European Commission

JRC TECHNICAL REPORT

Ready or Not? Constructing the Monetary Union Readiness Index

Erhart, S.

2021

Joint Research Centre

EUR 30578 EN

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JRC121303

EUR 30578 EN

PDF ISBN 978-92-76-29423-8 ISSN 1831-9424 doi:10.2760/226646

Luxembourg: Publications Office of the European Union, 2021

How to cite this report: Erhart, S., *Ready or Not? Constructing the Monetary Union Readiness Index*, EUR 30578 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-29423-8, doi:10.2760/226646, JRC121303

Abstract

While all EU Member States can join the group's monetary union, the eurozone, some members are far more ready for the adoption and use of the single European currency. Here, we construct a new Monetary Union Readiness Index (MURI) for EU Member States. The theoretical framework of the index is built on the economic theory of Optimal Currency Areas and EU regulations such as the Treaty and the Maastricht criteria, and the Regulation on the Macroeconomic Imbalance Procedure. The index measures (i) nominal convergence, (ii) real convergence and (iii) macroeconomic stability. The MURI Index provides an easy to use real-time policy tool to evaluate both candidate and current eurozone members. Hence, it complements, aggregates and communicates key information in annual convergence reports and in official statistics. Our evaluation finds that Austria, Finland, Denmark, Sweden and Germany showed the highest level of compliance with the different eurozone criteria in 2018, while Greece, Cyprus, Romania, Spain, and Italy the least.

JEL classification: E42, E58, E61, F15, F33, F45

The author gratefully acknowledges the help, comments and suggestions received from an anonymous reviewer, from the participants of the Joint Research Centre COIN Seminar, 22 October 2020, from Csaba Balogh (Central Bank of Hungary), William E. Becker (Joint Research Centre of the European Commission), Michael Fidora (European Central Bank), Balázs Forgó (European Commission, DG ECFIN), Balázs Kóczián (Central Bank of Hungary), Isabelle Méjean (European Economic Review), Judit Neményi (former Member of the Monetary Council in the Central Bank of Hungary), Eric Ruscher (European Commission, DG ECFIN), István Székely (European Commission, DG ECFIN) and from colleagues in the Euro Area External Sector and Euro Adoption Division of the European Central Bank.

1 Introduction

The conceptualisation of monetary integration started as a fuelled debate on the Optimal Currency Area (OCA) theory and on post-war economic integration of countries in Western Europe and in North America, Scitovsky (1957), Meade (1957), Mundell (1961). Pioneering authors stressed the importance of factors mobility, Mundell (1961), economic openness Mckinnon (1963) and the diversity of production, Mckinnon (1969). Fleming (1971) showed that inflation rate similarity helps keep the terms-of-trade rather stable. A fundamental contribution of the Mundell-Fleming framework was the mapping of the so-called impossible trinity, which states that a country simultaneously may choose any two, but not all, of the following three goals: monetary independence, exchange rate stability and financial integration, Mundell (1961), Fleming (1962). Aizenman et al. (2009) showed empirically the trade-offs of monetary integration and why free lunch does not exist in monetary integration. In the framework of impossible-trinity all options provide pros and cons in terms of output volatility, inflation and debt burdens.

Monetary integration and the convergence of eurozone economies has become again a topic of lively public and academic debates on the EU in repeated waves recently. The first wave of debate overlapped with the period when the single European currency was created at the end of 1990s, Frankel and Rose (1997). Discussions became heated again in the mid 2000s, when new Member States joined the EU and a quick enlargement of the eurozone was scheduled, Csajbok and Csermely (2001). The last wave of debate started after the eruption of the financial crisis and especially when the eurozne debt problem peaked in 2011-2012, Berti and Meyermans (2017), Creel (2018).

del Hoyo et al. (2017), Zuk et al. (2018), Arestis (2016), Bibow (2016) concluded that the temporary fulfilment of the numerical convergence criteria set in the Maastricht Treaty was not, in itself, a guarantee of smooth membership in the euro area (see further details of the Mastricht Treaty in Section 2.1). A holistic approach and the integration of all dimensions of sustainable economic convergence – be these real, nominal or institutional in nature – is, therefore, required. The president of the new European Commission confirmed prioritising further the deepening of the Economic and Monetary Union under the 2019-2024 European Commission, von der Leyen (2019).

Here, we contribute to the discussions by constructing a new comprehensive index, which is built on all relevant pillars of economic convergence and monetary integration. It reveals the various ways in which monetary union readiness is measured. First, the European regulatory framework (e.g. in the so-called Maastricht-criteria of nominal convergence and the European Commission's Macroeconomic Imbalance Procedure thresholds) used for the index construction. Second, further requirements of successful monetary integration suggested in the theoretical literature (real con-

vergence and institutional criteria) were also built into the index. Comparing the nominal, real and stability sub-indices of the MURI to each other help discuss the extent to which the official criteria are useful as normative criteria.

The MURI Index is compiled for all 2020 EU Member States (including the United Kingdom) for 14 years (between 2005 and 2018) and is based on official statistics. The Monetary Union Readiness Index (MURI) is derived from the normalized distance (i) to the Eurozone's Maastricht thresholds, (ii) to real convergence thresholds and finally (iii) to the European Commission's Macroeconomic Imbalance Procedure thresholds.

Readiness for euro in the majority of eurozone's founding Members (Austria, Belgium, Finland, France, Germany, Luxembourg, Netherlands) has varied in a range between 90 and 100, close to the maximum MURI Index value since 2005. According to our index, Denmark and Sweden could have considered adopting the euro throughout the entire sample period. Baltic and Central Eastern European Member States of the EU showed continuous progress in euro readiness except for the crisis years. According to our index, Cyprus and Greece seemed to be the least ready to use the euro in 2018.

The convergence has been achieved in terms of all index pillars in the best performing countries. The requirement of nominal convergence seems to be most fulfilled in most Member States, implying that the European regulatory framework helped to anchor nominal convergence. Real convergence is happening, although at a slower pace in new EU Member States than nominal convergence.

The usability of the MURI Index is investigated further by comparing it to public attitudes towards the single European currency in the Eurobarometer survey. There is a positive, although low (0.3) correlation in the eurozone between MURI Index value and the attitudes towards the euro measured in the Eurobarometer survey. The correlation is negative and stronger if a subsample, containing observations for Greece, is used. The Pearson correlation here is -0.75, implying that the happiness with euro is sometimes U-shaped (which could be called the euro-smile). In the same vein, non-eurozone countries opinion on the euro is better in times when the country itself is less prepared for the euro (correlation of -0.45). This phenomenon could also result in adverse selection of members, suggesting that good performers may opt-out and less good ones could be attracted more by monetary unions.

Understanding economic convergence at the twentieth anniversary of the European single currency may convey important policy messages. New candidates (Bulgaria and Croatia) announced their intention in 2019 to enter the Exchange Rate Mechanism (ERM II), the so-called waiting room of the European single currency. Also, the unity of the eurozone has been a serious concern since the 2009 financial crisis and may become again very pressing with the latest COVID19 developments in some Member States raising the issue of a possible exit from the euro area. Hence,

our results are useful to show the requirements of euro area membership for both existing members and candidates thus provide incentives for the normative discussion on deepening the Economic and Monetary Union (EMU).

The eurozone can also be interpreted as a contemporary model for forming currency unions. Hence, the MURI index could serve as a possible benchmark for other planned currency unions in the future (West African Monetary Zone, ASEAN, etc.).

The euro has been introduced in 19 EU Member States since January 1999, and the European Central Bank and the European Commission regularly issues Annual Convergence Reports on eurozone candidate Member States in terms of nominal convergence based on the Maastricht Criteria. These assessments provide detailed information before eurozone entry but not afterwards, once a Member State adopted the euro. Also, Denmark and the United Kingdom, gave notification that they would not participate in Stage Three of EMU. As a consequence, convergence reports are not available for these countries. Furthermore, convergence reports do not explicitly evaluate real convergence, which is an important factor for a successful monetary unions, Franks et al. (2018).

The contribution of our study to the current and future debate on the eurozone is threefold. First, as a starting point we systematically investigate the available indicators, used for gauging EU Member States readiness for euro adoption and use. We combine indicators stipulated both by the European regulatory framework behind the euro and further real convergence and institutional indicators suggested in the economic literature. Second, we construct an illustrative Monetary Union Readiness Index, which could be considered as an augmented and instant form of the convergence analysis. Third, we present methodological options to measure monetary readiness and Monte Carlo simulation based confidence intervals around the measurement. These can help assess the optimality of the monetary integration and the certainty of the optimality. Finally, the analysis constructs a novel dataset of key indicators which was not available earlier, and could be used for later research of the EU28 Members States.

The rest of the paper is structured as follows. Section 2 describes the indicators of nominal convergence, real convergence, and macroeconomic stability in the EU regulation and proposes a methodology for the Monetary Union Readiness Index. Section 3 presents our data and its treatment (winsorisation, distance-to-threshold transformation, normalisation). Section 4 discusses changes in euro readiness in EU Member States based on the MURI Index. Section 5 presents an analysis of the reliability and uncertainty of the MURI Index. Section 6 concludes.

2 Constructing the Monetary Union Readiness Index

The Monetary Union Readiness Index is a combination of three pillars and builds on economic theories and legal requirements of eurzone membership in the European Union. The MURI Index is constituted upon normalized indicators and is expressed on a scale between 0 and 100 (where 0 means the lack of readiness for the euro use/adoption and 100 perfect readiness).

The first pillar of the MURI Index builds on nominal convergence criteria of monetary integration stipulated as the Maastricht Criteria and thresholds for Eurozone entrants (in Article 140 of the Treaty on the Functioning of the European Union). Nominal convergence criteria were also suggested by authors of the OCA theory, Friedman (1953), Mckinnon (1963).

Table 1: The Monetary Readiness Index, pillars and indicators

	Indicators	**Pillar weight**	**Indicators**
Pillar 1	**Nominal convergence (Maastricht criteria)**	1/3	Inflation Long-term interest rates Government debt Government deficit Excessive Deficit Procedure (EDP)
Pillar 2	**Real convergence**	1/3	GDP per capita (PPP) Correlation of real GDP growth with the eurozone Share of trade with EU in total trade Worldwide Governance Indicators
Pillar 3	**Macroeconomic Balance (MIP Indicators)**	1/3	Current account balance Net international investment position Real effective exchange rate Export market shares Nominal unit labour cost index House price index, deflated Private sector credit flow Private sector debt General government sector debt Unemployment rate Total financial sector liabilities

The second pillar of MURI Index uses further standard indicators of real economic convergence in the economic literature on the Optimal Currency Area theory used for the evaluation of candidates' readiness for monetary union membership, including measures for income convergence, synchronicity of macroeconomic cycles, trade integration and factors of institutional and governance quality, Mundell (1961), Franks et al. (2018), del Hoyo et al. (2017).

The third pillar of the MURI is based on the Macroeconomic Imbalance Procedure (MIP) scoreboard indicators and its background Regulation (No 1176/2011). This supra-national surveillance framework in the EU monitors possible spill-over effects of macroeconomic imbalances, which could compromise the proper functioning of the monetary union, its functioning and institutions, Commission (2017). The MIP scoreboard integrates several indicators for the better identification

of internal and external problems in a monetary union ex-post of its creation and hence aims at the establishment of an improved macroeconomic governance framework to optimally manage the trade-offs of monetary integration.

2.1 The Maastricht nominal convergence criteria

The Maastricht Treaty, entered into force in 1993, outlined the five convergence criteria, to measure progress in Member States readiness to adopt the euro, Table 2. The Maastricht-criteria were defined as a set of macroeconomic indicators with thresholds, which focus on (i) price stability, (ii) sound and sustainable public finances, (iii) exchange-rate stability, (iv) long-term interest rate stability. Fulfilment of these criteria is mandatory before euro adoption.

Table 2: the Maastricht convergence criteria and their numeric thresholds

Price stability	**Sound and sustainable public finances**	**Durability of convergence**	**Exchange rate stability**
Harmonised consumer price inflation	Government deficit and debt	Long-term interest rate	Exchange rate developments in ERM II
=<average inflation of three best performing MSs + 1.5 percentage points	3 % - Gov. deficit 60% - Gov. debt Not under excessive deficit procedure at the time of examination	=<average long-term interest rate of the three best performing MS in terms of price stability + 2 perc. points	Participation in ERM II for at least 2 years without severe tensions, in particular without devaluing against the euro

Our new index includes four of the five Maastricht criteria, except for Exchange-rate stability criterion. The reason for omitting this criterion was that we wanted to design an index which measures "euro readiness" both ex-ante and ex-post of euro adoption. As the exchange-rate criteria can be evaluated only ex-ante and only for eurozone candidates but not ex-post for eurozone members, the exchange rate stability criteria has not been integrated into the index. Nevertheless, real-exchange rate stability assessment is part of the Macroeconomic Imbalance Procedure, and MIP Scoreboard indicators are grouped into the third pillar of our index.

2.2 The real convergence criteria

Franks et al. (2018) and the Central Bank of Hungary, MNB (2020) argued recently that nominal convergence criteria took center stage during EMU preparation. They criticize the Maastricht criteria as only loosely linked to the actual economic conditions of a successful euro adoption. Studies on monetary unions usually refer to Optimum Currency Area (OCA) theory which requires real economic convergence that business cycles are synchronized, otherwise the optimal monetary policy will diverge across countries, making the union less beneficial for its members, Scitovsky (1957), Meade (1957), Mundell (1961), Mckinnon (1963), Csajbok and Csermely (2001).

Hence, we added real convergence indicators, proposed and used in the literature, to our index in Pillar 2 (Table 3).

Union-wide macroeconomic stability can be better achieved when there are no significant cross-

country differences in income levels, Benczes and Szent-Ivanyi (2015), Franks et al. (2018). Moreover, income convergence may also be important for the macroeconomic stability after monetary integration. Income convergence is a guarantee for higher level of social cohesion and hence can help ensure that the benefits from the monetary union are better distributed over the long run.

To measure income convergence, we calculated the ratio of the real GDP per capita of EU Member States and that of the eurozone members on average. To assess the synchronicity of business cycles, pairwise Pearson correlation coefficients of Member States' real GDP growth and that of the eurozone was calculated (using a moving window of observations from the given year [t] to the year preceding this year by 9 calendar years [t-9y]).

Table 3: Real economic convergence pillar and indicators

Income convergence	**Synchronicity of business cycles**	**Trade integration**	**Institutions and Governance**
GDP per capita (PPP)	Correlation of real GDP growth	Share of trade with EU in total trade	Worldwide Governance Indicators
in % of eurozone average	Pearson correlation coefficient of MS's growth with EMU	(exports to and imports from EU)/ (total export +import)	Percentile rank

One of the key positive effects of economic and monetary integration was assumed to be trade-creation effect and the higher-business cycle synchronicity that it may entail at the time when the eurozone plan was rolled out, Frankel and Rose (1997), Frankel and Rose (1998). We used the share of trade (exports plus imports to and from the EU) in the total value of exports and imports to gauge trade integration over time.

The strength of the institutional environment is a further key factor in the analysis of the sustainability of economic integration and convergence, ECB (2018), Buti et al. (2019). It is also considered as relevant for maintaining an environment conducive to price stability after adoption of the euro. Furthermore, the principle of institutional quality of National Central Banks is expressly referred to in Article 130 of the Treaty and Article 7 of the Statute.

In our index, we used the Worldwide Governance Indicators (WGI), developed by the World Bank, and used in numerous empirical studies as common measure of institutional quality. The WGI reports governance indicators with a global coverage and with a long time-span over the period from 1996 to 2018, for six dimensions of governance. We took the simple average of the percentile rank for each of the six WGI Indicators: a. 'Rule of Law'; b. 'Control of Corruption'; c. 'Government Effectiveness'; d. 'Voice and Accountability'; e. 'Regulatory Quality' and f. 'Political Stability and Absence of Violence'.

2.3 The Macroeconomic Imbalance Procedure criteria

Disappearing economic and social convergence between euro area Member States after the 2009 crisis have fuelled again policy discussions over the issue of convergence, Berti and Meyermans (2017). To respond to the crisis, an augmented supra-national surveillance mechanism was stipulated in the Macroeconomic Imbalance Procedure (MIP, REGULATION (EU) No 1176/2011). The regulation sets out detailed rules for the detection of macroeconomic imbalances, Erhart et al. (2019).

In our index we used the MIP Scoreboard which is a set of headline indicators aiming at the assessment of macroeconomic imbalances, Table 4. It consists of 11 indicators currently, grouped into (I) five *'external imbalance indicators'*, and (II) six *'internal imbalance indicators'*, which were augmented by additional 3 employment indicators, Erhart (2019). However, these new employment indicators do not play a direct role in the identification of macro-financial risks and do not trigger by themselves steps in the MIP, hence our index does not cover them.

Table 4: The Macroeconomic Imbalance Procedure scoreboard and its indicators (indicator thresholds are in parenthesis)

EXTERNAL IMBALANCE INDICATORS	INTERNAL IMBALANCE INDICATORS
Current account balance in % of GDP, 3 years average (upper: +6% and lower - 4%)	**House price index, deflated** 1 year % change (6%)
Net international investment position in % of GDP (-35%)	**Private sector credit flow** consolidated, in % of GDP (14%)
Real effective exchange rate 42 trade partners, 3 years % change (-/+5)% for euro-area countries and (- /+) 11% for non-euro-area countries)	**Private sector debt** consolidated, in % of GDP (133%)
Export market shares 5 years % change (- 6%)	**General government sector debt** in % of GDP (60%)
Nominal unit labour cost index 3 years % change (+9% for euro-area countries and +12% for non-euro area countries)	**Unemployment rate** 3 years average (10%)
	Total financial sector liabilities non-consolidated - 1 year % change (16.5%)

Many of the MIP indicators could be also related to the concepts explained in later papers on the OCA theory focusing on the trade-offs of monetary integration. For example, Mundell (1961), Fleming (1962), Aizenman et al. (2009) showed in the well-known framework of the impossible-

trinity that all possible options (monetary independence, exchange rate stability and financial integration) provide pros and cons in terms of output volatility, inflation (MIP Internal imbalance indicators) and debt burdens (MIP external imbalance indicators).

2.4 Measuring public opinions on the euro

The success of monetary integration is mainly an economic and partly a communication issue. Hence, the Commission regularly measures attitudes towards the euro both in current and candidate Member States of the eurozone as part of the Eurobarometer surveys.

We used the Eurobarometer data to test the usability of the the Monetary Union Readiness Index. We used the following questions in Table 5 of the Eurobarometer surveys, which are slightly different in current and candidate eurozone Member States. In the former group, questions request opinion on actual experience with the euro, in the latter group the opinion on expectations is requested. Finally, we calculated the difference between positive and negative answers.

Table 5: The Eurobarometer survey questions on the euro

Eurozone countries	**Non-eurozone countries**
Generally speaking, do you think that having the euro is a good or a bad thing for your country?	Do you think the introduction of the euro would have positive or negative consequences for your country?

2.5 Weighting

The EU's regulatory framework on the eurozone does not differentiate between indicators required for euro adoption in terms of importance. All five Maastrricht criteria and all 11 Macroeconomic Imbalance Procedure criteria are considered as equally important.

Also, in practice, many composite indicators in every scientific and policy field rely on equal weighting schemes because this method is the easiest to understand and to communicate to the wider public, OECD-JRC (2008).

Hence, we gave equal weights to all three pillars each having 1/3 weight in the index. We applied the same equal weighting rule on the indicators in each pillar, meaning that each indicator was given 1/5 weight in Pillar 1 and 1/4 weight in Pillar 2, and therefore each had 1/15 weight (Pillar 1 indicators) and 1/12 weight (Pillar 2 indicators) weight in the aggregated index. The number of indicators is higher in case of the MIP Scoreboard, each having 1/11 weight in Pillar 3 and 1/33 in the aggregated Monetary Union Readiness Index.

As the general government deficit (in % of the GDP) and its distance from the 3% target appears in both among the Maastricht criteria (Pillar 1) and in the Macroeconomic Imbalance Procedure Scoreboard (Pillar 3) its weight is 1/12+1/33, e.g. approximately 11% in the overall

index. We think that this choice should not be considered as double counting, but as a reflection of the importance of sound fiscal stance in the EU's regulatory framework on the eurozone.

3 Data

The MURI Index is built on a rich panel dataset of three pillars and 20 indicators, Table 6. Underlying indicators are downloaded from official databases of the Eurostat, European Central Bank and the World Bank, and all indicators are available for the period from 2005 and 2018.

Table 6: Data sources of the MURI Index (by indicators and index pillars)

Indicator	**Source**	**Pillar**
Inflation (%, year-on-year, HICP)	Eurostat	Pillar 1
Long-term interest rates (%)	ECB	Pillar 1
General Government Debt (% of GDP)	Eurostat	Pillar 1
General government deficit (% of GDP)	Eurostat	Pillar 1
Excessive Deficit Procedure (Y/N)	ECB	Pillar 1
Real GDP growth rate (%)	World Bank WDI	Pillar 2
Real GDP per capita (PPP)	World Bank WDI	Pillar 2
Worldwide Governance Index (percentile rank)	World Bank	Pillar 2
Share of exports to + imports from EU (%in total export+import)	Eurostat	Pillar 2
MIP Scoreboard 11 Headline indicators	Eurostat	Pillar 3

[The data can be downloaded as a Mendeley dataset: https://data.mendeley.com/datasets/ymjbffrnrm/2].

3.1 Data treatment (winsorization, normalisation)

To gain indicators which are ready for building them into a meaningful index, we treated our data in three steps as recommended by the OECD-JRC Handbook on Constructing composite Indicators, OECD-JRC (2008).

In the first step, most of our headline indicators were expressed as a distance to target indicator, in other words the actual data was compared to thresholds. In case of the nominal convergence pillar, the Maastricht thresholds (Table 2), in case of the Macroeconomic Balance pillar, the MIP thresholds were used (Table 4). If a Member State met a given threshold the distance to target was set to zero. Finally, we took the absolute value of the distance to threshold in case of lower MIP thresholds.

As for the real convergence pillar, the real GDP per capita was compared to the average of the eurozone. The correlation coefficient was taken into account only in case of positive values, and

negative values were converted into zeros. The reason for this is that synchronicity of business cycles could be assessed only in case of some sort of co-movement of economic growth cycles. In other words, neither zero correlation nor negative correlation with the eurozone could be deemed as adequate for eurozone members. The share of trade with the EU was expressed in comparison to the total external trade of the given country. The Worldwide Governance Indicator is provided as a percentile rank.

In the second step, we treated extreme values with the Winsorization technique. We set all outliers at the 95th percentile above the 95th percentile and 5 percentile below the 5th percentile. Such treatment was necessary in case of the minority of indicators, eg. for inflation, government deficit (both in Pillar 1) and private sector credit flow (Pillar 3). As a matter of fact, in some countries extreme levels of inflation were observed in the early years of the economic transition reaching the levels of hundreds of percents annually (Bulgaria, Romania). Distance to threshold was also extremely high (hundreds of percents) in in case of the government deficit and private sector credit flow. Without such outlier treatment, distance-to-threshold metrics could become biased and show an unrealistic picture of the country performance. The treatment of extreme values with winsorization technique is a standard practice for building composite indicators and recommended by the OECD-JRC (2008).

Furthermore, we only take into account unacceptable difference from the thresholds, values in the accepted range were treated as indifferent (replaced by zeros).

In the third step, we normalized all indicators with min-max normalisation, OECD-JRC (2008) and reversed the scale for Pillar 1 and Pillar 3 indicators (where 0 means the lack of readiness for euro use/adoption and 100 perfect readiness).

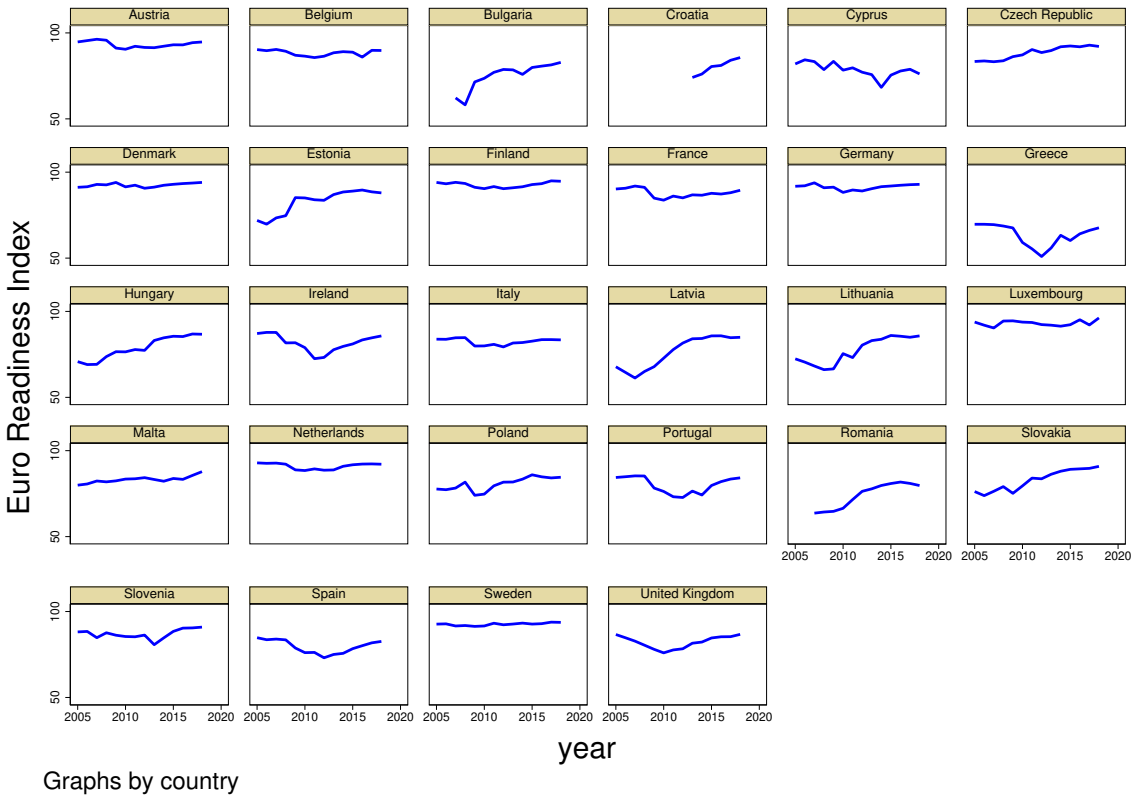
4 Monetary Union Readiness of EU Member States

Figure 1 plots the the Monetary Union Readiness Index by EU Member States, the higher the score of a Member State on the 0-100 scale the more ready it is for euro adoption and use.

Eurozone readiness in the majority of eurozone's founding Members (Austria, Belgium, Finland, France, Germany, Luxembourg, Netherlands) varied in a range between 90 and 100, close to the maximum MURI value. There is no significant difference in terms of performance by pillars for this group. Figures of all three pillars and their underlying indicators can be found in Appendix A.

The index value has been lower, about 75-85 for some Mediterranean countries Cyprus, Italy, Malta, Portugal, Spain and Ireland recently. Most members of this country group has suffered likely the most from the crisis, which had reversed the direction of their convergence temporarily.

Figure 1: Evolution of the Monetary Union Readiness Index across EU Member States



According to our index, Denmark and Sweden could have considered adopting the euro throughout the entire sample period.

Baltic and Central Eastern European Member States of the EU showed continuous progress in euro readiness except for the crisis years. Countries in this group achieved a score of 80-90 in the aftermath of the crisis. The Czech Republic was a forerunner of this group, achieving a MURI value comparable to current eurozone members.

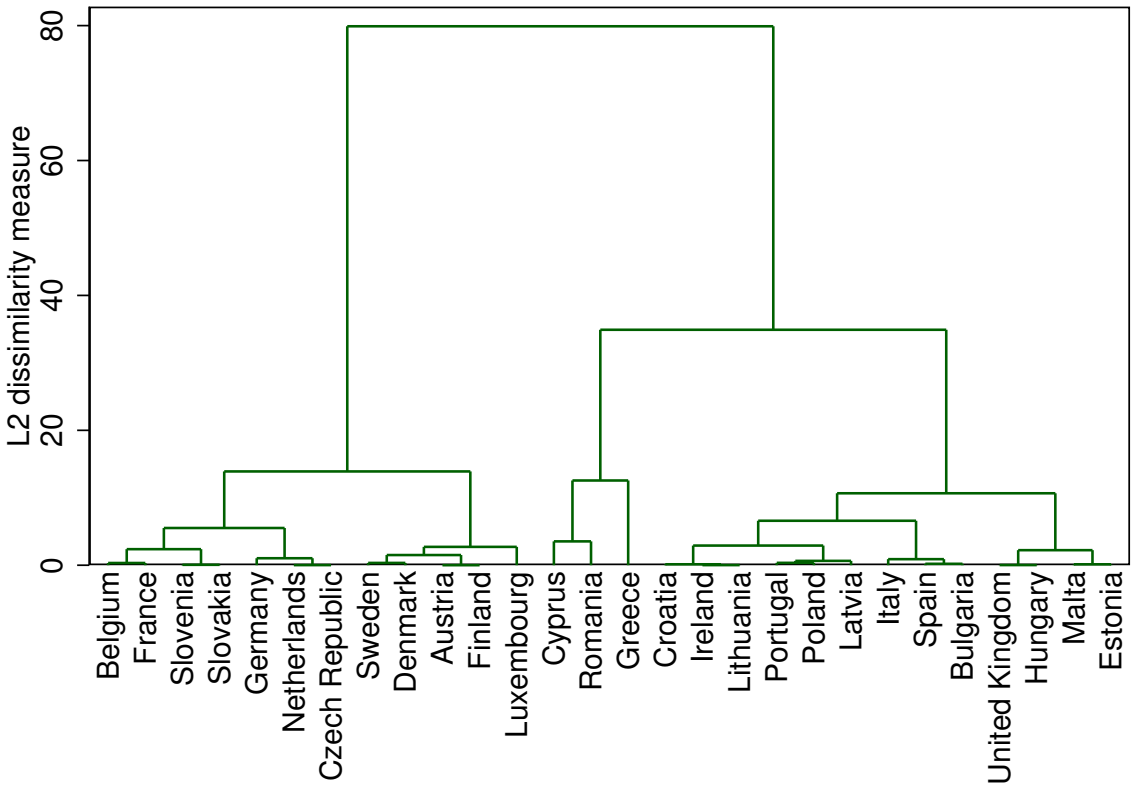
According to our index, Cyprus and Greece seemed to be the least ready to use the euro in the early years of the single currency, and the situation somewhat worsened temporarily due to the partly adverse effect of the financial crisis.

If one looks at all index pillars one by one, Figure 6, the convergence is high in terms of all index pillars in the best performing countries (in Austria, Denmark, Finland, Germany, Luxembourg, Sweden).

The requirement of nominal convergence seems to be most fulfilled in most Member States, Figure 6. This implies that the European regulatory framework and institutions helped to anchor nominal convergence. Furthermore, real convergence is happening, although at a slower pace in new EU Member States than nominal convergence.

A simple cluster analysis was conducted to group countries by the MURI Index. Three groups

Figure 2: Dendogram of the cluster analysis based on the MURI Indicators



of similar countries were identified. The first group is consist of Austria, Denmark, Finland, Sweden, Luxembourg, the Czech Republic, the Netherlands, Germany, Slovakia, Slovenia, France and Belgium. The second group consists of Croatia, Ireland, Lithuania, Portugal, Poland, Latvia, Italy, Spain, Bulgaria, the United Kingdom, Hungary, Malta and Estonia. Greece, Cyprus and Romania is found to be not very similar to countries in the other two groups.

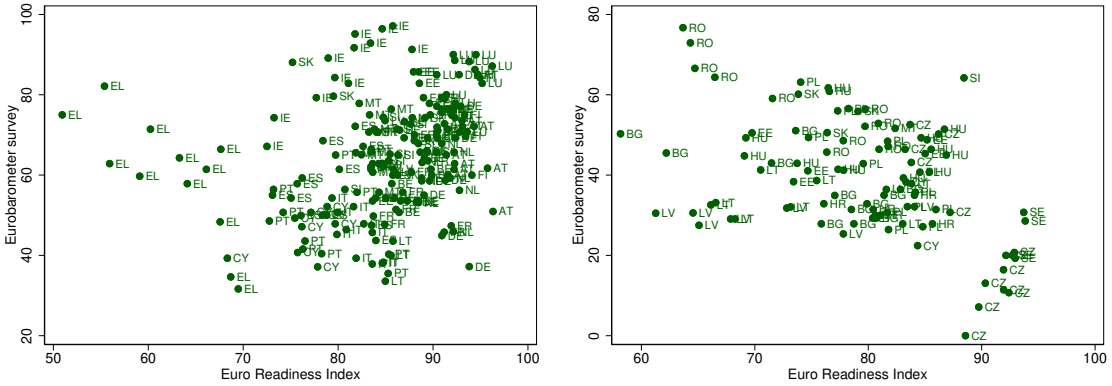
4.1 Association of the MURI Index with other eurozone indicators

Here we investigate further the usability of the MURI Index by comparing it to an important metric of euro adoption, to the Eurobarometer survey on the public attitudes towards the single European currency .

There is a positive, although low (0.3) correlation in the eurozone between the MURI Index values and the attitudes towards the euro measured in the Eurobarometer survey, Figure 3 (a). The correlation coefficient becomes negative and bigger in absoulute value if a subsample, containing observations for Greece, is used. The Pearson correlation is -0.75, implying that the happiness with euro is sometimes U-shaped in some cases (which could be called the euro-smile). In the same vein, non-eurozone countries opinion on the euro is better in times when the country itself is less prepared for the euro (correlation of -0.45, Figure 3 (b)). This phenomenon could also result

in adverse selection of members in monetary union, suggesting that good performers may opt-out and less good ones attracted more by monetary unions.

Figure 3: The MURI Index and the Eurobarometer survey results



(a) Eurozone Member States

(b) Non-eurozone EU Member States

5 Reliability and uncertainty of the MURI Index

The reliability of Monetary Union Readiness Index, measured by its components' Cronbach-alpha value is 0.74, above the 0.7 threshold for a reliable aggregate, recommended by the Handbook on Constructing Composite Indicators, OECD-JRC (2008).

The development of an index, like any measurement, entails assumptions and subjective decisions. Hence, this section also aims to test whether and to what extent some of these assumptions influence the index values, within a range of plausible alternatives in an uncertainty analysis. Here, we quantify the uncertainty in the Monetary Union Readiness Index, which can demonstrate the extent to which countries can be differentiated by their Index scores.

There are many underlying assumptions of the MURI, which could be tested. Here, we examined two particularly important ones of these in our uncertainty analysis (a. the aggregation method, b. weighting scheme). These were chosen as plausible alternative pathways in the construction of the MURI in line with the literature on constructing composite indicators:

(a) the aggregation method [arithmetic or geometric mean]

(b) the weights [Gaussian noise on the weights, $\sum$ w = 1.]

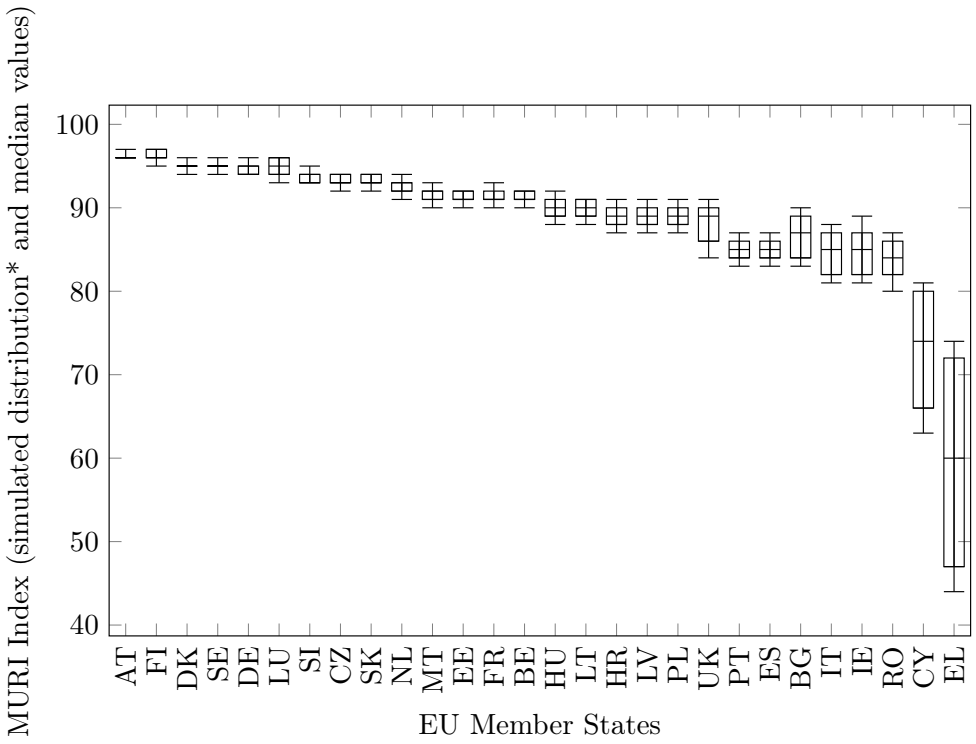
To tackle the problem of zeros when using the geometric average formula, we replaced zeros by 0.01 after min-max normalisation.

The first assumption which was varied was the aggregation method (arithmetic mean or geometric mean). In the MURI, the scores are aggregated into a single score using the arithmetic average formula (see Subsection 2.5 on weighting). The geometric average was chosen as an alternative approach, which is a non-compensatory aggregation method. In this way high scores in one Pillar do not compensate low scores in another, which is an alternative way to look at euro readiness. For instance, if a country scores high on nominal convergence indicators, can not offset its weak performance on real convergence ones. Second, nominal weights assigned at the pillar level are all equal. The effect of randomly varying these weights by +/-25% is also tested, to investigate the effect of modest variations in the importance of different convergence pillars.

We performed a Monte Carlo experiment to test the above two assumptions, and re-builded the Monetary Union Readiness Index 4000 times, each time with a randomly-selected combination of assumptions (a) the aggregation formula and (b) the weights using the 2018 observations.

In general, the MURI Index is very robust, above and close to average values are invariant to methodological choices. Mid-values can be stated to be within around 3-4 percentage points of precision in terms of the MURI Index 0-100 scale. This finding could be used to guide the conclusions that can be based on the index. For example, differences of two or three scores between Member States cannot be deemed as highly significant, whereas differences of 6-7 places upwards

Figure 4: Uncertainty of MURI Index scores (2018)



*The box plots show the 5%,30%,70% and 95% percentiles of the simulated score distribution, based on the 2018 observations of the MURI indicators.

or downwards can show a meaningful difference. The confidence intervals are generally narrower for top and mid-ranking Member States, and wider for some low-ranking ones. Still, it helps identify the least ready Member States for the euro adoption and use. As a robustness check of our uncertainty analysis we tested our index using observations from other years. There have been no major difference in the results, scores are robust to choices.

The overall finding of our uncertainty analysis is that the uncertainty in the MURI Index is manageable for most Member States. Hence, it allows meaningful conclusions to be drawn from the MURI index. Monte Carlo simulations could also be used in the future as a meaningful measure to judge the uncertainty about the eurozone readiness of a new candidate Member State. Finally, the MURI Index may provide a practical tool to cross-check new euro adoption plans in the future.

6 Conclusions

While all EU Member States has the right to join the eurozone, some members are far more ready for the use of the single European currency.

We constructed a novel Monetary Union Readiness Index (MURI) for EU Member States to contribute constructively to the ongoing discussion on the monetary integration and economic convergence of EU Member States. This discussion started with the conceptualisation of the

Optimal Currency Area (OCA) in the post-war era and continued with the creation of the eurozone at the late 1990s. It attracted even broader attention at times of the eurozone enlargement and after the 2008-9 financial crisis. The European Commission published a reflection paper on the deepening of the Economic and Monetary Union (EMU), confirming that the single currency is one of the most significant and tangible achievements in the EU, Commission (2017).

We derive the Monetary Union Readiness Index (MURI) from the European Regulatory framework on the Eurozone and from the economic theories on monetary unions. The MURI Index combines the indicators and thresholds of its three equally weighted pillars in the fields of (i) nominal convergence (e.g. the so-called Maastricht criteria), (ii) real convergence (e.g. the Optimal Currency Area requirements) (iii) macroeconomic stability requirements (e.g. the Macroeconomic Imbalance Procedure (MIP) indicators and thresholds). In total, the MURI Index has been built upon 20 indicators (5 nominal convergence indicators, 4 real convergence indicators, and 11 MIP indicators).

Readiness for euro in the majority of eurozone's founding Members (Austria, Belgium, Finland, France, Germany, Luxembourg, Netherlands) has varied in a range between 90 and 100, close to the maximum MURI value since 2005. According to our index, Denmark and Sweden could have considered adopting the euro throughout the entire sample period. Baltic and Central Eastern European Member States of the EU showed continuous progress in euro readiness except for the crisis years. According to our index, Cyprus and Greece seemed to be the least ready to adopt and use the euro in the early years of the eurozone.

The convergence has been achieved in terms of all index pillars in the best performing countries. The requirement of nominal convergence seems to be most fulfilled in most Member States, implying that the European regulatory framework helped to anchor nominal convergence. Real convergence is happening, although at a lower pace in new EU Member States than nominal convergence.

The development of an index, like any measurement, entails assumptions and subjective decisions. We performed Monte Carlo simulations to test our key assumptions: a) the aggregation formula and (b) the weights. We found that the MURI Index is very robust, index values above and close to the average are invariant to methodological choices and mid-values can be stated to be within around 3-4 percentage points of precision in terms of the 1-100 scale of the MURI Index. Our simulation method could be also used to check the uncertainty around the readiness of future eurozone candidate countries.

The contribution of our study to the debate on the eurozone is threefold. First, as a starting point we systematically investigated the available indicators, used for gauging EU Member States readiness for euro adoption and use. Second, we constructed an illustrative Monetary Union Readiness Index. Third, we provided scores and visualized the results to support discussions and

decisions of policymakers.

Our results are relevant for current and candidate eurozone members, as they allow an estimate of their euro readiness. Because the eurozone is a contemporary model for forming currency unions, the MURI index could also serve as a possible benchmark for other planned currency unions in the future (West African Monetary Zone, ASEAN, etc.). Bangake et al. (2007) concluded that for the aim of a Maghreb monetary unification, involved countries have to make more efforts to gather economic-institutional conditions, some of which are integral part of the improved regulatory framework behind the euro.

6.1 Discussion

The majority of indicators in the MURI Index has been taken from the European Regulatory framework on the euro. There are, however, indicators, mostly related to real convergence, which have not been stipulated yet in the European legislation, but mentioned frequently in the economic literature. The selection of the MURI indicators is, hence, to a certain degree subjective. Further discussions may help to identify the indicators which fit best the policy objectives. Our key goal was to help operationalize an easy-to-use but robust measurement of eurozone readiness and support formulate policy rules and monitor their effectiveness in the future.

We did not attempt to set a threshold for MURI that candidates of euro adoptions should reach before adopting the euro. Still, our index methodology could hopefully help future work on evidence based policy-making related to the deepening of the Economic and Monetary Union.

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A Appendix

Figure 5: Evolution of the Monetary Union Readiness Index by Pillars

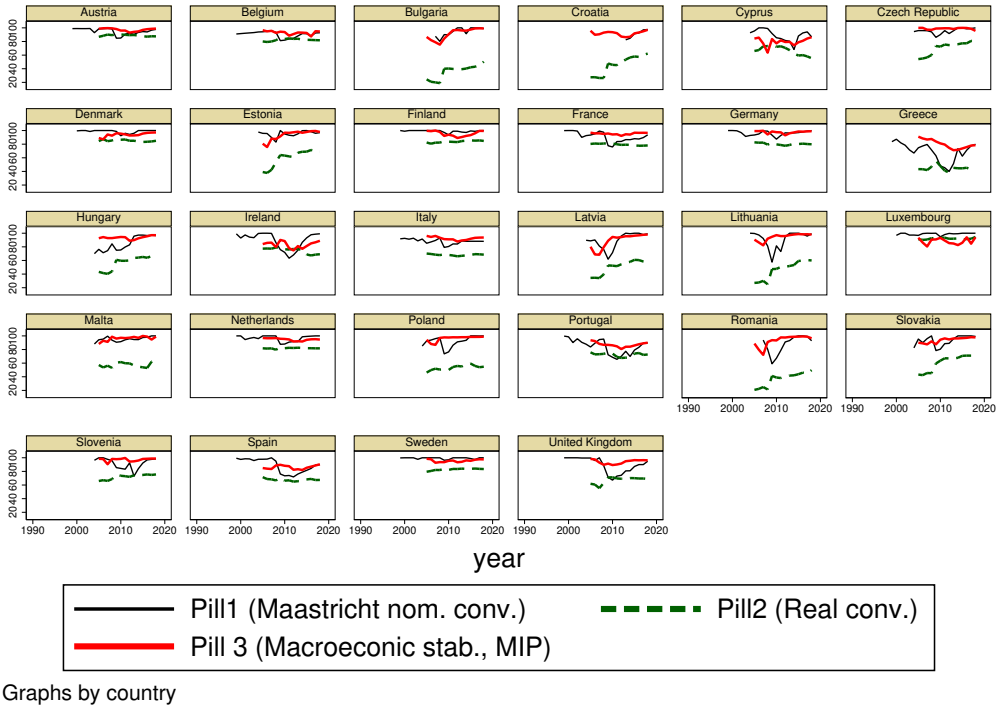
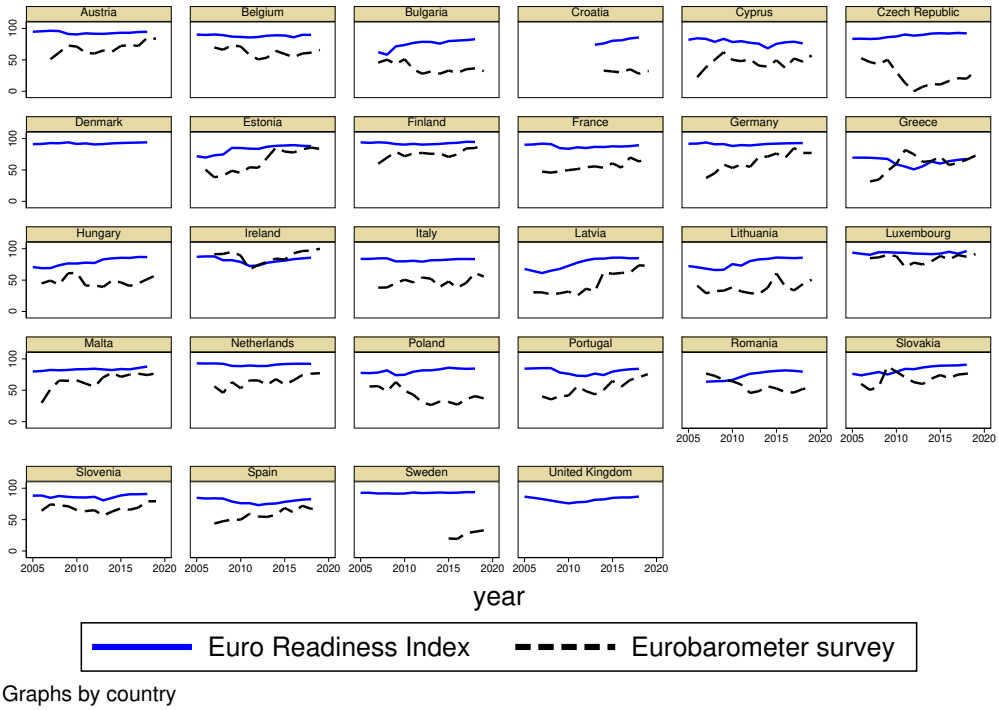
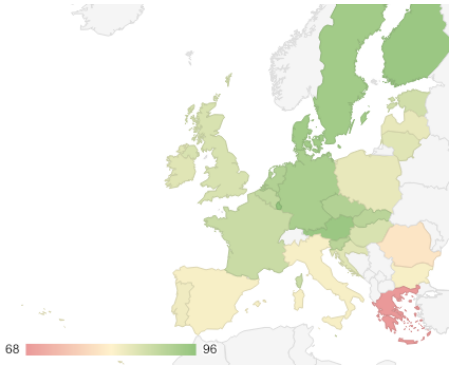


Figure 6: The MURI Index and Eurobarometer survey* results

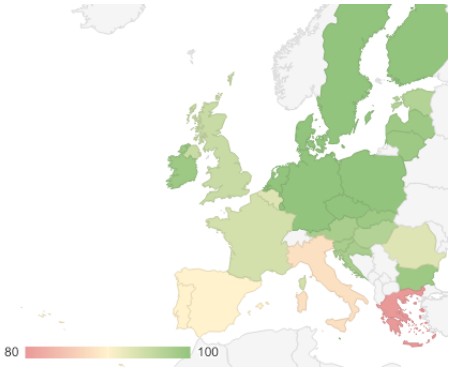


*Normalized difference between positive and negative answers in the Eurobarometer Survey.

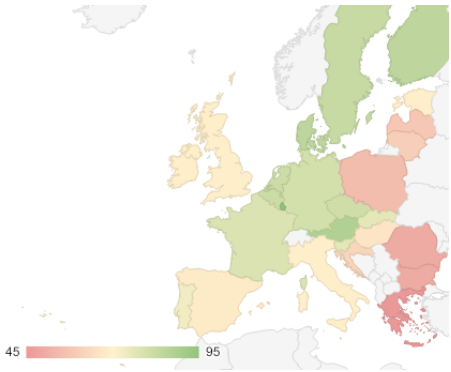
Figure 7: The MURI Index and its pillars



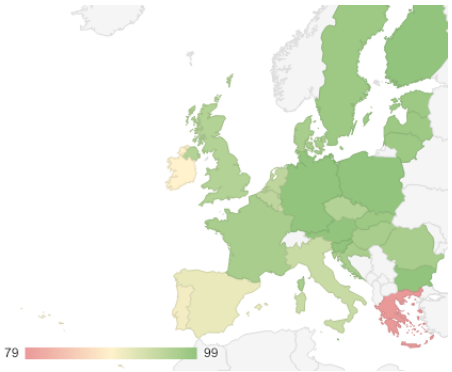
(a) ERI Index



(b) Pillar 1 - Nominal convergence



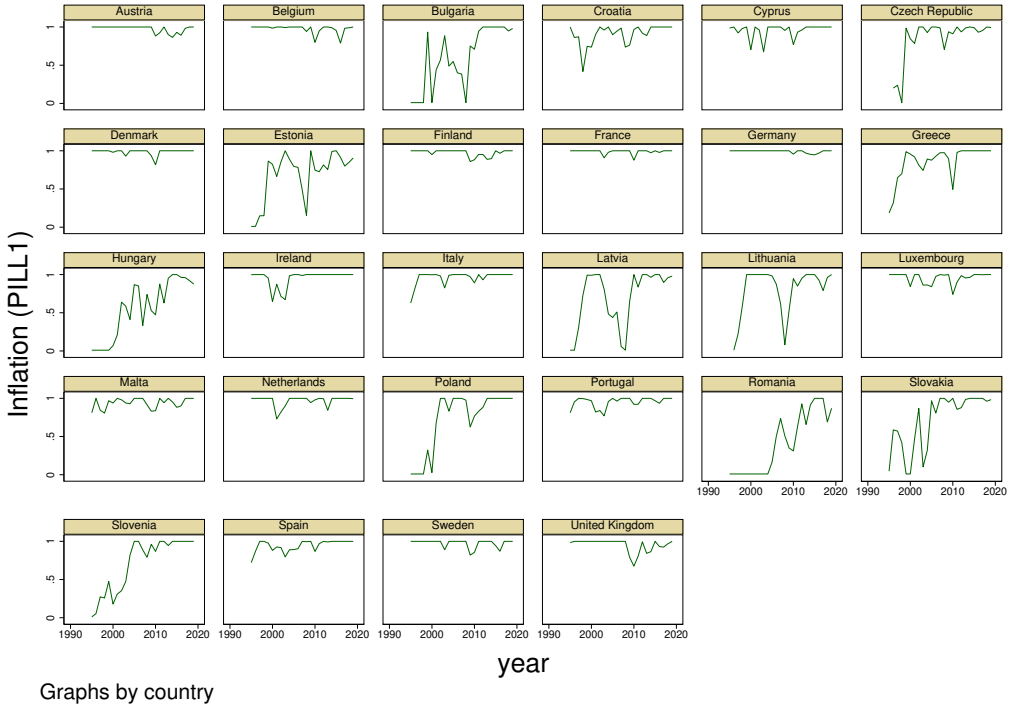
(c) Pillar 2 - Real convergence



(d) Pillar 3 - Macroeconomic balance

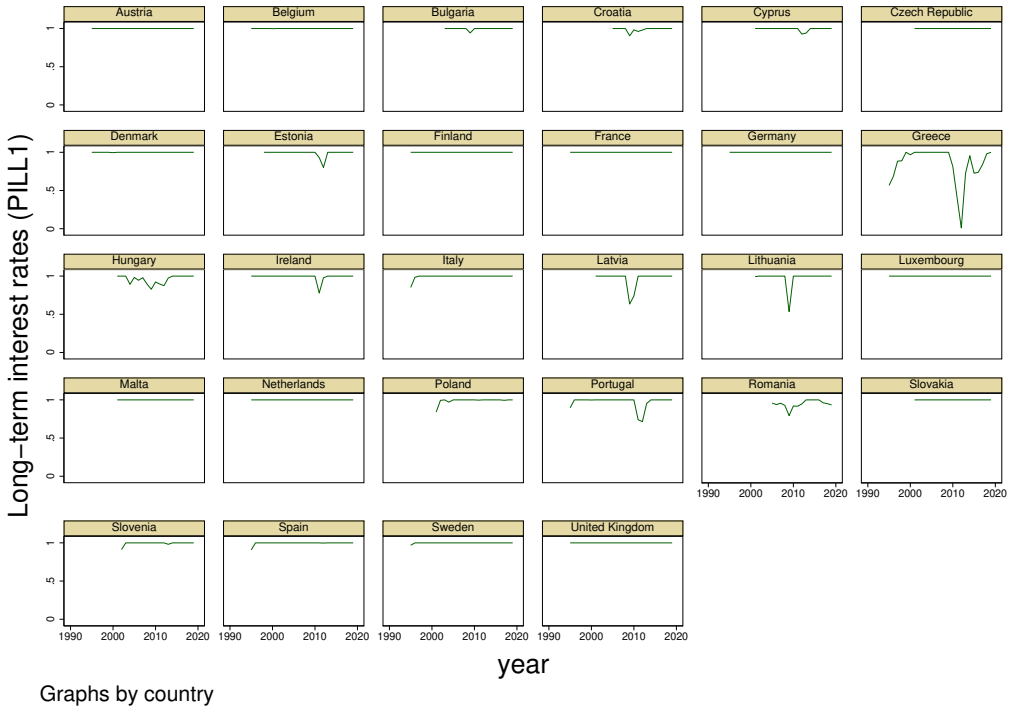
The maps show the 2018 observations of the MURI Index and its pillars.

Figure 8: CPI - Compliance with the Maastricht criteria (Pillar 1 - nominal convergence)*



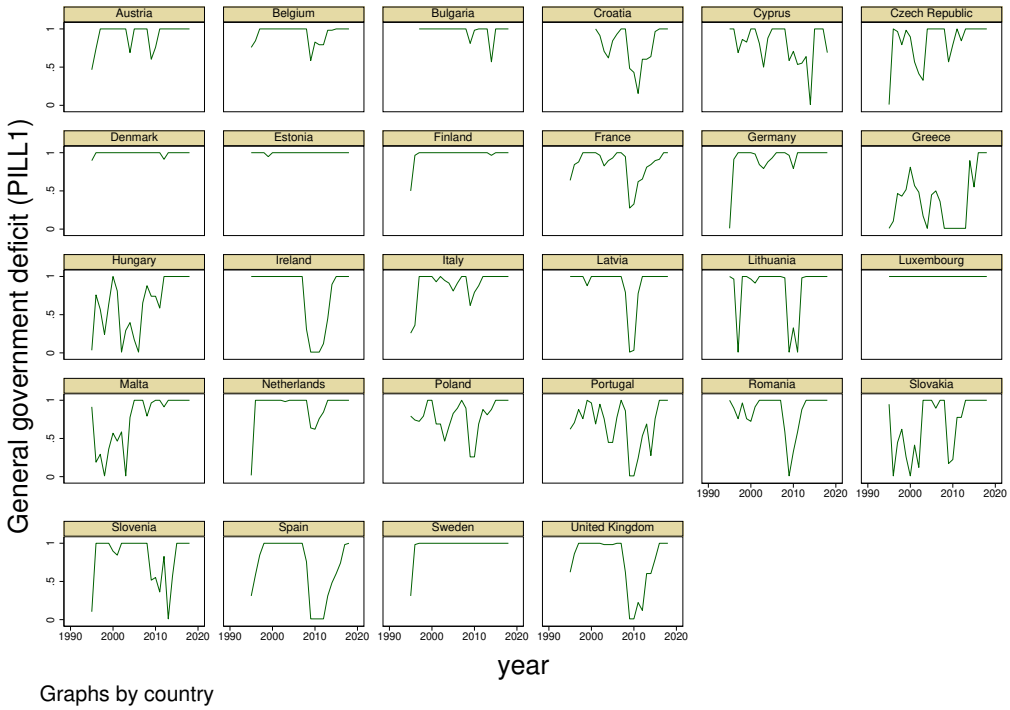
*100 full compliance, 0 non compliance

Figure 9: Long-term interest rates - Compliance with the Maastricht criteria (Pillar 1 - nominal convergence)*



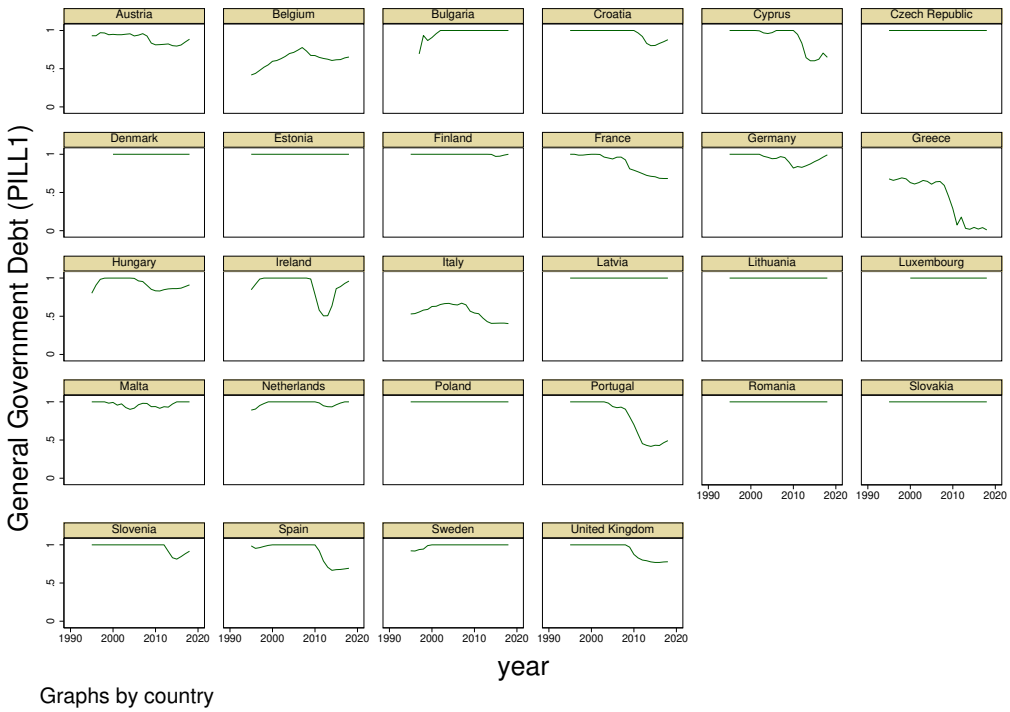
*100 full compliance, 0 non compliance

Figure 10: General government deficit - Compliance with the Maastricht criteria score (Pillar 1 - nominal convergence)*



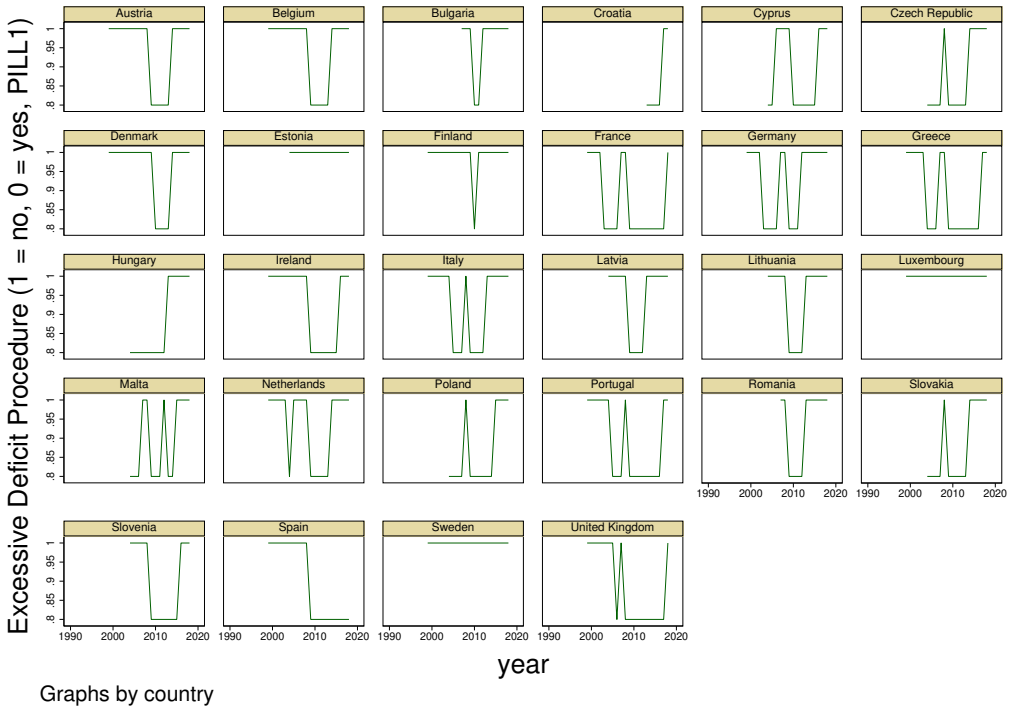
*100 full compliance, 0 non compliance

Figure 11: General government debt - Compliance with the Maastricht criteria score (Pillar 1 - nominal convergence)*



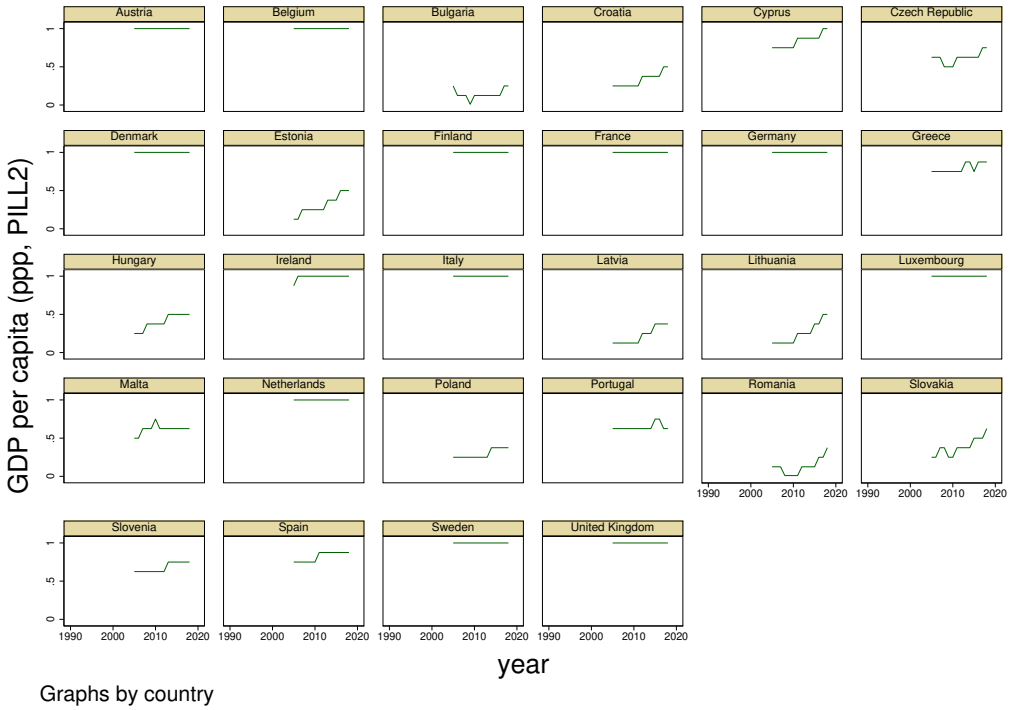
*100 full compliance, 0 non compliance

Figure 12: Excessive Deficit Procedure (Pillar 1 - nominal convergence)*



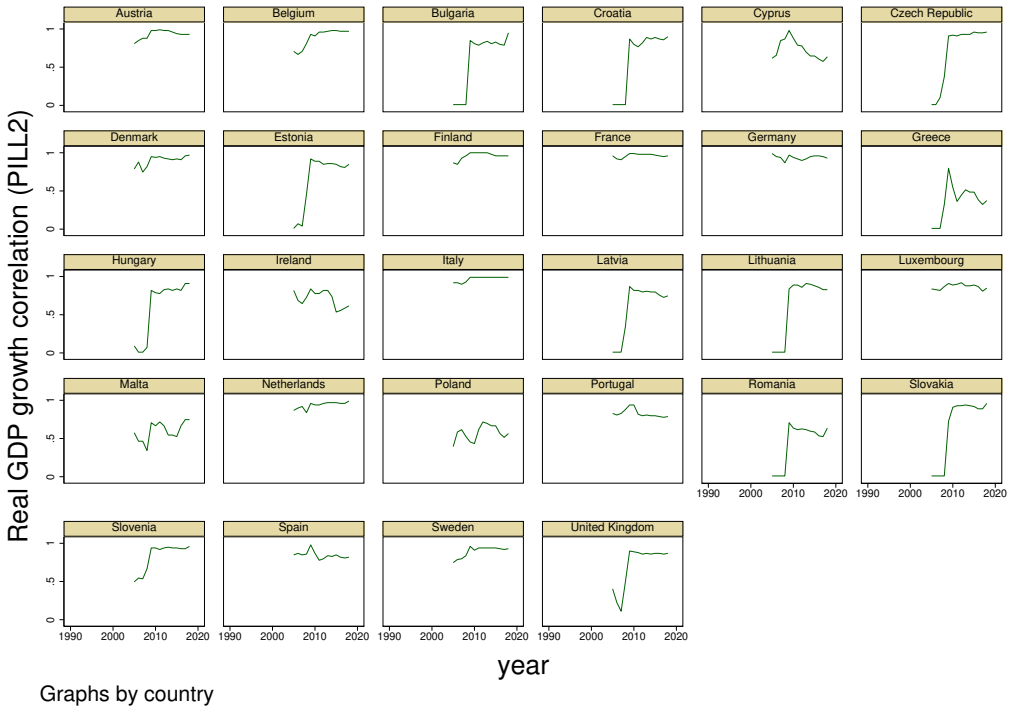
*100 full compliance (no EDP), 0 no compliance (EDP)

Figure 13: GDP per capita (PPP) (Pillar 2 - real convergence)*



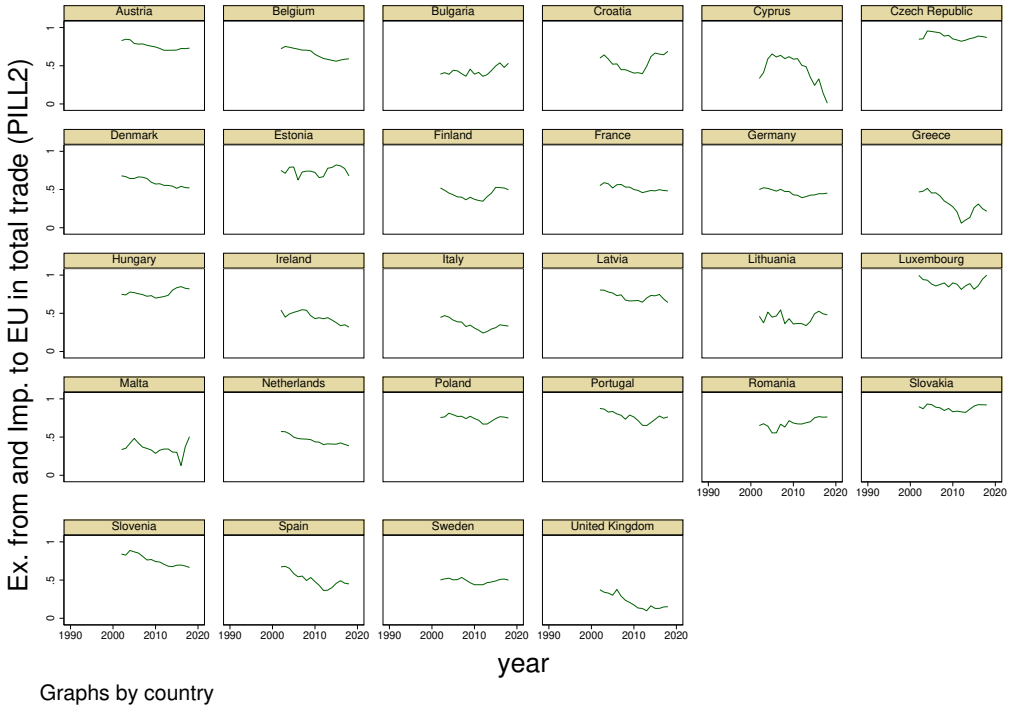
* Normalized values of GDP per capita compared to Eurozone average, 100 meaning the highest score in the EU, 0 the lowest in the EU.

Figure 14: Real GDP growth pairwise correlation (Pillar 2 - real convergence)*



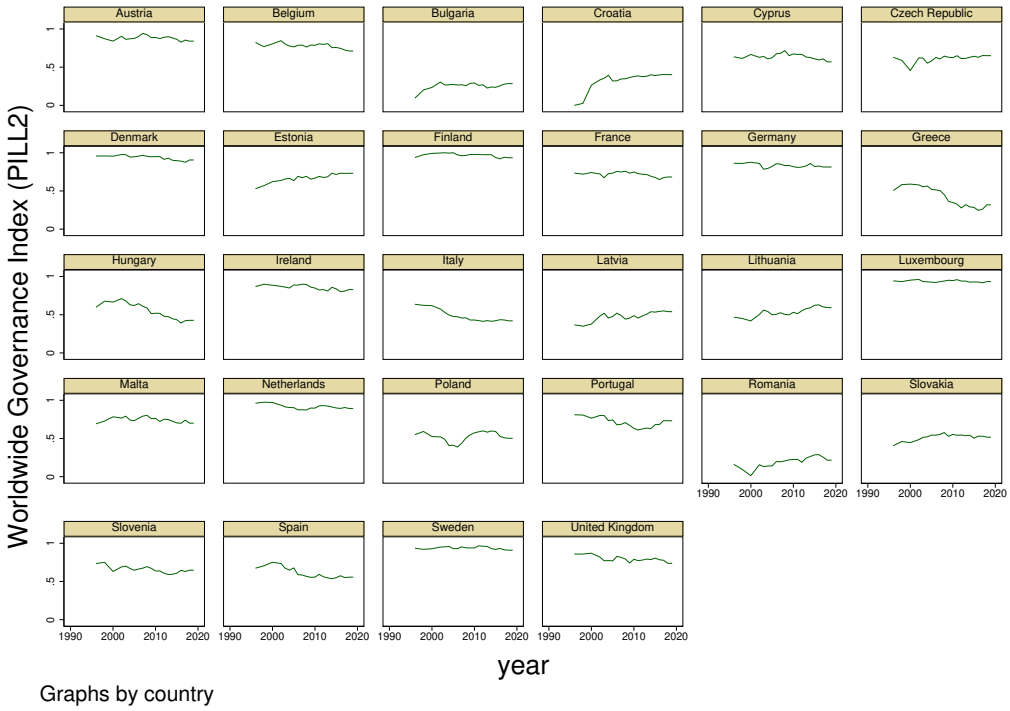
*100 perfect correlation, 0 zero or negative correlation.

Figure 15: Share of trade with EU in total trade (Pillar 2 - real convergence)*



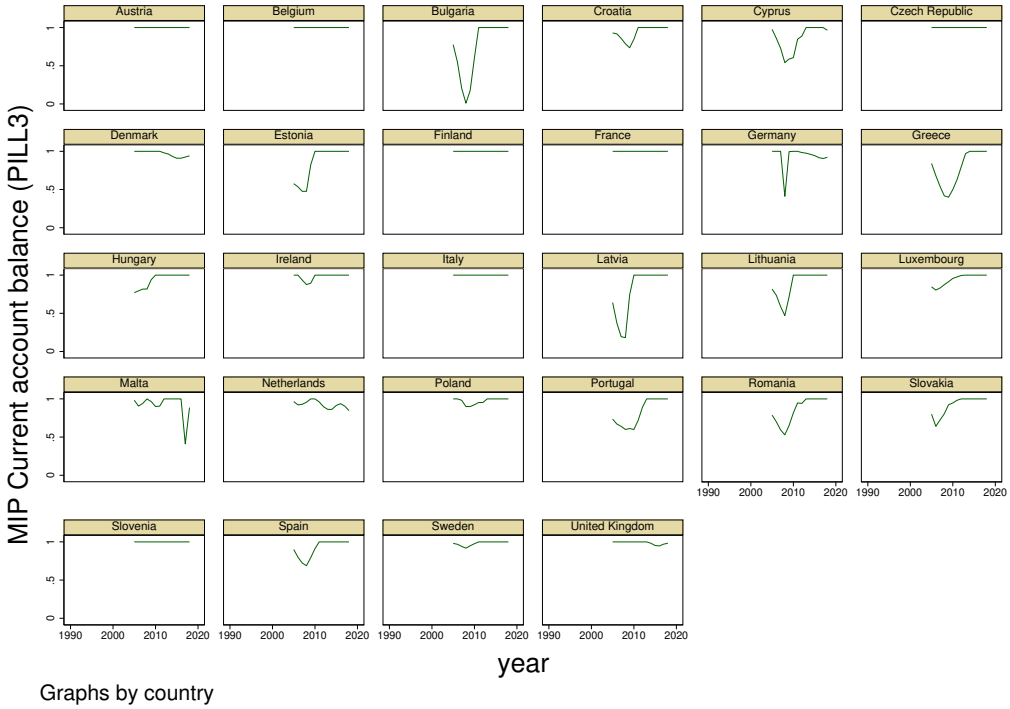
*(exports to and imports from EU)/(total export + import), 100 highest score, 0 lowest score

Figure 16: Worldwide Governance Indicator (Pillar 2 - real convergence)*



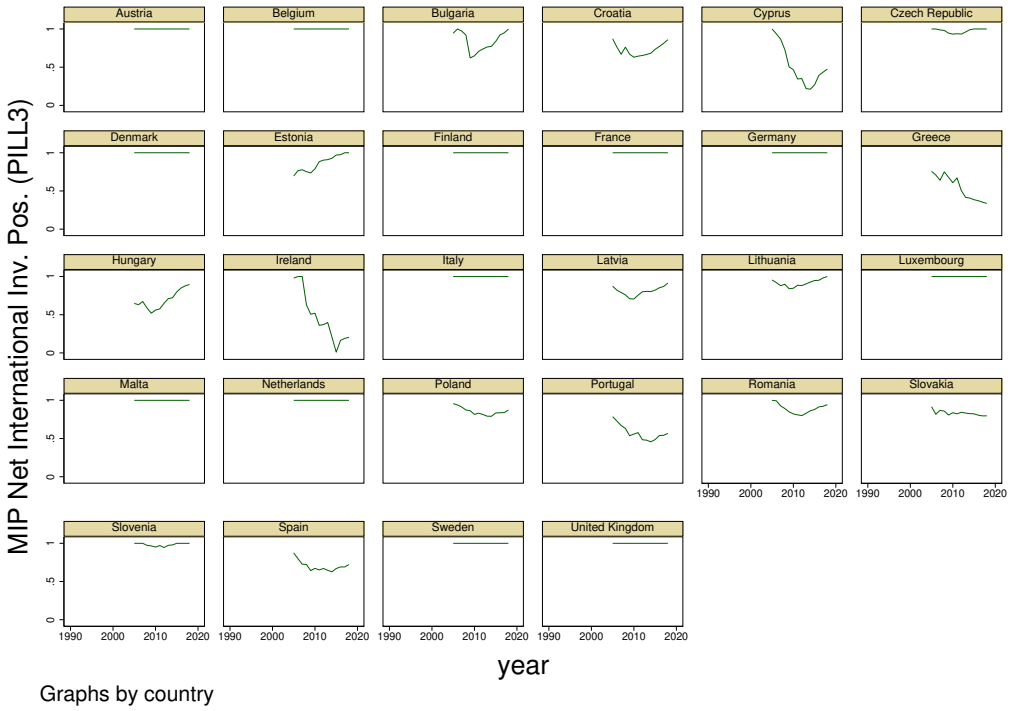
* Percentile ranks, 100 highest score, 0 lowest score

Figure 17: Current Account Imbalance (Pillar 3 - Macroeconomic Balance)*



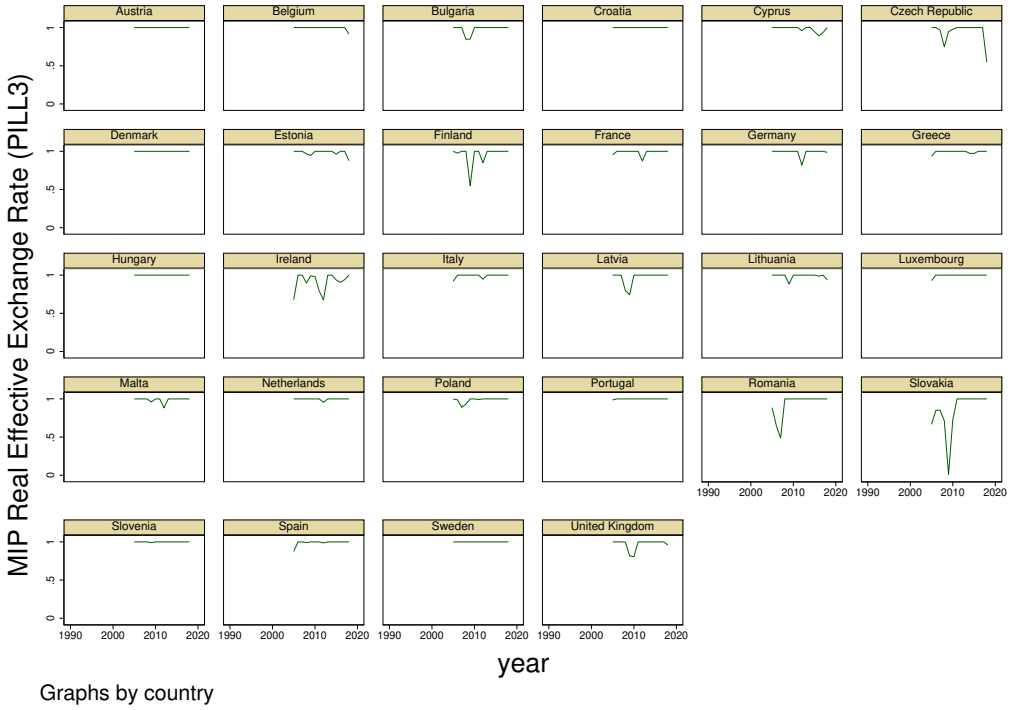
*100 full compliance with MIP, 0 lowest compliance

Figure 18: Net International Investment Position Imbalance (Pillar 3 - Macroeconomic Balance)*



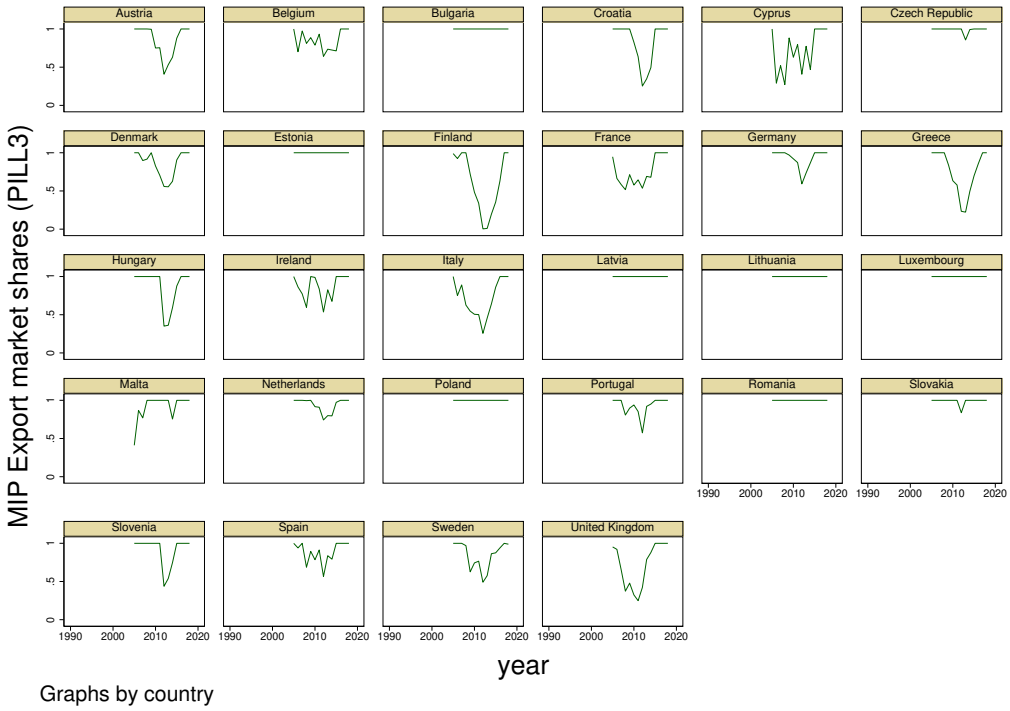
*100 full compliance with MIP, 0 lowest compliance

Figure 19: Real Effective Exchange Rate Imbalance (Pillar 3 - Macroeconomic Balance)*



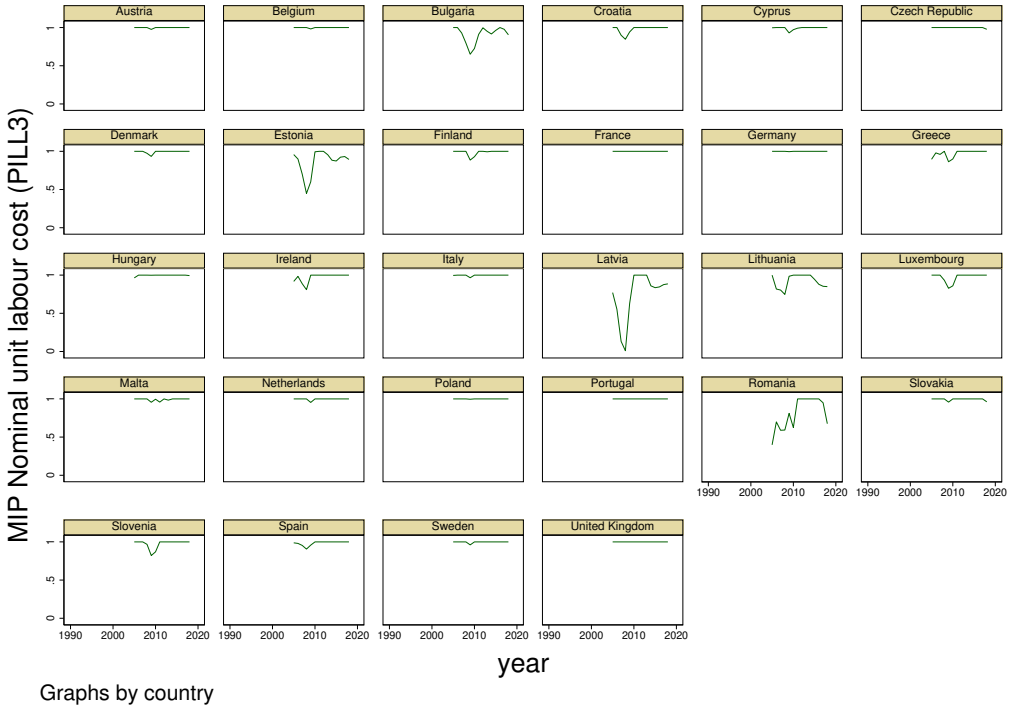
*100 full compliance with MIP, 0 lowest compliance

Figure 20: Export Market Shares Imbalance (Pillar 3 - Macroeconomic Balance)*



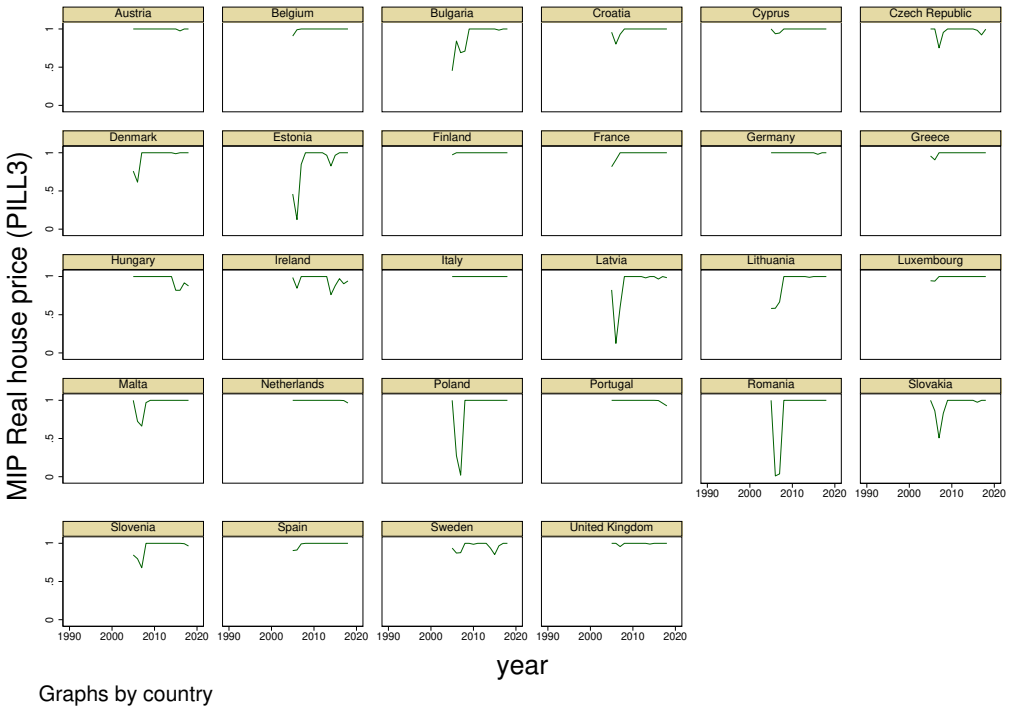
*100 full compliance with MIP, 0 lowest compliance

Figure 21: Nominal Unit labour cost index (Pillar 3 - Macroeconomic Balance)*



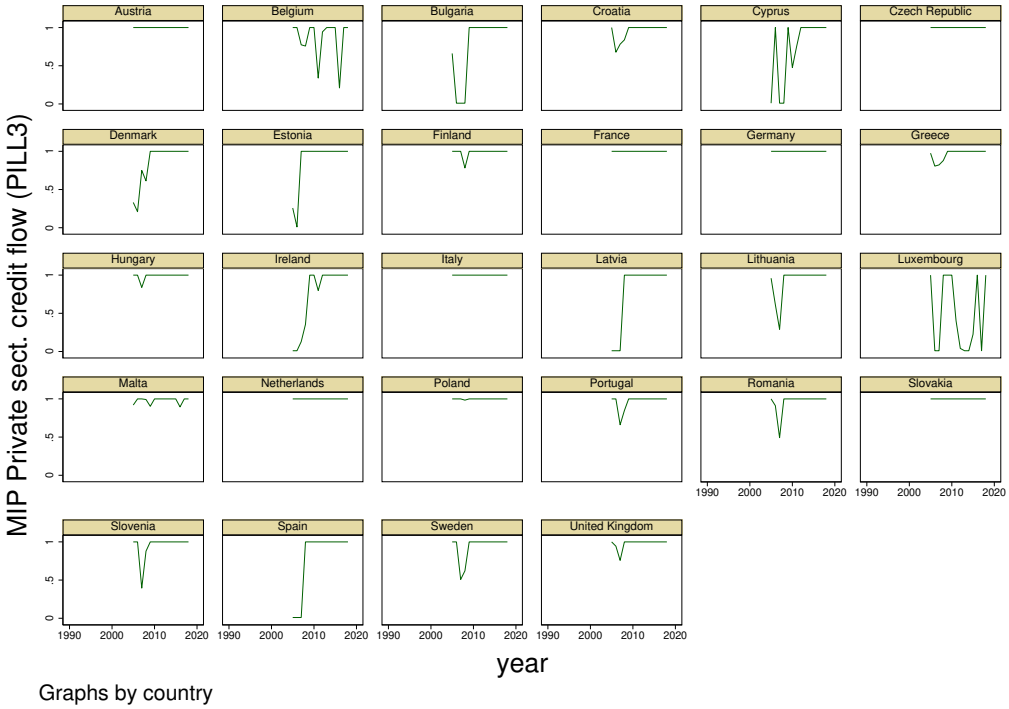
*100 highest score, 0 lowest score

Figure 22: Real house price index (Pillar 3 - Macroeconomic Balance)*



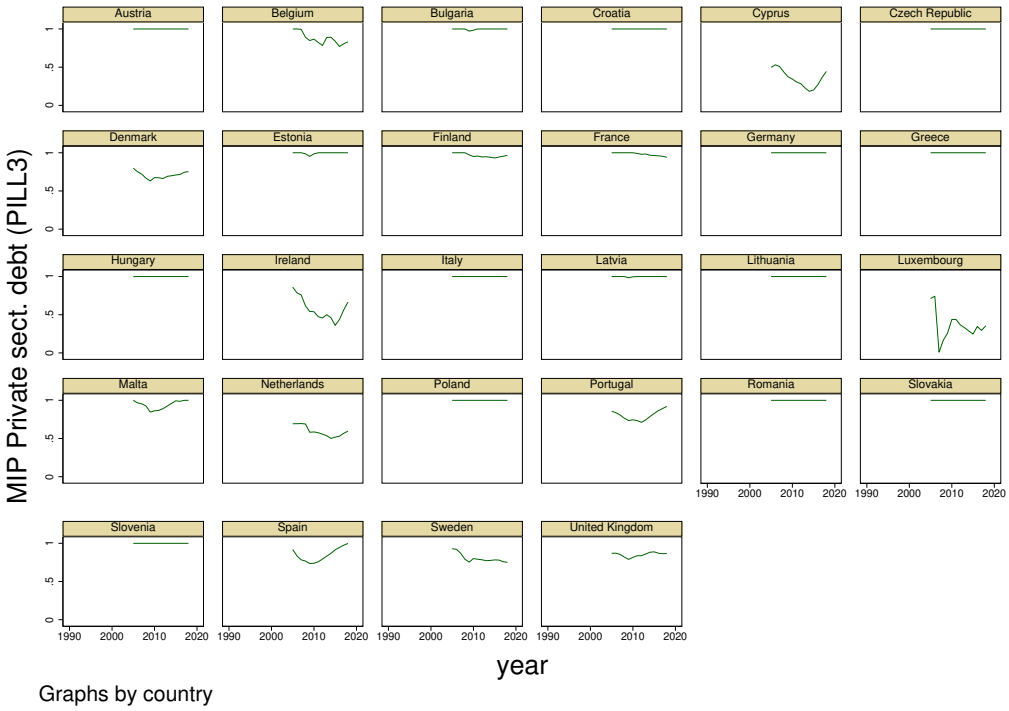
*100 full compliance with MIP, 0 lowest compliance

Figure 23: Private sector credit flow (Pillar 3 - Macroeconomic Balance)*



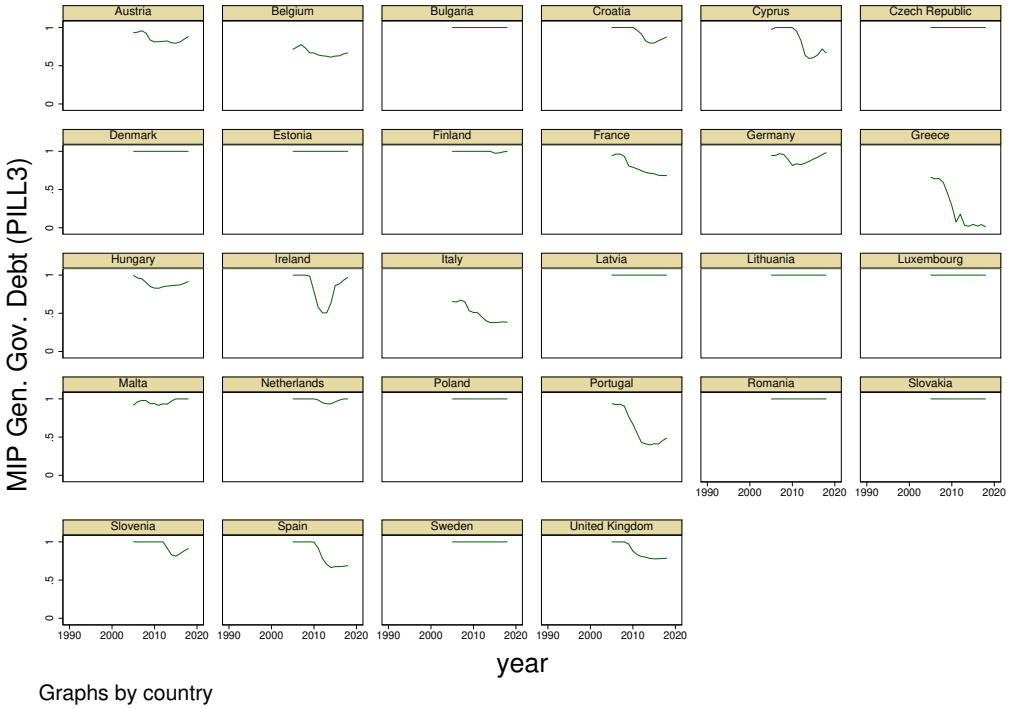
*100 full compliance with MIP, 0 lowest compliance

Figure 24: Private sector debt (Pillar 3 - Macroeconomic Balance)*



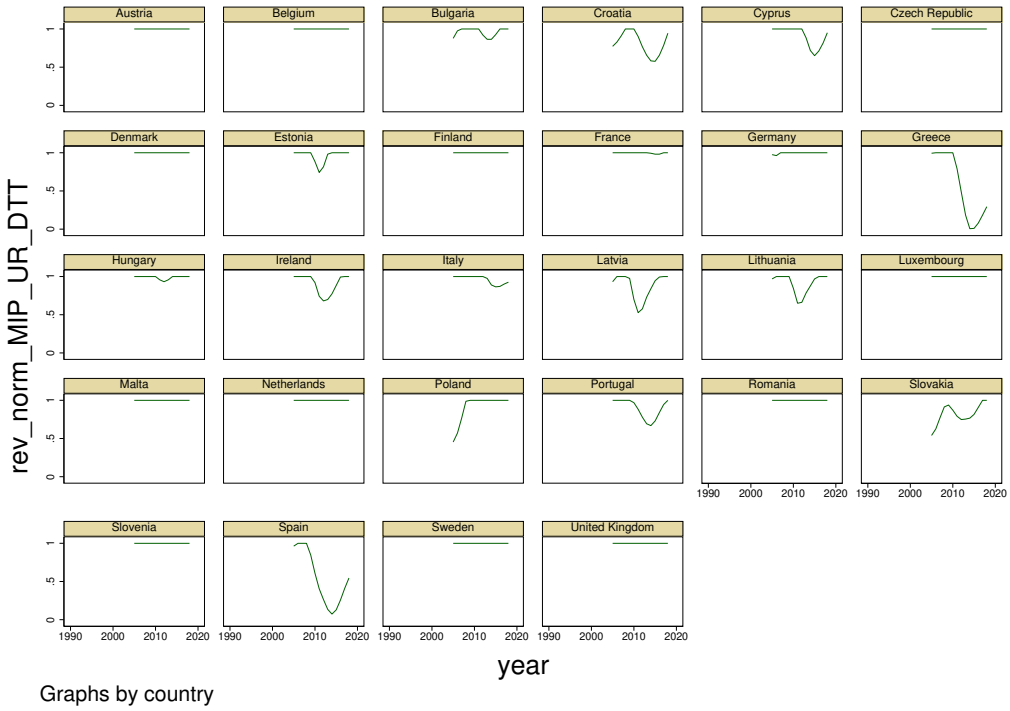
*100 full compliance with MIP, 0 lowest compliance

Figure 25: General government sector debt (Pillar 3 - Macroeconomic Balance)*



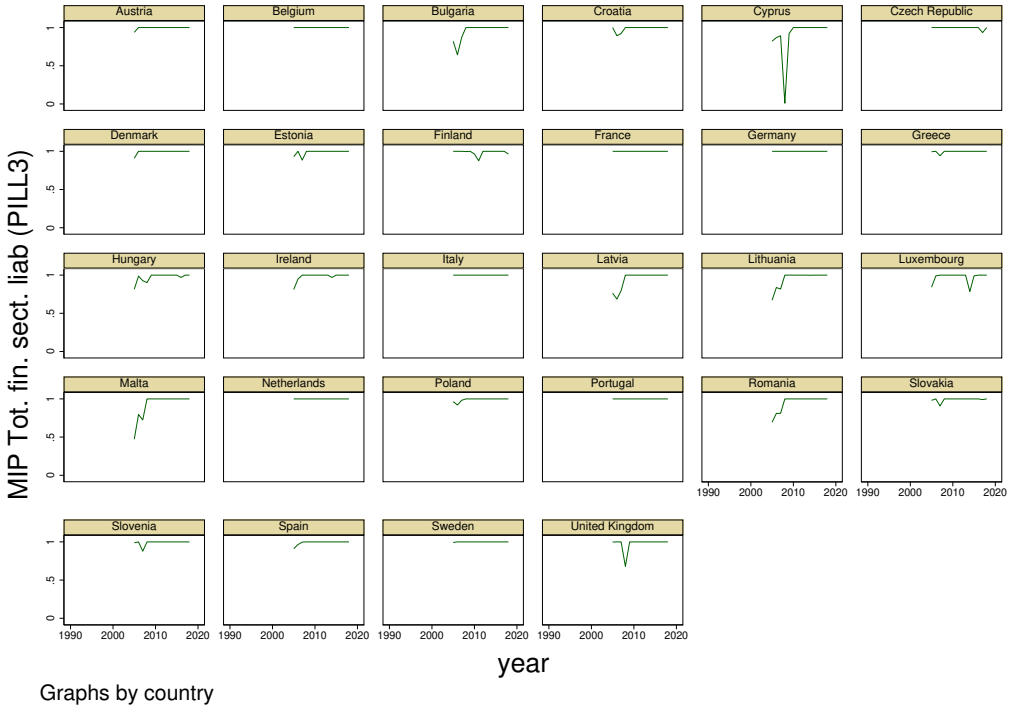
*100 full compliance with MIP, 0 lowest compliance

Figure 26: Unemployment rate (Pillar 3 - Macroeconomic Balance)*



*100 full compliance with MIP, 0 lowest compliance

Figure 27: Total financial sector liabilities (Pillar 3 - Macroeconomic Balance)*



*100 full compliance with MIP, 0 lowest compliance

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doi:10.2760/226646

ISBN 978-92-76-29423-8