# Factor Analysis of Business Cycle Synchronization in the Euro Area

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**Abstract**

A stylized fact from the literature of Optimal Currency Area is the need of a high degree of co-movement among member economies. In this study, I employ a Dynamic Factor Model to analyze business cycle synchronization among Euro Area members. The core idea underlying this class of models is that the co-movements among many time-series can be modeled by a few latent factors. My results confirm the existing findings in the literature. There is indeed a European Business Cycle that drives a significant part of the variance of GDP across the continent. However, certain countries have part of their variance explained by regional components, while, other have more idiosyncratic output patterns, which cannot be explained by any common factors. Over time, synchronization seems to increase for some countries but not for others. However, all economies experience increases during times of crisis.

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## List of Abbreviations

EA – Euro Area

EMU - Economic and Monetary Union

EU - European Union

DFM – Dynamic Factor Model

## Introduction

Since the early post-war years, the European authorities made efforts to foster integration and cooperation among countries. This involved the liberalization of the trade of goods and services, the reduction of capital and labor market barriers, as well as the coordination of monetary policy among European countries. This process culminated in the adoption of the Euro in 1999, when the member states of the Economic and Monetary Union (EMU) gave up on their own monetary policies and adopted a single currency.

A stylized fact from the Optimum Currency Area literature is the importance of a high level of business cycle synchronization for the effective work of a monetary union. The literature on this field has concluded that member economies must have a high degree of synchronization to ensure that a single monetary policy would suit the needs of its many member states. This conclusion derives from the rule of thumb of monetary policy, which suggests that the monetary authority should raise its interest rates when the output gap is positive. A positive gap indicates an economic activity above its potential, i.e., an overheated economy, which increases the inflationary pressure. When pooling different countries in a monetary union, it is desirable that the output gaps of the members have a high degree of synchronization so that the single monetary policy can meet the needs of its member states simultaneously (Gächter et al, 2012).

Since the beginning, the early founders of the Euro took the concern about synchronization into consideration. The Maastricht Treaty established four criteria that countries must meet in order to become a member of the Euro Area (EA), namely: inflation not greater than 1.5 p.p. than the best performing other members; a ceiling

for government and public debt; stability of exchange rate; interest rates not more than 2 p.p. greater than other members. Therefore, for a country to be part of the Euro, it had to satisfy criteria of similarity and convergence with other member economies. Additionally, once the countries join the Union, the economic integration should promote co-movement and synchronization among them. International shocks can be transmitted through two channels: trade and finance (Canova, 2005). Given the high degree of goods and financial integration created by the European Union, one would expect these forces to reinforce the existing convergence established by the Maastricht Treaty.

The benefits of joining the EA could be many. The reduction or elimination of trade barriers and labor and capital rigidities can foster economic growth (Alesina & Barro, 2002). The integrations make it easier for companies to invest and trade across the continent, while individuals can freely move around the continent. In addition, countries with a poor record of combating inflation tend to benefit from the monetary credibility offered by the new currency.

On the other hand, the greatest downside is the loss of a country's independent monetary policy/exchange rates control, some of the main instruments to stabilize economic activity following a shock. As Alesina et al. (2002) point out, the greater the association of shocks between countries in a monetary union, the lower the costs of giving up the monetary policy. The more symmetric the shocks are, the better the monetary policy set by the union's monetary authority will fit the needs of the member countries. Additionally, the variance of the cycles also matters. If a country joins the EA, even if its business cycle is highly correlated with the other members, if its variance is greater than that of the other economies, then the monetary policy implemented by the European Central Bank will not be enough to meet the stabilization needs.

These costs were taken into consideration since the early years of the monetary union in Europe. In 'One market, one money', Emerson et al. (1992) discuss the benefits and costs of the Economic and Monetary Union (EMU), which aimed to coordinate the economic policy among its members. Under the possible disadvantages of the Union, the authors say "The main potential cost of EMU is that represented by the loss of monetary and exchange rate policy as an instrument of economic adjustment at the national level [however] EMU will reduce the incidence of country-specific shocks". On the same topic, Amati and Patterson (1998), also working before the introduction of the European Union, argue that once the countries join the same Union, most of the external trade would become internal trade. As a result, the external vulnerability of the EU as a whole will be smaller than the individual countries' vulnerability.

Empirically, there are pieces of evidence supporting the existence of a high degree of synchronization and co-movement among the European economies. Bergman (2003) shows that business cycle synchronization is higher among EU members than among non-members, with bordering EU countries having a higher degree of synchronization. In addition, trade also plays an important role in synchronization, corroborating the argument that integration among European countries via trade should foster synchronization.

On the other hand, there is evidence suggesting the decoupling among member countries. Weyerstrass et al. (2011) partially confirm the results above mentioned, as they show the existence of a high degree of synchronization among the EU economies. However, opposing the theoretical view that economic integration should foster co-movement, they find that the introduction of the Euro has not increased synchronization. In addition, they show that some countries exhibit more idiosyncratic cycle patterns, namely Portugal and Greece. This evidence indicates that while some

economies are highly synchronized with others, there seem to exist a few that are not, which creates challenges for the monetary authority to implement its monetary policy.

I work on the topic of business cycle synchronization in the Eurozone assessing the degree of synchronization among its member states. I use a Dynamic Factor Model to estimate factors that drive the common dynamics of a large number of time series (Stock & Watson, 2016). GDP time series are used as proxies for the business cycle. I use two factors, one to capture the common dynamics across all economies, and a regional factor, which captures the co-movements across a group of selected countries. By decomposing the variance of the GDP series among these factors, I can assess how much countries co-move with the rest of the continent, with the other countries of their region, or idiosyncratically.

My results show that indeed there seems to exist a European Business Cycle that explains a significant part of the output fluctuation across the continent. Since the COVID period represents a shock that hit all the countries at the same time, synchronization increases during that period. Once the pandemic represents an extreme period, I restrict the sample to the period before it, which represents the 'normal economic conditions'. I find that countries, namely some of the richest ones, have a significant part of the output variation explained by a factor common to all economies, indicating synchronization. However, other economies have part of their fluctuations explained by a region-specific factor. Additionally, some nations show a significant idiosyncratic pattern, indicating they do not closely follow other EU members.

I also show that synchronization increases for all countries during turbulent times, such as the global economic crisis of 2008 and 2009 and the COVID period. When

analyzing less volatile periods, some countries seem to experience an increase in co-movement, while others do not. Finally, I discuss the implication of my findings for monetary policy.

## Literature Review

A large literature has analyzed business cycle synchronization among countries worldwide, with a particular focus on European nations. Kose et al. (2003) implement a Bayesian dynamic latent factor model to estimate common components in time series from 60 countries. They estimate 4 factors: a 'world factor' common to all countries; 'regional factors' common to some specific region; country factors; and a component capturing idiosyncratic dynamics, in a setup similar to mine. Their results show that the world factor accounts for a big portion of business cycle growth fluctuation in economies, which indicates the presence of a world business cycle. However, this factor plays a more relevant role for developed countries, while country-specific and the idiosyncratic component play a more important role for developing ones.

Focused on the European context, Ferroni & Klaus (2015) focus on the convergence of the four biggest euro area economies: Germany, France, Italy, and Spain. Using a similar factor model to Kose et al., they find that before the global financial crisis of 2008, the business cycles of these economies were highly synchronized. However, after that, the Spanish economy started to show divergent behavior compared to the other members. The economy seem to be overheated before the crisis and over-depressed after it. Additionally, they find an important role of the European factor in explaining output volatility, bringing evidence in favor of the existence of a European Business cycle. Spain, however, has a more idiosyncratic output. Their results are in line with those of Artis et al. (2004), which also find evidence in favor of a common business cycle for the economies of Europe.

Also working on the synchronization in Europe, Gächter et al. (2012) want to assess the impact of the financial crises on the business cycle synchronization in the Euro

Area. They find an increase in the dispersion of business cycles starting prior to the outbreak of the crisis, already in 2007. When analyzing the correlation of each country's cyclical component with the euro area aggregate cycle, they find that for some countries there are no big changes in the correlations before and after the crisis. However, for Spain, Cyprus, and Greece the change was statistically significant. Therefore, their overall findings are in line with those of Ferroni & Klaus (2015), as they also find an increase in de-synchronization and dispersion due to the crisis.

When assessing dynamically the co-movements among countries, Degiannakis et al. (2014) find an increase in synchronization among European Economies since the introduction of the Euro until the outbreak of the financial crisis. After the global recession, some countries experienced a halt in the synchronization increase, while for others it declined, such as Greece. Their result of a temporary increase in co-movement is the opposite of Weyerstrass et al. (2011), once they do not find evidence of the introduction of the EU to favor synchronization.

Overall, the assessments of synchronization seem to show that indeed there exists a European business cycle, which explains a significant part of the variation in output across the continent. However, there are evidence that some countries are decoupled from this cycle.

As already discussed, the literature on Optimum Currency Area (OCA) often postulates that close trade relations is a requirement for countries to join a monetary union. The greater the bilateral trade between countries, the more likely that a shock that affects one country will be transmitted to the other. However, theoretically, the outcome of greater trade can be the opposite. Greater trade connections could make countries more specialized in certain goods in which they have comparative

advantages, as the basic models of international trade postulate. This specialization could make countries more susceptible to shocks specific to that industry, making their business cycles more idiosyncratic.

On this argument, Krugman (2001) argues that the American experience, with its large and highly integrated economy, could be used as an example for the Economic and Monetary Union (EMU). He highlights the example of New England, a region whose industry back in the 1990's was concentrated in some technological niches, such as mini-computers, advanced medicine, and military hardware. The economy boomed until a series of adverse events to these industries caused an economic crisis in the region, which idiosyncratically raised unemployment. He argues that in the integrated Europe, it is more likely that concentrated niche economies would emerge, just like it happened to New England. In Europe, the abolishment of labor and capital restrictions would make these factors flow to regions where specific industries are flourishing. Then, these highly specialized European Economies would be subject to specific technology and demand shocks, which would lead to the risk of region-specific economic downturns and divergences in the long-run growth.

On the other hand, reinforcing the common view of economic integration fostering co-movements, Frankel (1998) argues that following the introduction of the EU, common shocks might prevail over idiosyncratic ones, such as common demand shocks that affect multiple markets. The author tests empirically which of the forces prevails. Using instrumental variables for bilateral trade intensity, their results show that the tighter the trade links between countries, the more correlated are their economic activities.

This result shows that once countries enter a monetary union, their fit to be part of the union (i.e., the closeness of business cycle) might increase, once their trade relations

with other members also increase. Therefore, as the authors point out, a country is more likely to satisfy the criteria of the high correlation of activity ex-post rather than ex-ante joining the union. The findings show that even though Krugman's hypothesis that greater economic integration could lead to more idiosyncratic business cycles is compelling and has theoretical groundings, it is likely to not be the case in Europe.

On the same topic, Böwer and Guillemineau (2006) analyze the factors determining business cycle synchronization in the Euro Area using extreme-bound analysis. They find a positive relationship between bilateral trade and business cycle synchronization, both when bilateral trade is measured as a ratio to total trade and or to GDP ratio. This result reinforces the ones from Frankel. However, regarding trade specialization, they find some negative relation with business cycle correlation, which implies that the more similar the trade, the higher the cycle correlation, supporting Krugman's argument. Therefore, there are arguments, and evidence, in favor of economic integration both favoring synchronization and increasing idiosyncrasies among economies.

## Methodology

In this section, I will describe the Dynamic Factor Model (DFM). This model assumes that there exist a few latent (unobservable) factors that drive the common dynamics of a large number of time series (Stock & Watson, 2016). The model depicts the evolution of a large number of time series in function of a few factors, which evolve over time, plus uncorrelated disturbances, these being measurement errors or idiosyncratic dynamics of the time series. The factors capture the common fluctuations across all series.

Some examples from the literature might be useful to gain an intuition of the idea behind this class of models. As Kose et al. (2003), suppose one has a set of variables measuring the academic performance of an individual: GPA, SAT, GRE, GMAT scores, etc. The dynamics of these variables can be explained by a few factors, such as intelligence, task-taking abilities, etc. Therefore, if there is a positive co-movement across these variables in a period, one can guess that the factor test-taking abilities increased in that period.

More related to the scope of this article, Stock and Watson (1988) use a DFM to capture the overall state of the economy, i.e., a factor that captures the co-movements of the time series of industrial production, real personal income, real manufacturing and trade sales, and employment. They explain this factor, which they call variables, as “an unobserved variable common to multiple aggregate time series”. They compare the estimated factor with The Index of Coincident Economic Indicators, a coincident index that tracks the overall state of economic activity, and they find a high correlation between them.

My approach is very similar to Stock and Watson's, but instead of using time-series representing different variables to estimate the common factor to all of them, which would represent the driving force of the American business cycle, I use time series measuring GDP of Euro Area countries, to estimate the factors that drive the 'Euro Area' business cycle.

Formally, the model has the following representation:

*Equation 1*

$$y_t = \Lambda f_t + \varepsilon_t$$

$y_t$ is a vector of GDP time-series (in this study, Austrian GDP, Portuguese GDP, Spanish GDP, etc), $f_t$ is a vector of latent factors, $\Lambda$ is a matrix containing the factor loadings, which relate the time series to the factors. The $\varepsilon_t$'s are the idiosyncratic errors, that follow an autoregressive process:

*Equation 2*

$$\varepsilon_t = \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \cdots + u_t$$

The factors follow a vector auto regressive process:

*Equation 3*

$$f_t = A_1 f_{t-1} + A_2 f_{t-2} + \cdots + u_t$$

The estimation method in an EM algorithm following the framework proposed by Bandura and Modugno (2014), which makes it easy to estimate models with missing data. The method consists of an iterative process of estimation in two steps: the E-step, which calculates the expectation of the log-likelihood function using the estimates from the previous iteration, and the M-step, in which the parameters are estimated again with the maximization of the expected log-likelihood of the previous step.

More precisely, in this research, I have 20 countries, $i = 1, 2, \dots, 20$, and one GDP time series per country. There are 2 factors, which are: global, common to all countries, and regional, $r = 1, 2$ in which I group countries. Therefore, for each of the variables:

*Equation 4*

$$y_{i,t} = b_i^{global} f_t^{global} + b_i^{regional} f_t^{regional} + \varepsilon_{i,t}$$

The b's are the factor loadings. They show how each factor and the dependent variable are related. $f_t^{global}$ and $f_t^{regional}$ are, respectively, the global and regional factors. The first captures the co-movements common to all countries, while the second captures the ones common to countries part of the same group. They play an important role in the synchronization analyses, since one expects that most of the variation of GDP in a monetary union to be explained by the global factor, while regional and idiosyncratic components should play a minor role.

The choice of adding regional factors has grounds in the evidence from the literature. Bergman (2003) shows that proximity plays a crucial role in favor of co-movement. Also, countries should trade more with their neighboring nations. Therefore, one should expect to see a high degree of synchronization among economies of the same region. Therefore, there are empirical and theoretical reasons supporting the choice of adding regional factors in the study of economic activity synchronization.

My model specification, i.e., the factors choice and the allocation of countries to them, is based on my institutional knowledge of the European economic context and from the results of the literature. For instance, there is evidence that Italy, France, and Germany have a high degree of co-movement, as shown by Ferroni & Klaus (2015) and already discussed here. Therefore, these countries should be allocated to the same regional factor. Also, one would expect that Portugal and Spain, given their

geographical proximity, should be in the same factor, as distance seem to play a role in promoting co-movement. I use these tools to allocate countries into the regional factor, as shown in Figure 1:

*Figure 1*

| Regional | | | |
|---|---|---|---|
| North | South | Baltic | Central |
| Austria | Cyprus | Estonia | Croatia |
| Belgium | Greece | Latvia | Slovakia |
| Finland | Ireland | Lithuania | Slovenia |
| France | Malta | | |
| Germany | Portugal | | |
| Italy | Spain | | |
| Luxemburg | | | |
| Netherlands | | | |

**Data**

The data is GDP series for each of the 20 countries members of the Euro Area. They are quarterly, going from Q1 1995 to Q4 2022. The data comes from the Eurostat, downloaded in real terms, and with no seasonal adjustment. I did that so I could run my own seasonal adjustment in such a way that I could guarantee that all series had been going through the same de-seasonalization method. This process was done using the TRAMO-SEATS method.

There are many available methods to estimate the cyclical component of time series. Some of the most common ones are the Hodrick-Prescott (HP) filter, Band-Pass filters, Moving Average, etc. The literature generally follows the framework proposed by Stock and Watson (1988), in which the authors, working with industrial production, real personal income, real manufacturing and trade sales, and employment, were unable to reject the hypothesis that the series are integrated. When testing, they find that the series are not cointegrated. Therefore, to estimate their model they take the first

difference of the log of each of the series, then standardize and de-mean them. Kose et al. (2003), which also use the same method, find that their results are almost unchanged when using the HP filter of the log of the original series**.** Therefore, I proceed using the log differentiating method widely used in this literature. By working with log-differences, all countries have the same contribution in the factor estimation, regardless of their size. Therefore, one does not need to worry about large economies driving the movements in the factors just because of their economy's size.

To motivate the discussion, Figure 1 shows the correlation of the cyclical components of GDP data for the Euro Area countries. The cyclical components were obtained using the HP filter. The sampling period is from 1995 to 2022.

*Figure 2*

| Correlation of Cyclical Components of Output | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AT | BE | HR | CY | EE | FI | FR | DE | GR | IE | IT | LV | LT | LU | MT | NL | PT | SK | SI | ES |
| AT | 1 | 0.92 | 0.8 | 0.72 | 0.53 | 0.78 | 0.9 | 0.86 | 0.54 | 0.48 | 0.91 | 0.56 | 0.52 | 0.57 | 0.76 | 0.92 | 0.87 | 0.69 | 0.87 | 0.89 |
| BE | 0.92 | 1 | 0.79 | 0.68 | 0.53 | 0.71 | 0.95 | 0.84 | 0.59 | 0.57 | 0.93 | 0.51 | 0.46 | 0.65 | 0.8 | 0.88 | 0.87 | 0.69 | 0.85 | 0.89 |
| HR | 0.8 | 0.79 | 1 | 0.62 | 0.55 | 0.65 | 0.74 | 0.68 | 0.7 | 0.48 | 0.8 | 0.59 | 0.61 | 0.5 | 0.83 | 0.77 | 0.74 | 0.76 | 0.82 | 0.83 |
| CY | 0.72 | 0.68 | 0.62 | 1 | 0.23 | 0.64 | 0.67 | 0.65 | 0.46 | 0.33 | 0.74 | 0.21 | 0.18 | 0.36 | 0.68 | 0.77 | 0.8 | 0.58 | 0.7 | 0.81 |
| EE | 0.53 | 0.53 | 0.55 | 0.23 | 1 | 0.72 | 0.5 | 0.68 | 0.2 | 0.29 | 0.51 | 0.85 | 0.85 | 0.56 | 0.26 | 0.47 | 0.26 | 0.62 | 0.58 | 0.36 |
| FI | 0.78 | 0.71 | 0.65 | 0.64 | 0.72 | 1 | 0.69 | 0.89 | 0.37 | 0.39 | 0.76 | 0.65 | 0.72 | 0.67 | 0.46 | 0.79 | 0.63 | 0.72 | 0.81 | 0.65 |
| FR | 0.9 | 0.95 | 0.74 | 0.67 | 0.5 | 0.69 | 1 | 0.84 | 0.54 | 0.49 | 0.93 | 0.47 | 0.45 | 0.62 | 0.76 | 0.84 | 0.86 | 0.67 | 0.83 | 0.87 |
| DE | 0.86 | 0.84 | 0.68 | 0.65 | 0.68 | 0.89 | 0.84 | 1 | 0.41 | 0.45 | 0.87 | 0.61 | 0.61 | 0.69 | 0.57 | 0.86 | 0.75 | 0.72 | 0.85 | 0.77 |
| GR | 0.54 | 0.59 | 0.7 | 0.46 | 0.2 | 0.37 | 0.54 | 0.41 | 1 | 0.47 | 0.57 | 0.36 | 0.32 | 0.47 | 0.72 | 0.63 | 0.69 | 0.54 | 0.65 | 0.73 |
| IE | 0.48 | 0.57 | 0.48 | 0.33 | 0.29 | 0.39 | 0.49 | 0.45 | 0.47 | 1 | 0.57 | 0.37 | 0.26 | 0.44 | 0.43 | 0.54 | 0.5 | 0.48 | 0.51 | 0.56 |
| IT | 0.91 | 0.93 | 0.8 | 0.74 | 0.51 | 0.76 | 0.93 | 0.87 | 0.57 | 0.57 | 1 | 0.46 | 0.44 | 0.62 | 0.77 | 0.88 | 0.88 | 0.69 | 0.86 | 0.9 |
| LV | 0.56 | 0.51 | 0.59 | 0.21 | 0.85 | 0.65 | 0.47 | 0.61 | 0.36 | 0.37 | 0.46 | 1 | 0.87 | 0.56 | 0.3 | 0.52 | 0.3 | 0.61 | 0.62 | 0.42 |
| LT | 0.52 | 0.46 | 0.61 | 0.18 | 0.85 | 0.72 | 0.45 | 0.61 | 0.32 | 0.26 | 0.44 | 0.87 | 1 | 0.54 | 0.29 | 0.48 | 0.27 | 0.71 | 0.64 | 0.36 |
| LU | 0.57 | 0.65 | 0.5 | 0.36 | 0.56 | 0.67 | 0.62 | 0.69 | 0.47 | 0.44 | 0.62 | 0.56 | 0.54 | 1 | 0.37 | 0.62 | 0.53 | 0.53 | 0.65 | 0.54 |
| MT | 0.76 | 0.8 | 0.83 | 0.68 | 0.26 | 0.46 | 0.76 | 0.57 | 0.72 | 0.43 | 0.77 | 0.3 | 0.29 | 0.37 | 1 | 0.76 | 0.83 | 0.61 | 0.7 | 0.87 |
| NL | 0.92 | 0.88 | 0.77 | 0.77 | 0.47 | 0.79 | 0.84 | 0.86 | 0.63 | 0.54 | 0.88 | 0.52 | 0.48 | 0.62 | 0.76 | 1 | 0.9 | 0.71 | 0.89 | 0.9 |
| PT | 0.87 | 0.87 | 0.74 | 0.8 | 0.26 | 0.63 | 0.86 | 0.75 | 0.69 | 0.5 | 0.88 | 0.3 | 0.27 | 0.53 | 0.83 | 0.9 | 1 | 0.65 | 0.83 | 0.94 |
| SK | 0.69 | 0.69 | 0.76 | 0.58 | 0.62 | 0.72 | 0.67 | 0.72 | 0.54 | 0.48 | 0.69 | 0.61 | 0.71 | 0.53 | 0.61 | 0.71 | 0.65 | 1 | 0.81 | 0.7 |
| SI | 0.87 | 0.85 | 0.82 | 0.7 | 0.58 | 0.81 | 0.83 | 0.85 | 0.65 | 0.51 | 0.86 | 0.62 | 0.64 | 0.65 | 0.7 | 0.89 | 0.83 | 0.81 | 1 | 0.85 |
| ES | 0.89 | 0.89 | 0.83 | 0.81 | 0.36 | 0.65 | 0.87 | 0.77 | 0.73 | 0.56 | 0.9 | 0.42 | 0.36 | 0.54 | 0.87 | 0.9 | 0.94 | 0.7 | 0.85 | 1 |

*Note : AT - Austria, BE - Belgium, HR – Croatia, CY - Cyprus, EE - Estonia, FI - Finland, FR - France, DE - Germany, GR - Greece, IE - Ireland, IT - Italy, LV - Latvia, LT - Lithuania, LU - Luxembourg, MT - Malta, NL - Netherlands, PT - Portugal, SK - Slovakia, SI - Slovenia, ES – Spain.*

Figure 1 shows that there is great heterogeneity in correlations across Euro Area countries. While some nations exhibit a bilateral correlation of over 0.9, others exhibit

a correlation as low as 0.2. Also, there seem to exist some clusters, such as among the Baltic countries (Latvia, Lithuanian, and Estonia), that show a high degree of co-movement with each other. This result is another evidence in favor of the choice of adding regional factor allocation, since economies seem to co-move with other countries of their region.

Figure 2 shows the average correlation of the cyclical component for each country *vis-à-vis* all other countries except the country itself. Here, there are also big differences in the average level of correlation. While Slovenia has an average correlation of 0.74, Ireland is below 0.5. From a research perspective, the results of Figures 2 and 3 are interesting as it suggests that some countries might be more closely connected to a European business cycle than others, while others might be more closely related to the economies of their regions. Additionally, some countries seem to have a low correlation with all the others, indicating an idiosyncratic behavior. These results make the factor analysis likely to bring interesting results

*Figure 3*

| Average Corr. of Cyclical Components of Output | |
|---|---|
| Slovenia | 0.75 |
| Netherlands | 0.74 |
| Belgium | 0.74 |
| Austria | 0.74 |
| Italy | 0.74 |
| Spain | 0.73 |
| France | 0.72 |
| Germany | 0.72 |
| Croatia | 0.70 |
| Portugal | 0.69 |
| Finland | 0.67 |
| Slovakia | 0.66 |
| Malta | 0.62 |
| Cyprus | 0.57 |
| Luxembourg | 0.55 |
| Greece | 0.52 |
| Latvia | 0.52 |
| Lithuania | 0.50 |
| Estonia | 0.50 |
| Ireland | 0.45 |

## Results

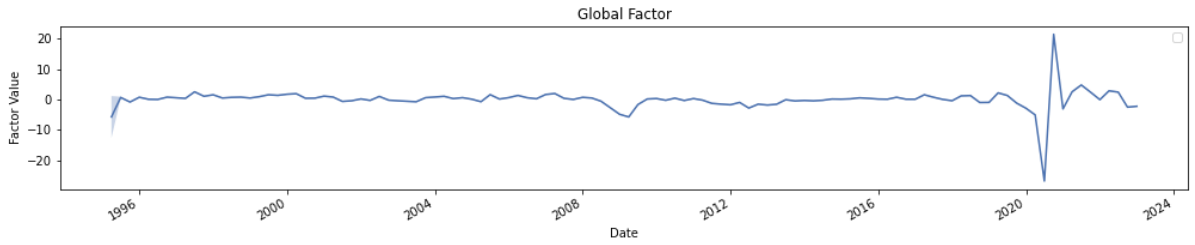
Figure 4 shows the factor loadings, which are the parameters $b$ of equation 4. The estimation of the factor loadings shows how each variable, i.e., the output of each country, is related to the factors.

*Figure 4*

| Factor Loadings | | | | | |
|---|---|---|---|---|---|
| Country | Global | North | South | Baltic | Central |
| Austria | 0.24 | -0.24 | | | |
| Belgium | 0.26 | -0.33 | | | |
| Croatia | 0.21 | | | | 0.59 |
| Cyprus | 0.19 | | -0.30 | | |
| Estonia | 0.20 | | | -0.55 | |
| Finland | 0.25 | 0.27 | | | |
| France | 0.29 | -0.22 | | | |
| Germany | 0.25 | -0.18 | | | |
| Greece | 0.18 | | -0.37 | | |
| Ireland | 0.07 | | -0.20 | | |
| Italy | 0.28 | -0.19 | | | |
| Latvia | 0.17 | | | -0.41 | |
| Lithuania | 0.21 | | | -0.42 | |
| Luxembourg | 0.16 | 0.15 | | | |
| Malta | 0.10 | | -0.07 | | |
| Netherlands | 0.29 | -0.12 | | | |
| Portugal | 0.24 | | -0.33 | | |
| Slovakia | 0.13 | | | | 0.38 |
| Slovenia | 0.26 | | | | 0.33 |
| Spain | 0.30 | | -0.30 | | |

Figure 5 shows the estimated global factor, the one common to all countries, which captures the co-movements among economies of the Eurozone.

*Figure 5*



The estimated factor captures some of the most relevant movements that happen in the European economy in the past decades. Around 2009 there is a decline in the factor, indicating negative growth among the economies. This period follows the 2008 global financial crisis that generated a recession all over the world. The factor also captures the extreme period of the COVID-19 pandemic. Right after the beginning of 2020, the factor shows a sharp fall, capturing the economic slowdown caused by the lockdowns. A few periods later, the economies caught up with their pre-recession level, which is also shown by the factor.

**Business Cycle Synchronization**

The primary goal of this research is to use the Dynamic Factor Model to assess the degrees of synchronization and co-movements among economies. To do so, I employ two approaches: variance decomposition and the R2 of the regressions. Following Kose (2003), the variance decomposition estimates the contribution of each factor in explaining the variation in GDP for each country. I estimate that in the following way:

$$var(y_{i,t}) = \left(b_i^{global}\right)^2 var\left(f_i^{global}\right) + \left(b_i^{region}\right)^2 var\left(f_{r,t}^{region}\right)$$

The share of the variance explained by a factor, say the global, is:

$$\frac{\left(b_i^{world}\right)^2 var\left(f_i^{world}\right)}{var(y_{i,t})}$$

These results will be crucial in assessing business cycle synchronization. One would expect for a country to fit the requirements to join a monetary union it should have most of its variance explained by the global factor and little by regional or idiosyncratic factor, which is the share of variance not captured by any of the factors.

Another way to assess the synchronization is the R2, which is calculated by regressing the variables on a constant and the factor estimates and storing the R2. Both the measures of variance decomposition and R2 should tell the same story: how useful the factors are for explaining the dynamics of the variables.

I split the sample into two periods: one between 1995 and 2019 and the other from 1995 and 2022. The reason for that is that the period from 2020 to 2022 represented an abnormal period in history, which likely has generated impacts on economic synchronization.

Table 6 summarizes the findings:

*Figure 6*

| | | 1995:2019 | | | | 1995:2022 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Variance Decomposition | | R2 | | Variance Decomposition | | R2 | |
| Region | Country | Global | Regional | Global | Regional | Global | Regional | Global | Regional |
| North | Austria | 42.1% | 3.0% | 53.8% | 9.7% | 90.9% | 2.3% | 87.5% | 1.7% |
| | Belgium | 49.4% | 5.7% | 57.5% | 18.2% | 90.9% | 3.8% | 93.1% | 5.3% |
| | Finland | 45.6% | 3.8% | 58.6% | 14.2% | 59.3% | 6.7% | 55.8% | 19.4% |
| | France | 61.4% | 2.5% | 76.1% | 7.5% | 90.9% | 3.4% | 91.8% | 5.4% |
| | Germany | 45.6% | 1.7% | 55.0% | 3.9% | 84.1% | 0.0% | 79.0% | 0.2% |
| | Italy | 57.3% | 1.9% | 71.8% | 6.9% | 90.9% | 2.3% | 91.7% | 3.5% |
| | Luxembourg | 18.7% | 1.2% | 20.4% | 1.1% | 38.9% | 1.4% | 34.7% | 2.2% |
| | Netherlands | 61.4% | 0.7% | 72.7% | 4.9% | 90.9% | 0.2% | 90.2% | 0.2% |
| South | Cyprus | 26.4% | 12.6% | 27.5% | 18.5% | 65.1% | 2.0% | 61.0% | 1.8% |
| | Greece | 23.7% | 19.2% | 18.6% | 32.2% | 59.3% | 0.6% | 50.5% | 2.4% |
| | Ireland | 3.6% | 5.6% | 3.5% | 5.1% | 16.3% | 0.1% | 15.7% | 0.0% |
| | Malta | 7.3% | 0.7% | 7.1% | 0.4% | 38.9% | 0.0% | 41.7% | 1.5% |
| | Portugal | 42.1% | 15.2% | 47.1% | 18.3% | 90.9% | 4.2% | 89.3% | 3.9% |
| | Spain | 65.7% | 12.6% | 69.9% | 25.1% | 98.0% | 2.8% | 94.8% | 1.7% |
| Baltic | Estonia | 29.2% | 18.5% | 33.7% | 27.9% | 38.9% | 22.7% | 33.5% | 38.7% |
| | Latvia | 21.1% | 10.3% | 17.4% | 27.0% | 34.4% | 12.1% | 28.7% | 28.9% |
| | Lithuania | 32.2% | 10.8% | 34.9% | 24.3% | 34.4% | 18.6% | 28.5% | 34.4% |
| Central | Croatia | 32.2% | 19.9% | 28.3% | 31.8% | 71.1% | 0.3% | 60.4% | 0.5% |
| | Slovakia | 12.3% | 8.2% | 12.0% | 12.1% | 43.6% | 1.5% | 36.0% | 14.0% |
| | Slovenia | 49.4% | 6.2% | 52.8% | 6.4% | 84.1% | 0.6% | 81.6% | 4.4% |

When analyzing Figure 6, it stands out the increase in synchronization during the pandemic, confirming the hypothesis that the event generated impacts in terms of co-movements of economies. Since the beginning of 2020, many economies across the world implemented lockdowns that slowed economic activity and threw countries into recession. Some quarters later, the economies reopened, and many experienced a sharp increase in activity. Therefore, the COVID shock hit many economies at the

same time, which the model captures as an increase in both the role of the global factor in the variance decomposition, and an increase in the R2 of this factor compared to the period prior to the pandemic. As Figure 5 shows, the global factor captures well the extreme period of the pandemic, showing the sharp decline and then the increase the economic activity.

The COVID period was an abnormal period, in which a common shock hit the whole world at the same time, which caused the increase in synchronization. Therefore, most of the analysis should focus on the period before the pandemic, which better reflects the 'normal' economic conditions.

The results show a significant heterogeneity in the relative roles of the global and regional factors. In the before COVID period, while for some countries, such as Spain, over 65% of their variance is explained by the global factor, for others, such as Ireland only 4% is. In addition, there is a big heterogeneity in the role of the regional factor. Since a significant share of the variance in the northern countries is explained by the global factor, there is little room left for the regional factor, which captures a small share of the variance. For the other groups, to which the global factor is less relevant, the regional factor explains around 12%. The R2 shows the same pattern, with the explanatory power of the Global factor being around 70% for some nations and around 5% for others. The regional factor plays a significant role for some nations, while it is almost neglectable for others, such as Malta.

The COVID period seems to increase synchronization, for the reasons already mentioned. Both in terms of variance decomposition and R2, the global factor increases to levels of about 90% for some countries, indicating a high degree of co-movements. Once most of the variation was being captured by the global factor, there

was little room left for the regional one, except for a few nations, namely the Baltic ones.

To better visualize the results by regions, table X shows the average share of variance and R2 explained by each factor, simply calculating the average variance decomposition and R2 for each region in each one of both samples. The results for the before-COVID period show that there are heterogeneities in the role played by the factors across regions. Precisely, the global factor plays a much more important role for Northern countries, explaining, on average, almost 50% of their variance, while only 27% for the Baltic nations. Meanwhile, the regional factor plays an important role for the South, Baltic, and Central economies, while not for the Northern ones. This result indicated that there is a significant level of regional co-movements among some regions. The R2 tells a very similar story, as the explanatory power of the Global factor is greater for the Northern nations, and the regional factor plays a more important role for the other nations.

For the COVID period, as also seen in the individual countries' results, there is an overall increase in economic synchronization. This can be seen in the role played by the Global factor, both in terms of the variance decomposition and R2. The regional factor shows a decrease in importance, as most of the variation in output is captured by the global factor. There is an exception, which is the Baltic Nations. Even including the pandemic period, the role played by the global factor is considerably smaller than for other regions, while the regional factor being still relevant. This result indicates a strong degree of synchronization among the Baltic nations.

*Figure 7*

| | 1995:2019 | | | | 1995:2022 | | | |
|---|---|---|---|---|---|---|---|---|
| | Variance Decomposition | | R2 | | Variance Decomposition | | R2 | |
| | Global | Regional | Global | Regional | Global | Regional | Global | Regional |
| North | 47.7% | 2.6% | 58.2% | 8.3% | 79.6% | 2.5% | 78.0% | 4.7% |
| South | 28.1% | 11.0% | 29.0% | 16.6% | 61.4% | 1.6% | 58.8% | 1.9% |
| Baltic | 27.5% | 13.2% | 28.7% | 26.4% | 35.9% | 17.8% | 30.2% | 34.0% |
| Central | 31.3% | 11.4% | 31.1% | 16.7% | 66.3% | 0.8% | 59.3% | 6.3% |

Taken together, one can take a few conclusions from the results: first, the pandemic did increase the synchronization across the EA. Second, the global factor indeed plays a relevant role in explaining the fluctuations of output across the continent. This result confirms the previous findings in the literature of the existence of a European Business cycle. It has, however, a much more important role for the North region. Third, the regional factor also plays a significant role in explaining fluctuations, for the South, Central, and, in special, for the Baltic countries. Forth, there are decoupled countries, such as Ireland, Malta, Slovakia, and Luxemburg to which neither the global nor the regional factor plays a role in explaining fluctuations. The reasons for that are many. One could suggest that the fact that the Luxemburg economy being closely related to the financial services industry makes it an ‘abnormal’ economy.

The fact that the global factor is more relevant for the richest nations of the continent, such as the Northern ones, is aligned with Kose et al. (2003) that find, when assessing synchronization across the whole world, that the global factor is more important in explaining the fluctuations of developed and rich nations. On the other hand, the less developed ones exhibit a higher level of idiosyncrasies.

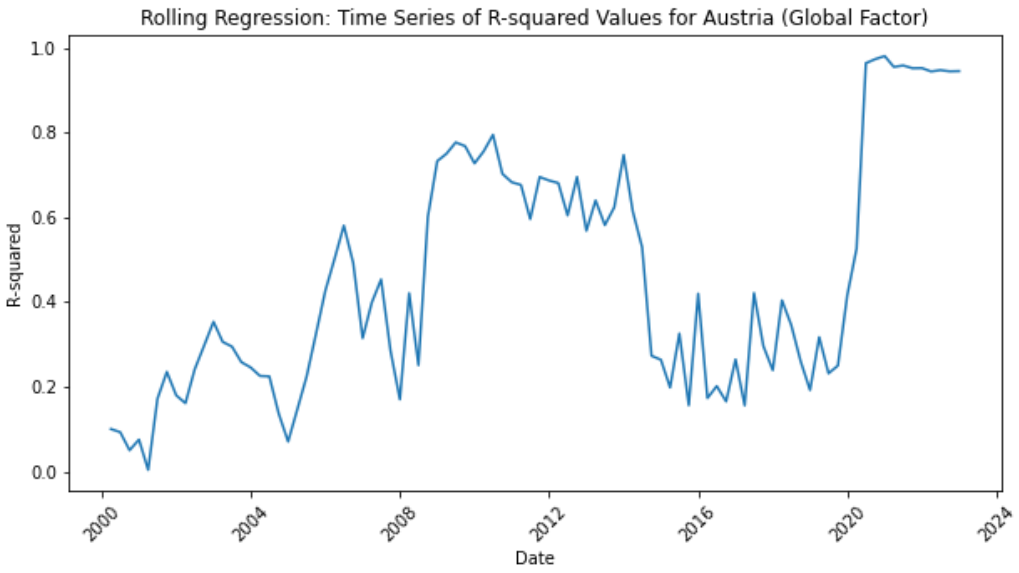
**Rolling window regression**

As previously mentioned, in theory, being part of a union, such as the EU and EA, generates forces in opposite directions in terms of synchronization. With the integration, the main shock transmission mechanisms, such as trade and capital, tend to increase the co-movements across economies. However, the increased integration might lead to production specialization that might make economies more susceptible to a sectorial idiosyncratic shock, as Krugman (2001) comments.

To test which forces are prevailing in the European economies, I perform a rolling window regression and compute the R2 of the global factor. I set a window of 5 years starting from 1995, and run the model using the data for that period. Then, I sore the R2 of the global factor. Then, I run the regression again for the next quarter and take note of the R2 one more time. I keep doing this process until the end of the sample period. Since the R2 measures the explanatory power of a factor, in this case the global, this method allows for a dynamic assessment of the explanatory power of this factor. The results indicate the evolution of synchronization across time, once one would expect the global factor to have a more important role in economies with high degrees of co-movement.

I use a window of 5 years, since there are pieces of evidences indicating that the average business cycle length is between 4 to 6 years. For instance, Artis et al. (1997) find an average length for the G7 of 51 months. In line with the evidence, I choose 20 quarters. I run the rolling regression and store the R2 of each series (each country) in a separate chart.

*Figure 8*



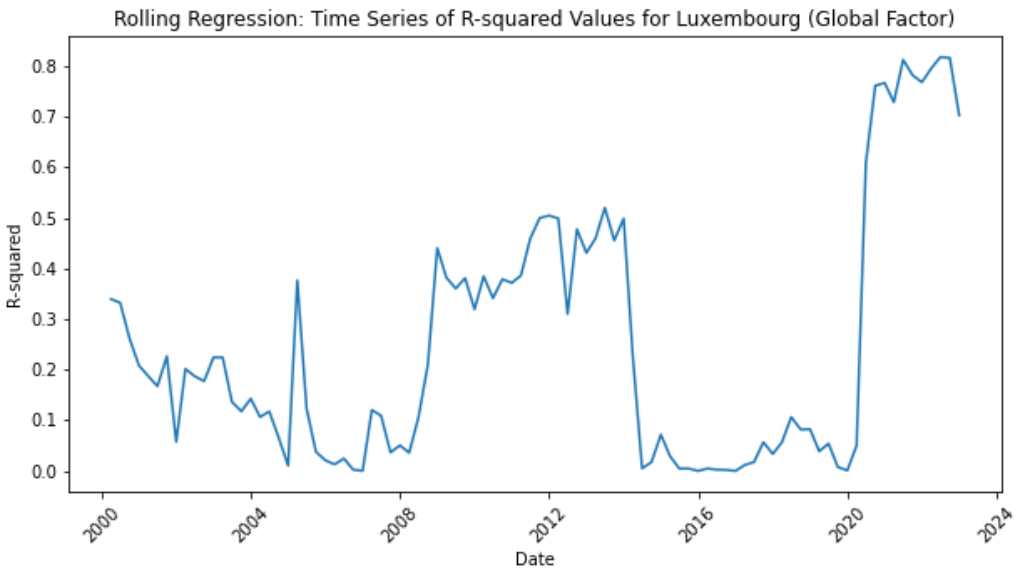

As an example, Figure 8 shows the results for Austria. The data shows a positive trend indicating an increase in synchronization. The first data point, which in the chart is the year 2000, shows the R2 of the regression from 1995 until 2000. There seems to be a positive trend in the following years, indicating an increase in co-movement following the introduction of the Euro. It reaches a local peak during the 2008 global economic crisis. This reflects the global shock that affected all the economies, and threw many of them into economic slowdown and lead to the Euro crisis. After that, there was a decrease in synchronization, as economic activity returned to its normal levels. The next big event was the COVID pandemic, which increased the synchronization among all economies as already discussed here.

The two 'normal' periods of the sample, the one going from before the introduction of the Euro, between 1995-2000, and the one between the two recessions, show an increase in synchronization. This indicates that Krugman's hypothesis of the increase of idiosyncrasies does not seem to dominate for some countries and indeed co-movement increases after the introduction of the Euro. Charts for the rest of the

countries are displayed in Appendix 1. The same positive trend seen in Austria happened in other economies of the continent, such as Spain, Portugal, Belgium, Finland, etc, indicating an increase in synchronization with time.

On the other hand, this does not seem to be the case for all countries. Figure 9 shows the evolution of the synchronization of Luxemburg. During both recessions, the synchronization increases, reflecting the common shocks that affected the economies of the continent, just like Austria. However, unlike Austria, there is no increase in co-movement between the two normal periods, there is actually decrease in it.

*Figure 9*




When analyzing the rolling windows charts, one must take into consideration the fact that nations joined the EA in different periods. Therefore, checking Figure 10, which shows the joining dates of the nations, might be useful.

Overall, the rolling window regression shows that for all economies, synchronization increases during turbulent times, such as the global financial crises and the pandemic. For the non-crisis periods, for some nations there seems to exist a positive trend in synchronization. There are possibly many reasons causing this increase, and among

them, is the co-movement forces of being part of the EU and EA. However, for other countries, this phenomenon is not detected.

## Discussion/Monetary Implications

As discussed, business cycle synchronization is a key requirement for a well-functioning monetary union. Despite the efforts of economic unification that should translate into a higher level of synchronization, this work reinforces the findings from previous studies that there are some members of the EA exhibiting less synchronized economic activity than others.

Besides that, there are further challenges for monetary policy in a monetary union. Using data from before the introduction of the Euro from Austria, Denmark, France, Germany, Netherlands, and Italy, Capoarale, and Soliman (2009) analyze the responses of these economies to monetary shocks using a VAR framework. They find heterogeneities in the responses among these countries. Despite all experiencing negative effects on output from a shock in short-term interest rates, the magnitude and persistence of the effects vary among countries. These differences are credited to the different financial structures among these nations, such as how the households' debt is indexed with the interest rate.

Orsetti et al. (2020) also find large heterogeneity in the response to monetary policy among Euro Area members. The responses of GDP and its components vary significantly. For instance, the reaction to consumption to a monetary shock is 20 times larger in Ireland than in Germany. This might be one of the causes for Ireland to exhibit a much more idiosyncratic business cycle, as Figure 6 highlights. Moreover, they find that the greater the level of integration of a market, the smaller the heterogeneity of the responses. Stock prices react quite homogenously across countries, since they are highly integrated, while less integrated markets, such as the real estate ones react in asymmetric ways.

This result suggests that the common monetary policy might have different results for the member nations of the monetary union. Since the timing and magnitudes of the responses of monetary policy on activity vary across countries, the single monetary policy imposed by the European Central Bank will have distinct impacts on the economies, which is not ideal in a monetary union, since one should expect countries to behave as closely as possible.

These papers used data from the period prior to the introduction of the Euro, and since then there have been efforts in the direction of promoting financial integration in the Eurozone. These efforts should reduce the differences in the transmission mechanisms that act in the economies of the continent. These efforts indeed had their intended results, at least momentously. Since the introduction of the Euro, ECB's financial integration indicator rose fairly steadily until the outbreed of the global financial crisis in 2008. After that, there was a deterioration, which started to be recovered throughout the 2010's (ECB, 2017). This higher level of financial integration should help reduce the heterogeneity of the responses to monetary policy – as the literature seems to confirm that integration promotes integration.

Besides the difference in responses to monetary shocks, there is another level of complexity to the conduction of monetary policy in the EA. The recent shock caused by the Russian invasion of Ukraine has created a case to study heterogeneities in price dynamics across the continent. The war quickly translated into inflation, once energy and food prices, known to be volatile components of price indexes, rose sharply. There was significant heterogeneity across nations though. While Latvia and Lithuania experienced annual inflation above 20%, more than 18 p.p. above the European Central Bank inflation target, in Spain, France, and Italy it was below 7%, less than 5 p.p. above the target. This divergence comes from a variety of factors,

such as the energy structure of each individual country, the pass-thought of energy prices to other sectors, and the difference in policies used to mitigate the rise in energy prices (Felke and Philiponnet, 2023).

These differences in inflation have many impacts on economic policy, in special monetary. First, one single monetary policy is likely not to be suitable for countries with such a striking difference in price change. Even though the shock hit the countries in the same direction, i.e., increased the prices, the magnitudes of the increase in inflation vary significantly. The European Central Bank faces a dilemma. It can increase its interest rates to meet the needs of the countries with the smallest inflation rates, which would not be enough to combat the prices increase of the economies with the highest inflation rates. On the other hand, it can increase its police rates to meet the needs of the high inflation economies having the side effect of causing unnecessary economic slowdown in nations with small inflation rates.

Second, as Felke and Philiponnet point out, these heterogeneities in inflation rates might translate into divergences in the countries' competitiveness and labor market performance. Considering the role of market integration in promoting economic synchronization, these divergences could exacerbate the countries' de-synchronization, making being part of the monetary union more costly to these economies.

Overall, there are several evidence in the literature, which I confirm in this work, that while some members of the EA closely follow a 'European Business Cycle', others do not. Additionally, there are divergences in the countries' reactions to monetary policy, which can is not ideal from a currency area perspective. Also, there are significant divergences in the inflation patterns across the continent, which creates further

challenges for the implementation of the monetary policy by the European Central Bank. Taken together, these facts show that the everyday work of the monetary authority faces several challenges, as some countries are in different faces of business cycles and it is the role of the policymakers to balance all these factors to implement the best possible monetary policy.

## Conclusions

The decision of joining a currency union involves balancing the benefits and costs of it. The more obvious benefits come from the economic growth driven by the integration of goods, capital, and labor, which should generate great economic performance. On the other hand, the downside is the loss of monetary policy tools to fight shocks.

Besides that, the theory of Optimal Currency Area says that a country, in order to join the Union, should have a high degree of synchronization. This is because the greater the synchronization among members, the easier it is for the monetary authority to set a single monetary policy that fits the needs of multiple countries at the same time.

There is a large literature in the field of business cycle synchronization among EA members. In general, the results show a high degree of co-movement among its member states, even though some countries seem to decouple from others.

I contribute to this literature with a Dynamic Factor Analysis, which is an econometric framework that models the co-movements among many time-series with a few unobserved factors. My results show that synchronization increased during the pandemic, as a result of the common shock that affected all nations. Additionally, I find that the global factor plays a significant role in explaining the fluctuations across the EA, confirming the findings of previous studies that indeed there is a European Business Cycle. Also, regional factors seem to also play a role, in special for some countries, such as the Baltic ones. Finally, I find that there are decoupled economies for which neither of the factors explains a significant part of their fluctuations.

When assessing whether the economic integration has increased synchronization or created more idiosyncratic business cycles, I find an increase in synchronization during turbulent times, such as the global financial crisis and the COVID pandemic.

However, during ‘normal times’, there seems to be an increase in synchronization for some economies, while it does not for others.

Finally, I discuss and review some papers from the literature of monetary policy in the Euro Area. Their main finding is that there are divergences in the responses to monetary policy among European economies. Additionally, recent evidence from the increase in prices caused by the Russian invasion of Ukraine has shown big differences in inflation patterns across the continent, which has further impacts in synchronization, as it affects a country’s competitiveness.

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## Appendix

*Figure 10*

| 1999 | 2001 | 2007 | 2008 | 2009 | 2011 | 2014 | 2015 | 2023 |
|---|---|---|---|---|---|---|---|---|
| Austria | Greece | Slovenia | Cyprus | Slovakia | Estonia | Latvia | Lithuania | Croatia |
| Belgium | | | Malta | | | | | |
| Finland | | | | | | | | |
| France | | | | | | | | |
| Germany | | | | | | | | |
| Ireland | | | | | | | | |
| Italy | | | | | | | | |
| Luxembourg | | | | | | | | |
| Netherlands | | | | | | | | |
| Portugal | | | | | | | | |
| Spain | | | | | | | | |

*Figure 11*

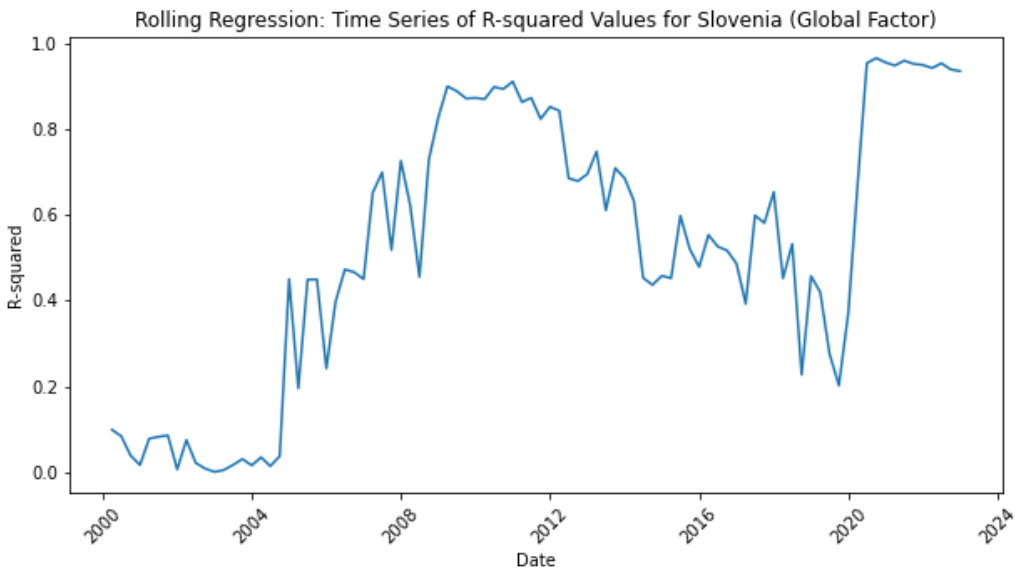

*Figure 12*

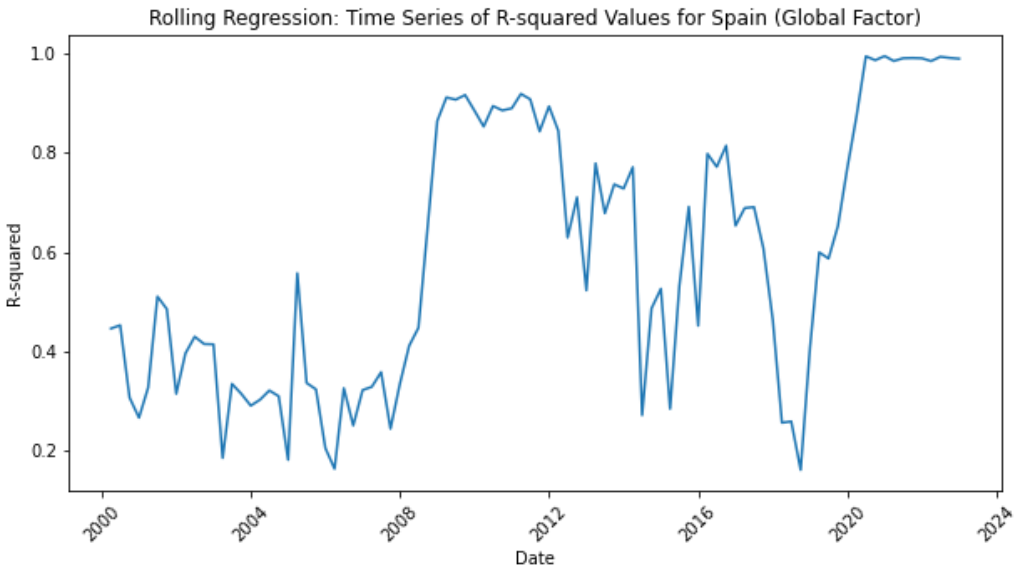


*Figure 13*

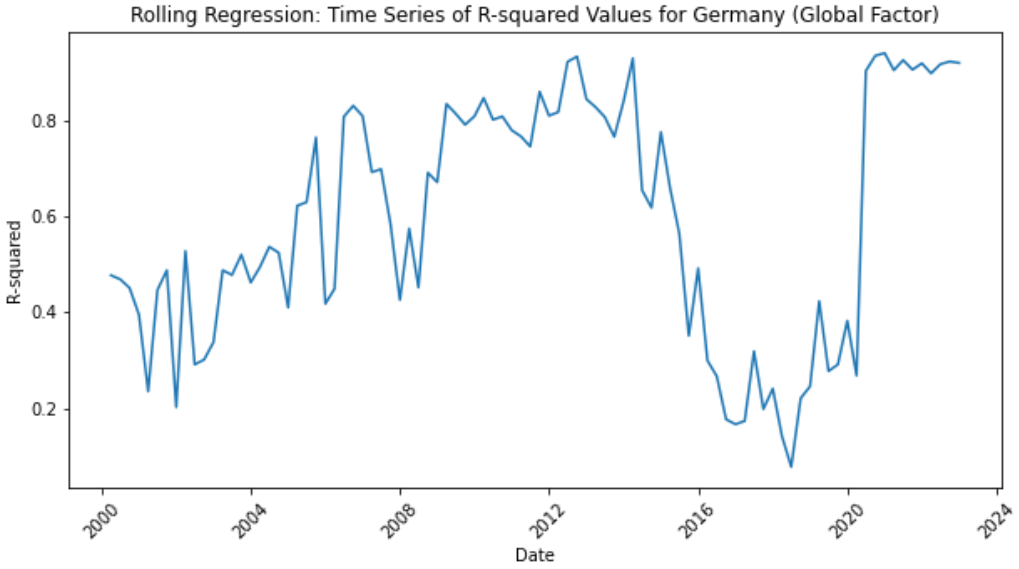

*Figure 14*

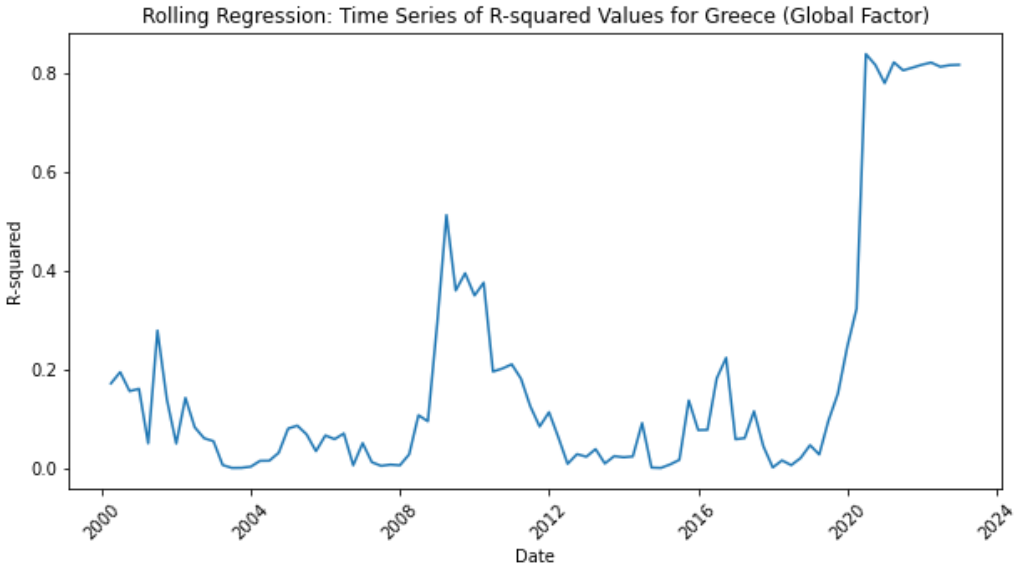


*Figure 15*

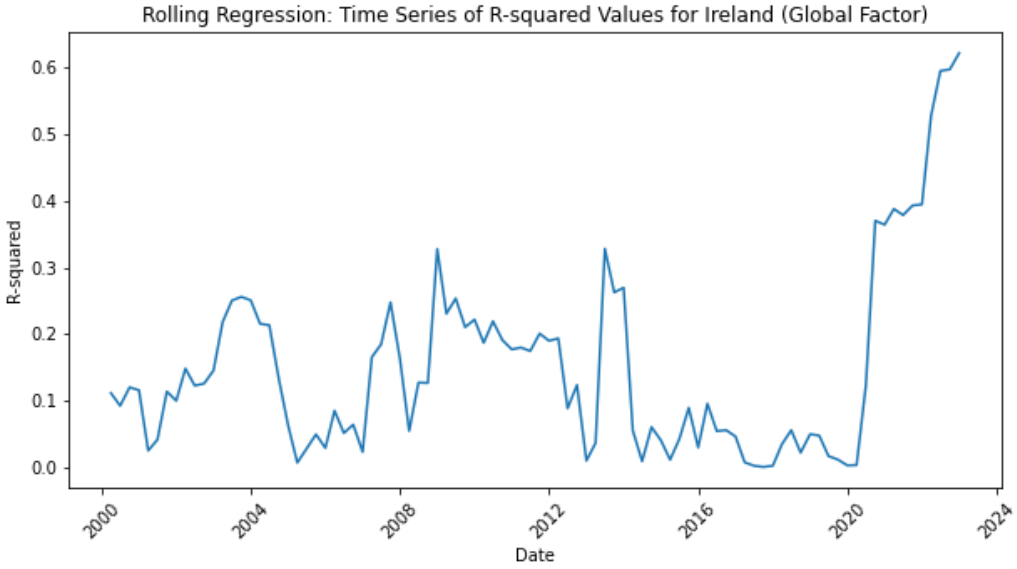

*Figure 16*

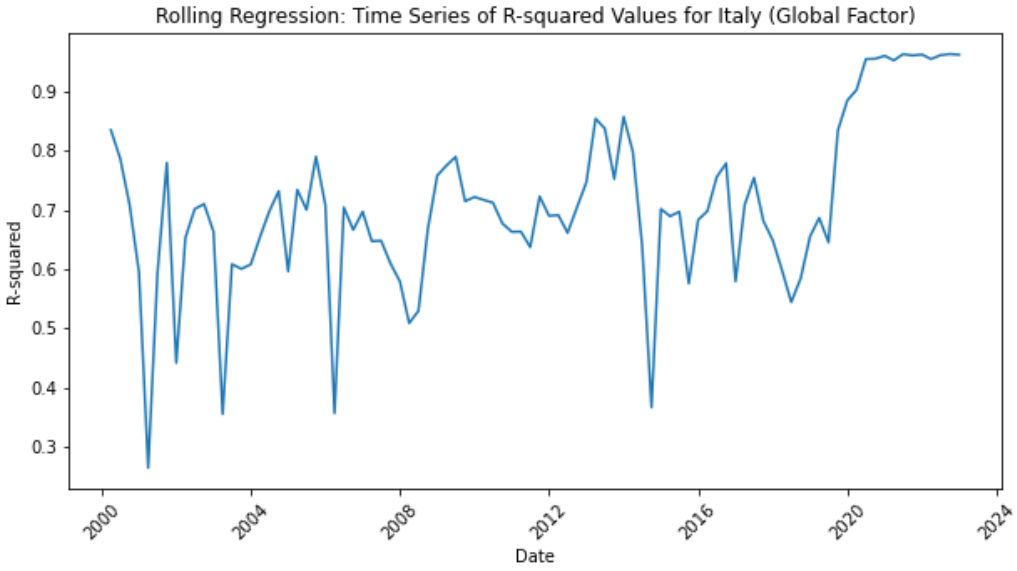


*Figure 17*

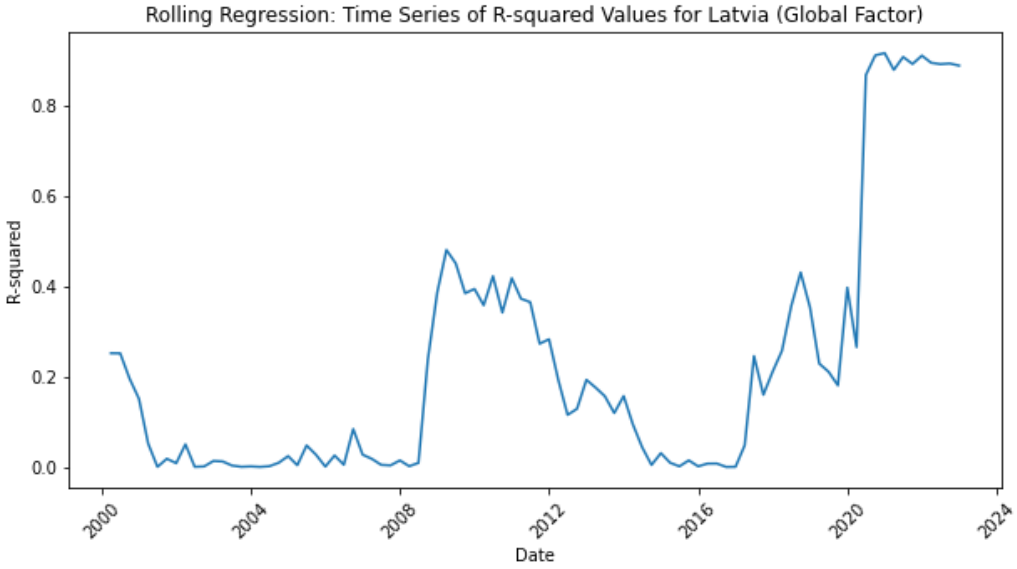

*Figure 18*

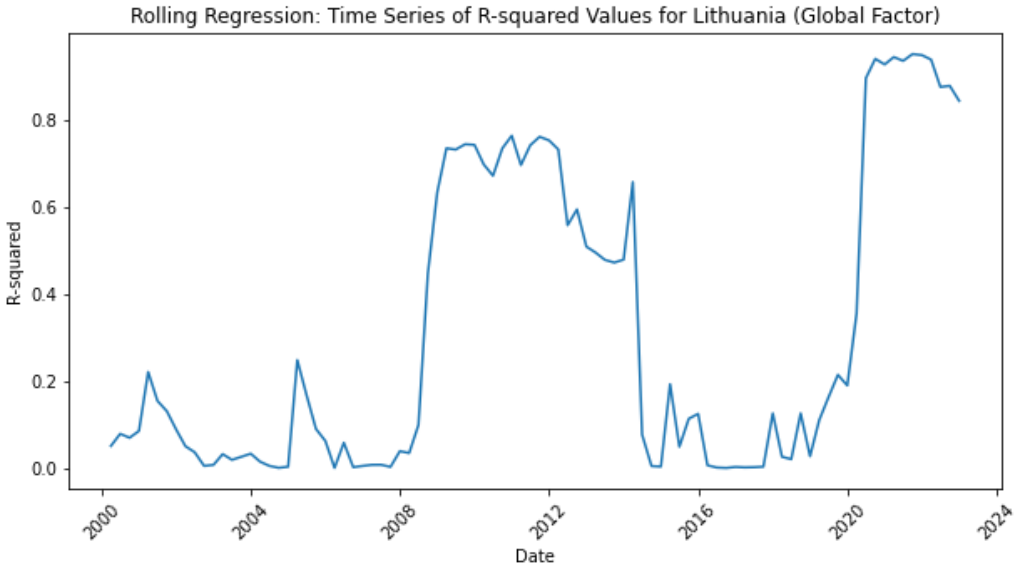


*Figure 19*

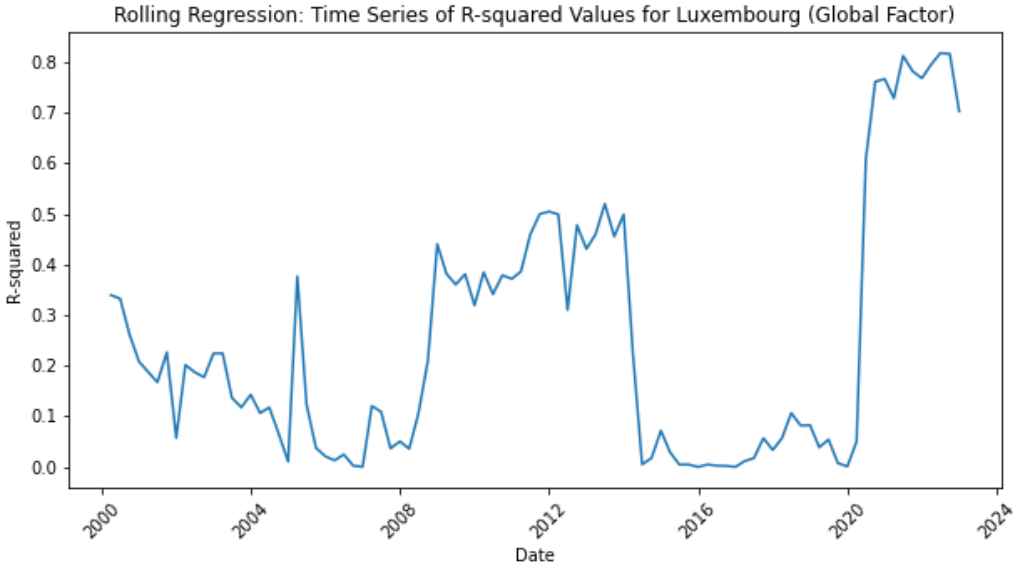

*Figure 20*

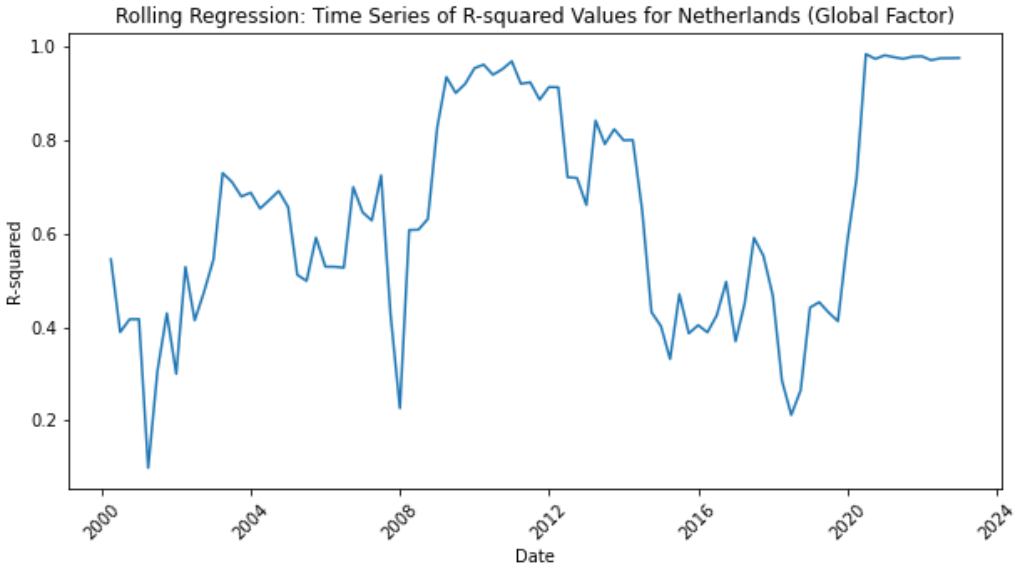


*Figure 21*

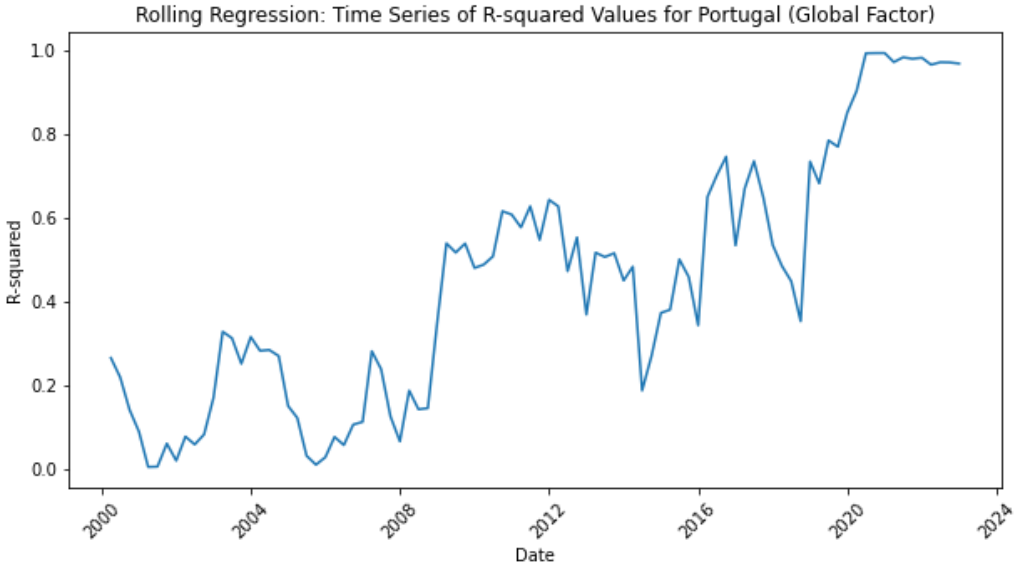

*Figure 22*

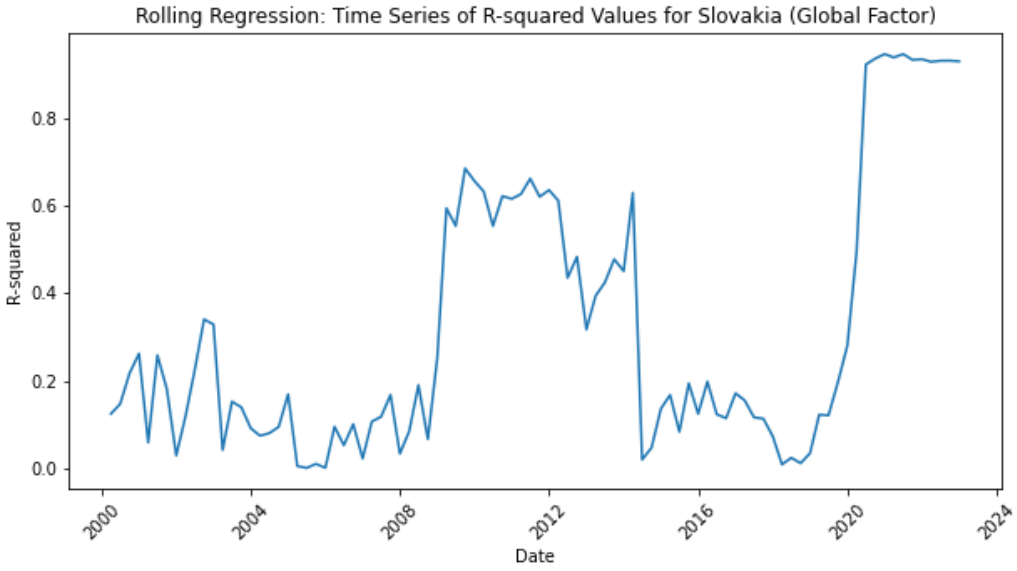


*Figure 23*

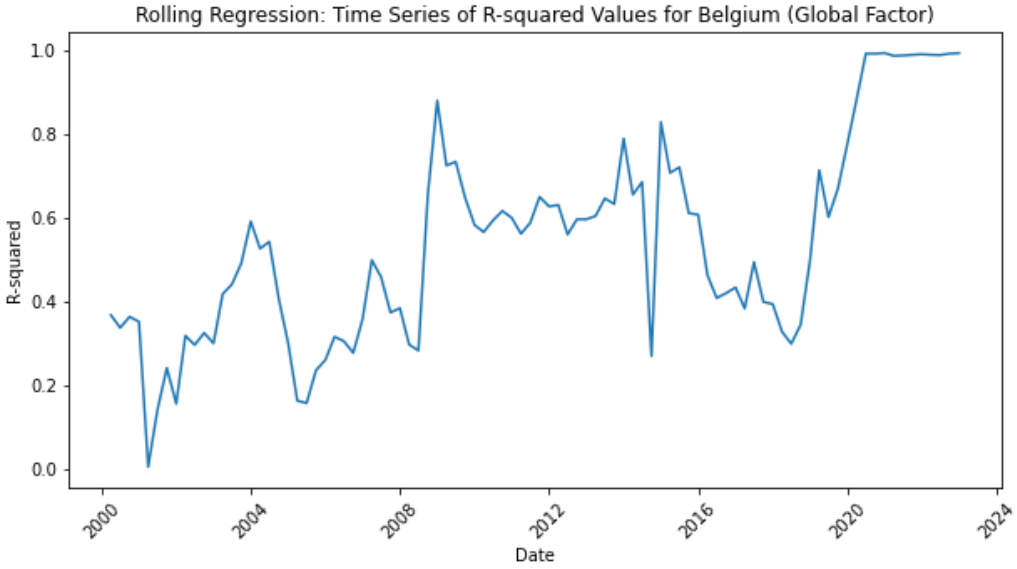

*Figure 24*

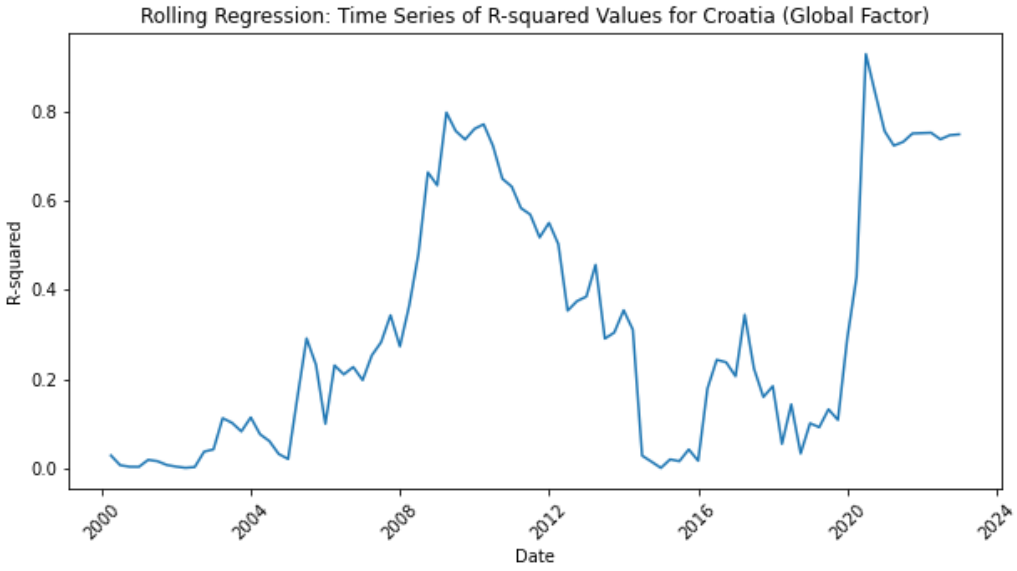


*Figure 25*

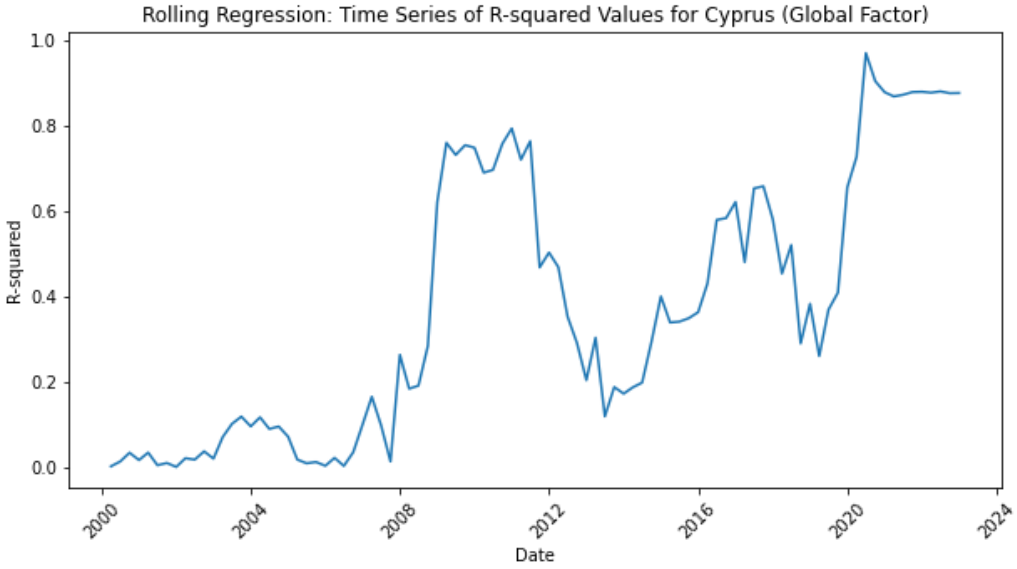

*Figure 26*


*Figure 27*

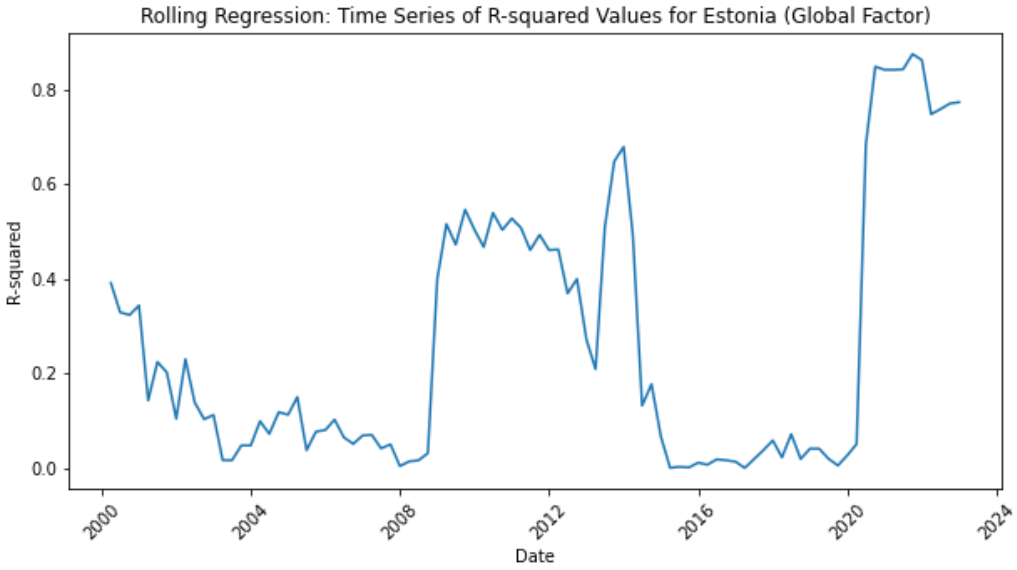

*Figure 28*