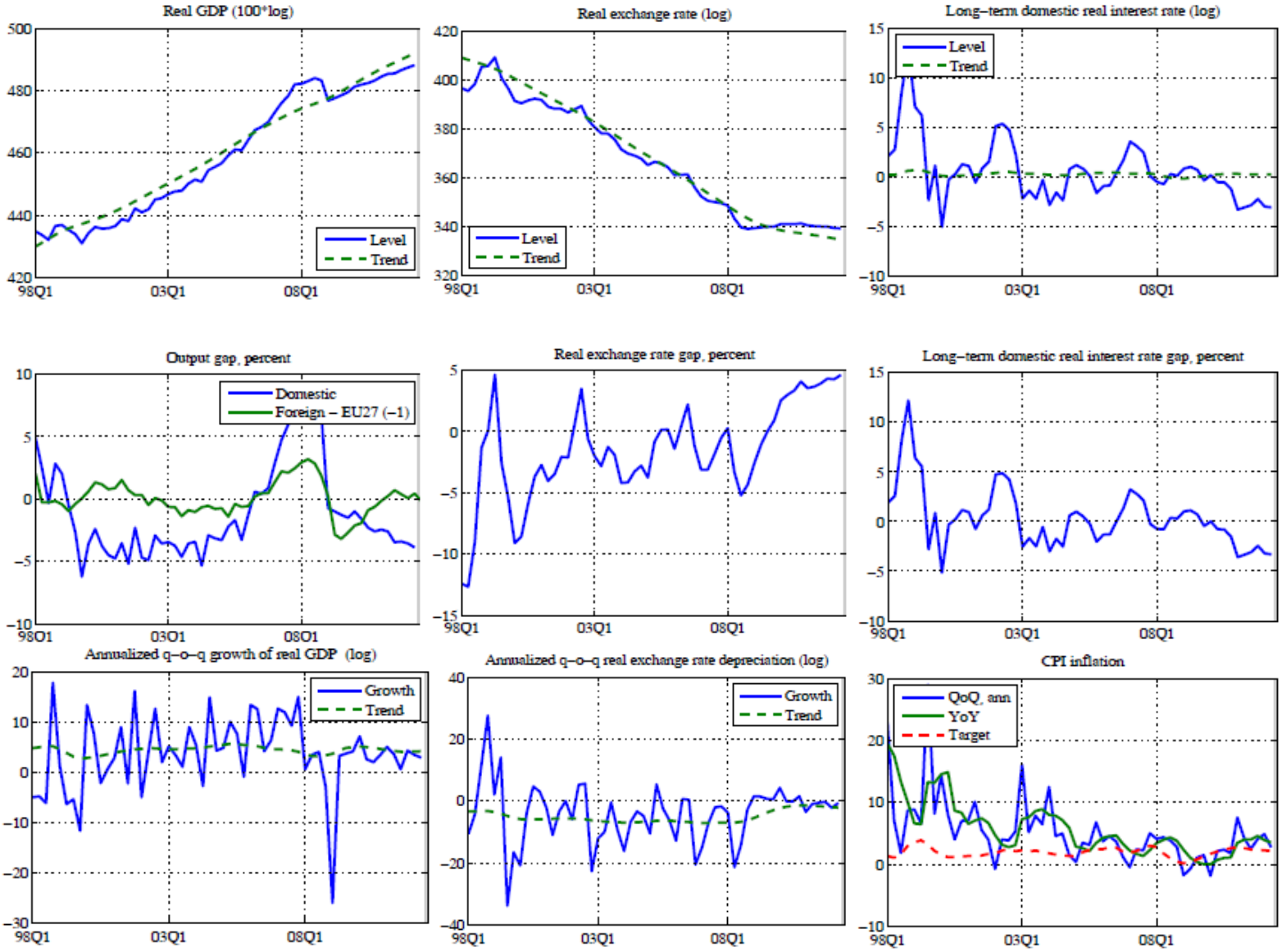
Portugal


Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long−term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign − EU27 (−1)
Real exchange rate gap, percent
Long−term domestic real interest rate gap, percent
Annualized q−o−q growth of real GDP (log)
Growth
Trend
Annualized q−o−q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

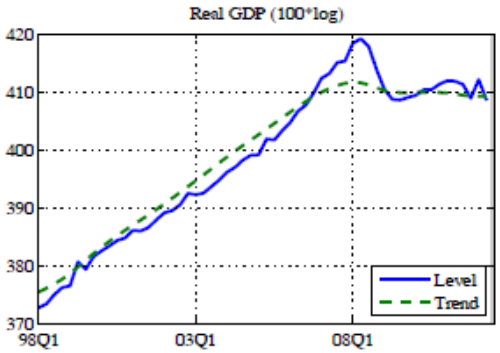
Romania

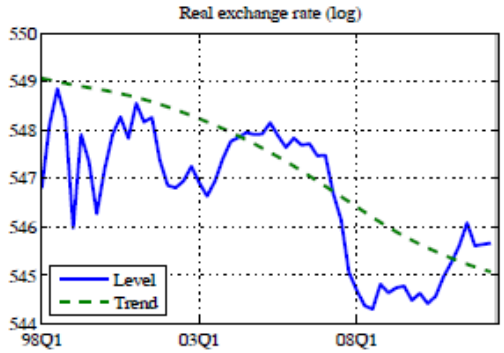

Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long−term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign − EU27 (−1)
Real exchange rate gap, percent
Long−term domestic real interest rate gap, percent
Annualized q−o−q growth of real GDP (log)
Growth
Trend
Annualized q−o−q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

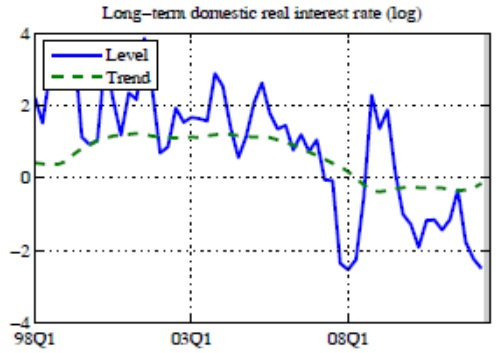
Slovakia

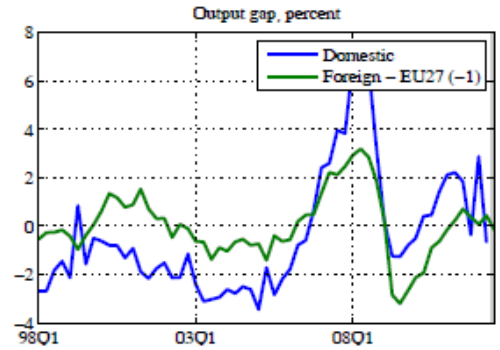

Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long–term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign – EU27 (–1)
Real exchange rate gap, percent
Long–term domestic real interest rate gap, percent
Annualized q–o–q growth of real GDP (log)
Growth
Trend
Annualized q–o–q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

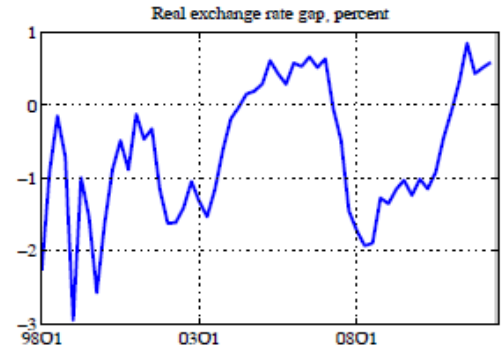
Slovenia

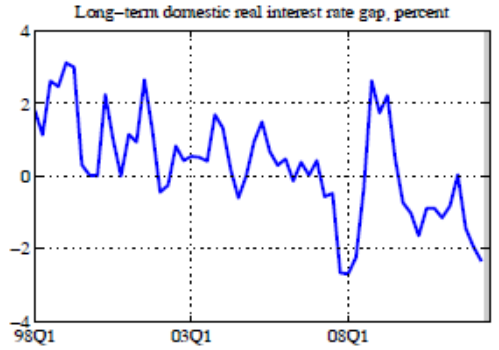

Real GDP (100*log)
Level
Trend
98Q1
03Q1
08Q1

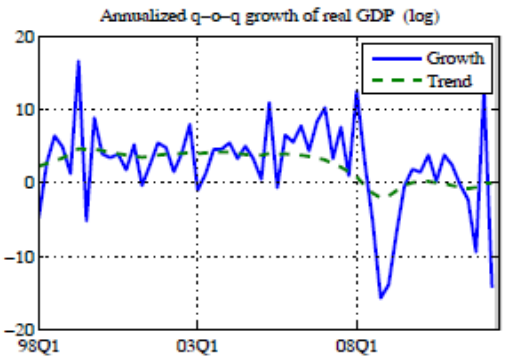

Real exchange rate (log)
Level
Trend
98Q1
03Q1
08Q1

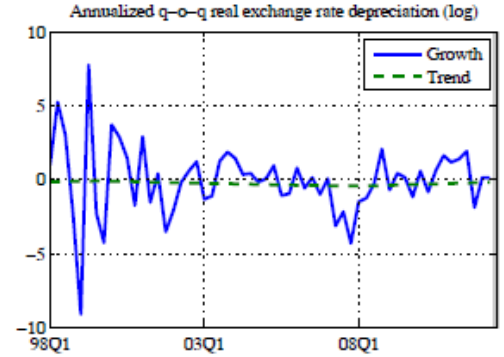

Long−term domestic real interest rate (log)
Level
Trend
98Q1
03Q1
08Q1

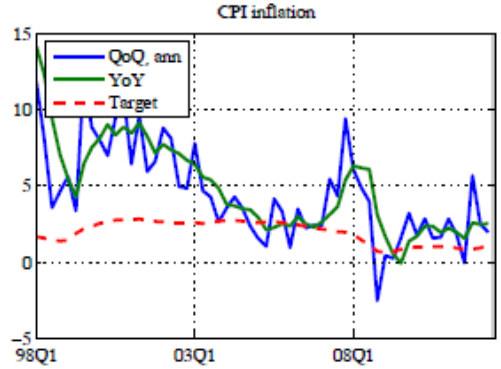

Output gap, percent
Domestic
Foreign − EU27 (−1)
98Q1
03Q1
08Q1


Real exchange rate gap, percent
98Q1
03Q1
08Q1

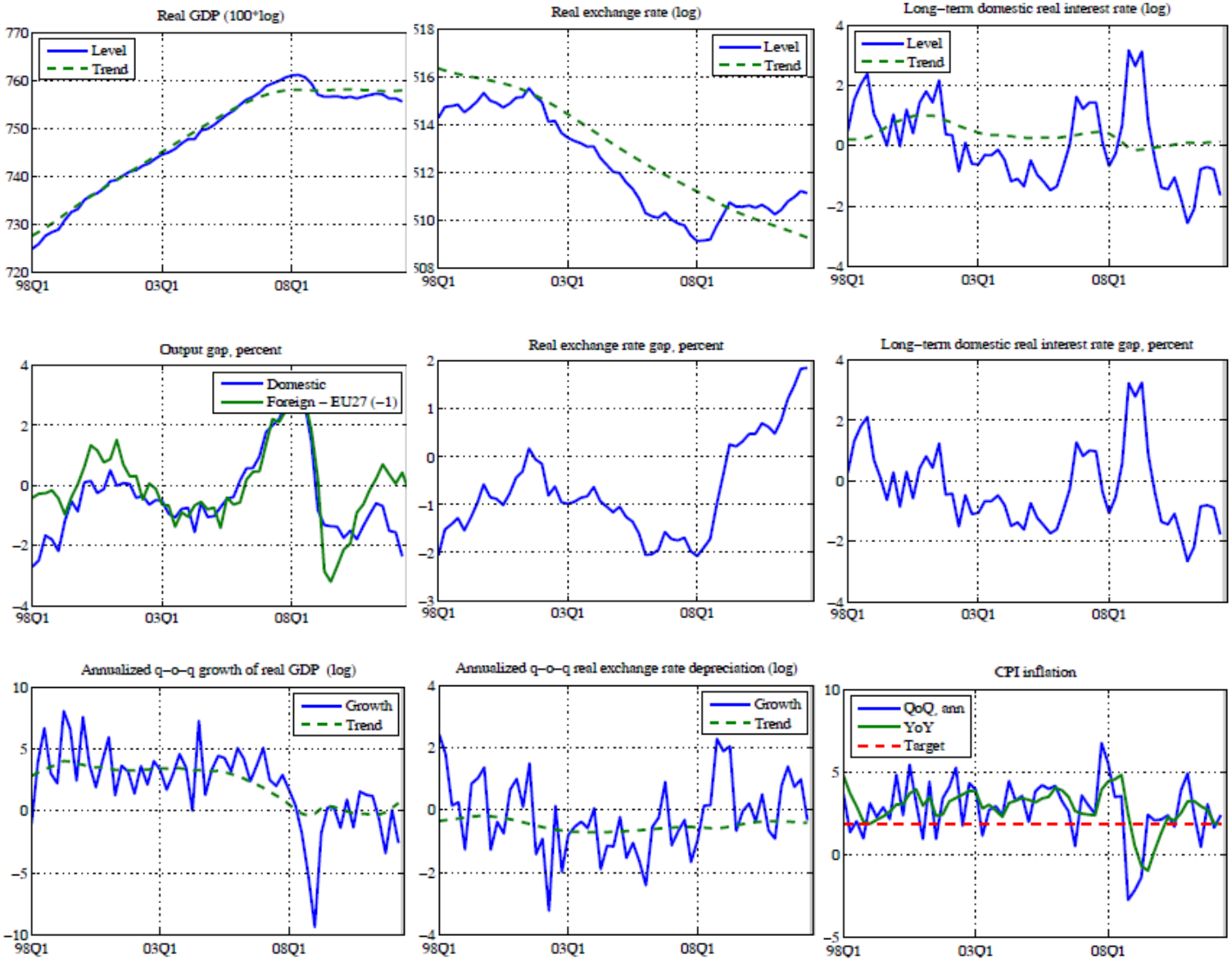

Long−term domestic real interest rate gap, percent
98Q1
03Q1
08Q1


Annualized q−o−q growth of real GDP (log)
Growth
Trend
98Q1
03Q1
08Q1

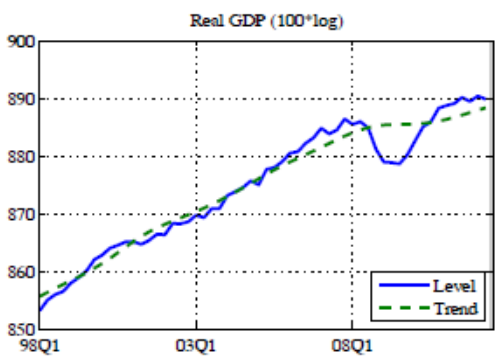

Annualized q−o−q real exchange rate depreciation (log)
Growth
Trend
98Q1
03Q1
08Q1

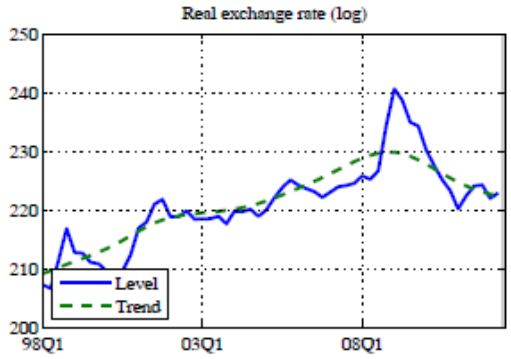

CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

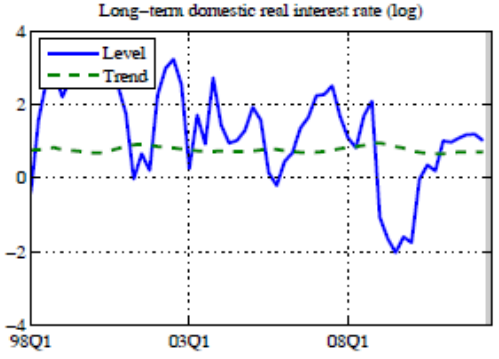
Spain

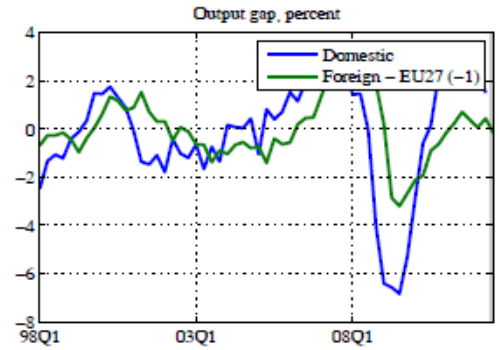

Real GDP (100*log)
Level
Trend
Real exchange rate (log)
Level
Trend
Long–term domestic real interest rate (log)
Level
Trend
Output gap, percent
Domestic
Foreign – EU27 (–1)
Real exchange rate gap, percent
Long–term domestic real interest rate gap, percent
Annualized q–o–q growth of real GDP (log)
Growth
Trend
Annualized q–o–q real exchange rate depreciation (log)
Growth
Trend
CPI inflation
QoQ, ann
YoY
Target
98Q1
03Q1
08Q1

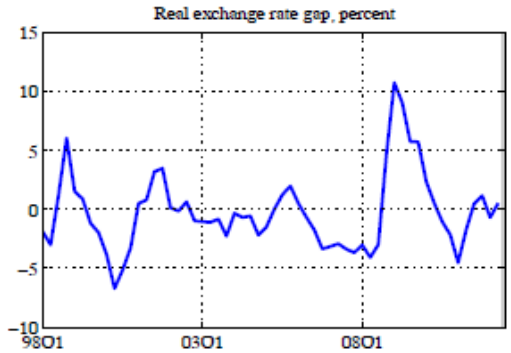
Sweden

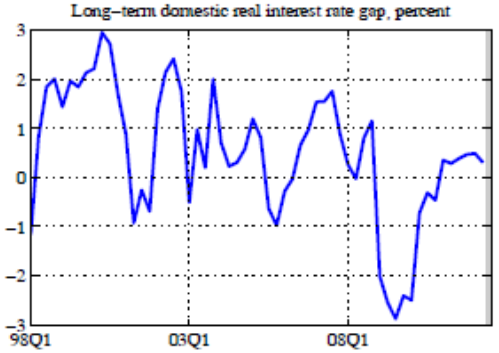

Real GDP (100*log)
900
890
880
870
860
850
98Q1
03Q1
08Q1
Level
Trend

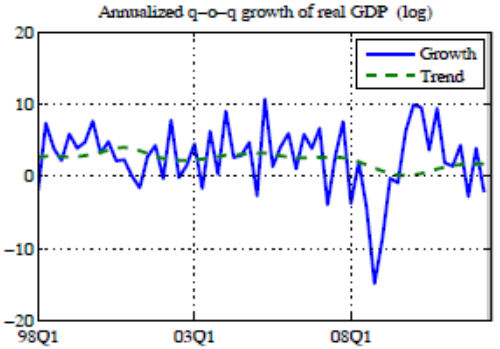

Real exchange rate (log)
250
240
230
220
210
200
98Q1
03Q1
08Q1
Level
Trend

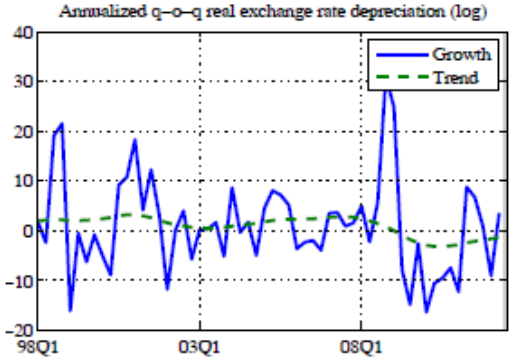

Long−term domestic real interest rate (log)
4
2
0
−2
−4
98Q1
03Q1
08Q1
Level
Trend

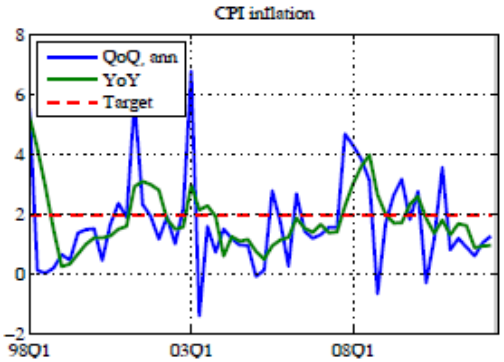

Output gap, percent
4
2
0
−2
−4
−6
−8
98Q1
03Q1
08Q1
Domestic
Foreign − EU27 (−1)


Real exchange rate gap, percent
15
10
5
0
−5
−10
98Q1
03Q1
08Q1


Long−term domestic real interest rate gap, percent
3
2
1
0
−1
−2
−3
98Q1
03Q1
08Q1


Annualized q−o−q growth of real GDP (log)
20
10
0
−10
−20
98Q1
03Q1
08Q1
Growth
Trend


Annualized q−o−q real exchange rate depreciation (log)
40
30
20
10
0
−10
−20
98Q1
03Q1
08Q1
Growth
Trend


CPI inflation
8
6
4
2
0
−2
98Q1
03Q1
08Q1
QoQ, ann
YoY
Target

Appendix D – OCA Index

Table 1: OCA Index by Component with Respect to Germany

Country	SIZE			TRADE			DISSIM			SDY			OCA INDEX		
	1997-2001	2002-2006	2007-2011	1997-2001	2002-2006	2007-2011	1997-2001	2002-2006	2007-2011	1997-2001	2002-2006	2007-2011	1997-2001	2002-2006	2007-2011
AT	6.470	6.728	7.058	0.062	0.071	0.073	0.292	0.269	0.266	0.009	0.007	0.011	0.004	0.003	0.013
BE	6.563	6.831	7.161	0.071	0.092	0.094	0.329	0.210	0.141	0.010	0.011	0.015	0.007	0.007	0.015
BG	5.083	5.511	6.011	0.017	0.020	0.023	0.648	0.702	0.543	0.023	0.011	0.031	0.018	0.007	0.038
CY	4.928	5.264	5.651	0.002	0.002	0.002	0.725	0.375	0.212	0.009	0.010	0.026	-0.002	-0.005	0.020
CZ	5.873	6.274	6.724	0.090	0.103	0.111	0.317	0.224	0.081	0.016	0.013	0.016	0.007	0.003	0.010
DK	6.372	6.640	6.957	0.032	0.032	0.031	0.416	0.359	0.302	0.007	0.007	0.006	0.005	0.006	0.008
EE	4.677	5.143	5.596	0.020	0.020	0.015	0.703	0.573	0.343	0.038	0.011	0.056	0.036	-0.001	0.066
ES	7.008	7.364	7.718	0.017	0.018	0.017	0.314	0.268	0.221	0.012	0.007	0.018	0.018	0.014	0.033
FI	6.230	6.509	6.835	0.022	0.021	0.018	0.299	0.267	0.213	0.005	0.010	0.015	-0.003	0.007	0.017
FR	7.435	7.701	8.016	0.032	0.034	0.035	0.084	0.102	0.112	0.007	0.016	0.051	0.010	0.026	0.081
GB	7.452	7.737	7.972	0.022	0.022	0.022	0.036	0.050	0.017	0.004	0.017	0.015	0.004	0.027	0.026
GR	6.256	6.600	6.952	0.007	0.006	0.005	0.742	0.660	0.503	0.004	0.015	0.011	0.007	0.026	0.020
HU	5.751	6.189	6.529	0.098	0.092	0.096	0.113	0.077	0.124	0.020	0.014	0.024	0.005	0.002	0.021
IE	6.084	6.507	6.796	0.047	0.023	0.019	0.148	0.127	0.151	0.004	0.008	0.008	-0.010	0.001	0.006
IT	7.345	7.614	7.909	0.026	0.026	0.026	0.403	0.377	0.296	0.021	0.008	0.069	0.036	0.020	0.111
LT	5.019	5.459	5.919	0.023	0.021	0.025	0.444	0.273	0.291	0.035	0.020	0.058	0.030	0.010	0.071
LU	5.307	5.662	6.069	0.051	0.053	0.045	0.592	0.431	0.306	0.018	0.012	0.019	0.010	0.002	0.015
LV	4.802	5.225	5.733	0.020	0.018	0.014	0.991	0.885	0.665		0.018	0.019	-0.012	0.017	0.020
MT	4.490	4.768	5.123	0.031	0.025	0.024	0.028	0.062	0.112	0.010	0.006	0.016	-0.023	-0.023	-0.004
NL	6.805	7.099	7.421	0.077	0.086	0.104	0.214	0.206	0.077	0.019	0.010	0.024	0.020	0.009	0.031
PL	6.384	6.697	7.148	0.033	0.045	0.051	0.520	0.422	0.301	0.010	0.011	0.022	0.011	0.013	0.032
PT	6.208	6.498	6.804	0.021	0.016	0.016	0.583	0.478	0.425	0.036	0.012	0.039	0.048	0.016	0.056
RO	5.632	6.086	6.660	0.021	0.023	0.026	0.732	0.594	0.305	0.020	0.007	0.027	0.022	0.005	0.035
SE	6.568	6.829	7.145	0.021	0.021	0.022	0.126	0.167	0.162	0.009	0.006	0.027	0.004	0.003	0.038
SI	5.334	5.650	6.021	0.060	0.051	0.061	0.477	0.371	0.237	0.003	0.010	0.021	-0.014	-0.002	0.015
SK	5.338	5.756	6.307	0.071	0.094	0.076	0.399	0.237	0.024	0.011	0.009	0.013	-0.006	-0.008	0.001

Table 2: OCA Index by Component with Respect to Italy

Country	SIZE			TRADE			DISSIM			SDY			OCA INDEX		
	1997-2001	2002-2006	2007-2011	1997-2001	2002-2006	2007-2011	1997-2001	2002-2006	2007-2011	1997-2001	2002-2006	2007-2011	1997-2001	2002-2006	2007-2011
AT	6.191	6.499	6.828	0.016	0.021	0.019	0.111	0.108	0.031	0.012	0.003	0.008	0.004	-0.007	0.003
BE	6.284	6.602	6.932	0.024	0.026	0.024	0.074	0.166	0.155	0.011	0.003	0.008	0.002	-0.003	0.007
BG	4.805	5.282	5.781	0.025	0.026	0.021	0.245	0.325	0.247	0.024	0.005	0.031	0.006	-0.013	0.029
CY	4.650	5.035	5.421	0.001	0.001	0.001	0.322	0.222	0.085	0.012	0.004	0.021	-0.010	-0.019	0.007
CZ	5.595	6.045	6.495	0.010	0.013	0.016	0.086	0.152	0.216	0.015	0.014	0.015	0.000	0.005	0.014
DK	7.345	7.614	7.909	0.012	0.014	0.014	0.403	0.377	0.296	0.009	0.006	0.004	0.019	0.017	0.016
EE	6.094	6.411	6.727	0.006	0.006	0.006	0.015	0.021	0.009	0.035	0.012	0.062	0.035	0.005	0.081
ES	4.399	4.914	5.366	0.003	0.003	0.004	0.300	0.213	0.072	0.013	0.003	0.024	-0.012	-0.022	0.010
FI	6.729	7.135	7.489	0.014	0.015	0.015	0.089	0.109	0.076	0.008	0.003	0.008	0.004	0.001	0.013
FR	5.952	6.280	6.606	0.007	0.006	0.005	0.104	0.110	0.084	0.004	0.008	0.008	-0.011	-0.001	0.003
GB	7.157	7.472	7.786	0.023	0.023	0.022	0.319	0.275	0.184	0.009	0.014	0.045	0.014	0.026	0.071
GR	5.977	6.371	6.722	0.005	0.005	0.005	0.339	0.283	0.207	0.007	0.008	0.015	-0.001	0.004	0.016
HU	5.472	5.960	6.299	0.016	0.016	0.020	0.290	0.391	0.420	0.021	0.009	0.021	0.011	0.003	0.024
IE	5.806	6.278	6.566	0.029	0.026	0.023	0.551	0.504	0.447	0.020	0.009	0.075	0.019	0.008	0.106
IT	4.741	5.230	5.690	0.005	0.005	0.005	0.048	0.103	0.036	0.034	0.016	0.064	0.018	-0.001	0.072
LT	5.029	5.433	5.840	0.013	0.018	0.014	0.189	0.070	0.057	0.020	0.008	0.015	0.002	-0.012	0.003
LU	4.524	4.996	5.503	0.002	0.003	0.003	0.588	0.508	0.369		0.016	0.014	-0.023	0.004	0.005
LV	4.212	4.539	4.893	0.012	0.009	0.011	0.375	0.329	0.409	0.013	0.006	0.011	-0.014	-0.021	-0.007
MT	6.526	6.870	7.191	0.019	0.020	0.020	0.189	0.171	0.220	0.020	0.011	0.018	0.021	0.011	0.026
NL	6.105	6.468	6.918	0.007	0.010	0.013	0.117	0.046	0.008	0.014	0.005	0.015	0.005	-0.005	0.014
PL	5.930	6.269	6.575	0.006	0.006	0.005	0.180	0.102	0.129	0.034	0.011	0.040	0.035	0.003	0.050
PT	5.353	5.857	6.431	0.032	0.033	0.022	0.328	0.217	0.026	0.021	0.010	0.029	0.010	-0.003	0.029
RO	6.290	6.600	6.915	0.007	0.007	0.006	0.278	0.210	0.135	0.012	0.003	0.030	0.008	-0.002	0.039
SE	5.056	5.421	5.791	0.029	0.032	0.038	0.074	0.019	0.059	0.007	0.005	0.016	-0.019	-0.019	0.002
SI	5.060	5.527	6.077	0.025	0.023	0.022	0.014	0.143	0.278	0.014	0.002	0.016	-0.010	-0.019	0.011
SK	7.174	7.508	7.743	0.011	0.010	0.009	0.368	0.334	0.287	0.006	0.011	0.008	0.012	0.023	0.020

Appendix E: Contents of Enclosed CD

Kalman Filtration:

- Databases (.xlsx and .csv formats for individual countries)
- Functions
    - Model_obs (.m and .asv formats)
    - Report_data (.m and .asv formats)
    - Report_filter (.m and .asv formats)
    - Set_range (.m and .asv formats)
    - Sa_x12.m
- Results
    - Data (in .csv and .mat)
    - Report (in .pdf)
    - Output diabase.xlsx
- Estimated Parameters.xlsx
- Model.mod

OCA Index:

- DISSIM.xls
- OCA Index.xlsx
- SDY.xls
- Size.xls
- Trade.xlsx