IMPACT OF GLOBAL CRISIS ON REER FLUCTUATIONS – PRE-INFLATION-PANDEMIC ASSESSMENT

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Purpose: This paper examines the impact of global crises, including the Global Financial Crisis (GFC), the COVID-19 pandemic, and the subsequent inflation crisis, on the fluctuations of the Real Effective Exchange Rate (REER). The cyclicality of REER has been examined as influenced by economic shocks, highlighting how pandemic-induced economic disruptions have reshaped REER dynamics differently from the more financially triggered fluctuations of the Global Financial Crisis.

Design/methodology/approach: The methodology employs a comparative spectral analysis approach, utilizing time-series data to track REER movements across various countries.

Findings: The findings indicate that the GFC and the COVID-19 pandemic led to shortening periods of cyclicality. Moreover, there has been a noticeable improvement in the synchronization of REER movements post-GFC, suggesting that economies may converge in their responses to global economic shocks. This convergence implies a potential stabilization of exchange rate movements in the face of future crises, underlining the importance of coordinated monetary policies.

Research limitations/implications: To model the REER index, one can use also classical analytical methods such as VAR models, where macroeconomic factors can serve as variables. In spectral analysis itself, other filters like the Hodrick-Prescott filter or applying a spectral window can be used.

Practical implications: The conducted study implies an improvement in synchronization among financial systems, with this knowledge, more appropriate and rational monetary decisions can be made, and private entities can better employ hedging strategies against currency exchange rate fluctuations. The study also aids in identifying inflationary pressures and the impact of the global financial system on the inflation index in individual countries.

Originality/value: The methods used in the article represent an innovative approach to modeling the REER index, providing new insights into the cyclicality of the index and the shortening periods of its occurrence. The article is addressed both to researchers in this field and to individuals involved with the monetary system and those working in the financial industry.

Keywords: REER, Cyclicity, Global Financial Crisis, COVID-19 pandemic.

Category of the paper: Research paper.

1. Introduction

The Global Financial Crisis (GFC), which began in 2007, marked a turning point for the global economy, sparking profound transformations in the financial system (Adrian, Shin, 2010; Firlej, 2011) affecting monetary policy (ECB & Stark, 2009), and exchange rates worldwide (Tsangarides, 2012). In the years leading up to it, there was an increase in financial globalization (Mendoza, Quadrini, 2010), capital market liberalization (Semmler, Young, 2010; Roy, Kemme, 2020), and an intensification of international trade (Saracco et al., 2016), which led to increased volatility in currency exchange rates (Coudert et al., 2011) and a diversity of economic paths. Initiated by the crash in the U.S. real estate market and spreading through the globalized banking system, the crisis caused significant turbulence in financial markets (Verick, Islam, 2010), resulting in a drastic drop in the value of many currencies and an increase in economic uncertainty (Helleiner, 2011). In response, measures were taken to stimulate the economy and stabilize markets, such as lowering interest rates (Helleiner, 2011) and implementing unconventional monetary policy programs (Cecioni et al., 2018). Concurrently, over the following years, a series of regulations and standards were introduced at the supranational level (Anginer et al., 2019; Porter, 2014), aimed at reducing the risk of a financial crisis recurrence, which simultaneously leads to an increased role of global financial markets for individual economies, and may lead to synchronization of selected elements of monetary and fiscal policies (Nanto, 2010).

In the context of the presented global economic integration, an important element at the European level is the progressing synchronization of the real effective exchange rate (REER), which on one hand reflects similar reactions of national economies to global events and challenges (Baghestani, 2021), enabling more effective and consistent political actions at the supranational level, and in the context of the European System of Central Banks, contributes to improving the coherence of monetary policy (Pistoresi et al., 2017), thereby enhancing the stability of the entire region. On the other hand, REER synchronization improves its predictability, facilitating entrepreneurs' determination of future exchange rate trends, which improves the precision of decisions regarding, among others, foreign investments (Goldberg, Klein, 1997), pricing products for export (Grennes, 2019), and currency risk hedging strategies (Bernoth, Herwartz, 2021), which become less exposed to adverse currency fluctuations (Mierzejewski et al., 2019). In the context of the impact of financial globalization, it can be assumed that both the cyclicality of the REER index, resulting from following changes in economic cycles, and the impact of regulations implemented in the economic-financial system on the synchronization of the index between countries, may occur. As a result, the occurrence of economic crises may change the shaping of this index, which the perspective of the global post-pandemic crisis, which has significantly translated into the shaping of global monetary policies (Wei, Han, 2021) and the functioning of economies (Akbulaev et al., 2020),

may signify the beginning of a new phase in the REER index's time cycle, and thus a change in the functioning of enterprises operating in the real economy.

The significance of this work lies in its ability to provide new insights into the behavior of REER during periods of global economic turbulence. By employing an innovative comparative spectral analysis approach, this research contributes to the existing body of knowledge on exchange rate economics and offers valuable information for policymakers and financial industry stakeholders. The findings of this study are crucial for making informed decisions regarding monetary policies and for understanding the synchronization of REER movements among different economies during crises. The significance of this work lies in its ability to provide new insights into the behavior of REER during periods of global economic turbulence. By employing an innovative comparative spectral analysis approach, this research contributes to the existing body of knowledge on exchange rate economics and offers valuable information for policymakers and financial industry stakeholders. The findings of this study are crucial for making informed decisions regarding monetary policies and for understanding the synchronization of REER movements among different economies during crises.

The current state of research in the field of exchange rate economics includes significant contributions from various scholars. Key publications have examined the effects of financial globalization (Mendoza, Quadrini, 2010), capital market liberalization (Semmler, Young, 2010; Roy, Kemme, 2020), and international trade intensification (Saracco et al., 2016) on currency exchange rates. The volatility of exchange rates during the GFC and its aftermath has been documented extensively (Coudert et al., 2011), highlighting the importance of understanding these dynamics. Recent studies have also focused on the impact of the COVID-19 pandemic on economic indicators and financial markets (Akbulaev et al., 2020; Wei, Han, 2021). The novelty of the results presented in this study lies in the use of spectral analysis to model the cyclicality of the REER index, providing new insights into the synchronization of REER movements during and after major economic crises. The study's innovative approach and its focus on the comparative analysis of different crisis periods contribute to the originality and value of the findings. These results are expected to be of interest to researchers, policymakers, and practitioners in the field of exchange rate economics and monetary policy. According to what we were able to find, no studies are referring and reporting on the comparative spectral analysis of REER fluctuations specifically addressing the simultaneous impacts of the Global Financial Crisis, the COVID-19 pandemic, and the subsequent inflation crisis on the synchronization of REER movements across various European countries. This lack of existing research highlights the novelty of our approach and underscores the importance of our findings. By filling this research gap, we have demonstrated that the issue is relevant, and we have also proven that our study does indeed fill a research gap.

This research involves a comparative spectral analysis of time-series data to track REER movements across various countries. The analysis utilizes the Fourier Transform to identify cyclical behaviors in the REER index and employs the Dickey-Fuller and Philips-Perron tests

to confirm the stationarity of the series. Additionally, the study examines the synchronization of REER fluctuations by comparing the spectral density indices of individual countries.

The research is guided by the following hypotheses:

H1: The Global Financial Crisis (GFC) and the COVID-19 pandemic have shortened cyclical periods in REER movements.

H2: There is an improvement in the synchronization of REER movements post-GFC, suggesting a convergence in economic responses to global shocks.

H3: The synchronization of REER indices among European countries has increased, indicating a stabilization of exchange rate movements in response to coordinated monetary policies.

2. Literature Review

With the end of the COVID-19 pandemic in 2022, global inflation began to rise (Słomba, Palac, 2023), driven by a series of factors including demand-related shocks (Giovanni et al., 2022), global supply (Giovanni et al., 2022), oil prices (Ha et al., 2023a), and global changes in interest rates (Pallotti et al., 2023). Particularly, shocks in oil prices and global demand play a key role in the movements of global inflation (Ha et al., 2023b). As a result, many European countries lost competitiveness (Kotkowski, 2020) compared to countries where this problem did not occur, or which dealt with it better and faster. The real effective exchange rate, which is already adjusted for inflation (Economic Governance Support Unit, 2017), is a tool that allows for the comparison of competitiveness between countries. Apart from the impact of inflation itself, this index also depends on the value of a country's currency compared to an index or basket of other major currencies, one of the tools used for this is the average level of bilateral exchange rates (Chinn, 2006). Weights are assigned to account for the trade allocation of each partner. The REER formula is weighted to consider the relative importance of each trade partner to the home country (Economic Governance Support Unit, 2017). An increase in REER indicates that a country's exports become more expensive and imports cheaper. This may mean a loss of trade competitiveness (Chinn, 2006). Cyclical factors influencing the level of the index include Consumer Price Index (CPI) (Stock, Watson, 2019), Producer Price Index (PPI) (Zapata et al., 2023), GDP deflator (Kanago, 2023), and unit labor costs (ULC) (Gu et al., 2020; Darvas, 2012). They are cyclical, meaning they exhibit regular fluctuations in each of the studied cycles, and their lengths are determined in similar time intervals, e.g.: 1998-2015 (Stavárek, Miglietti, 2015), 1994-2007 (Comunale, 2015), 1981-2008 (Asif, Rashid, 2010), 1955-1990 (Mendoza, 1995). Historically studied periods of cyclicity lasted between 12 and 27 years. Currently, we can observe shortening periods of cyclicity, the last analyzed period falls between the Global Financial Crisis and the Pandemic-Inflation Crisis, i.e., from 2011 to 2020.

The Consumer Price Index (CPI) shows synchronization with real GDP and wage dynamics in the euro area, suggesting a strong correlation between macroeconomic indicators and the fluctuation of the index (Misztal et al., 2020). This means that movements in the index are not isolated but impact higher economic activities such as production costs. There is a unidirectional causality between the Producer Price Index (PPI) and CPI, through wavelet analysis it can demonstrate clear cyclical effects (Tiwari et al., 2013). However, the PPI itself may indicate changes in the CPI in advance as an indicator of inflationary pressure in the economy. This relationship underscores PPI's reaction to changes in raw material costs and production processes before these cost adjustments impact consumer prices (Fan et al., 2009). Similarly, the consumer price index shows synchronization with fluctuations in real GDP, but also with its deflator. The cyclicity of the producer price index is closely related to the phases of the economic cycle, intensifying during periods of economic expansion, and moderating during recessions (Berry et al., 2019). Studies emphasize the cyclicity of economic indicators, particularly the GDP deflator, which reflects cyclical patterns like CPI and PPI, but with unique nuances due to its comprehensive range. The GDP deflator often shows a stable long-term relationship with the CPI and a less stable relationship with the PPI, highlighting its wide coverage of goods and services produced in the country (Becsi, 1994). The interrelated dynamics of economic indicators and labor market situations illustrate unit labor costs (ULC), which measure the average labor cost per unit of production (Firlej, Matras, 2022). It has a naturally cyclical nature and undergoes fluctuations in response to changes in labor productivity and wage rates. Unit labor cost tends to be procyclical and shows significant synchronization with CPI and PPI, reflecting changes in labor costs passed on to consumer and producer prices (Herwartz, Siedenburg, 2013; Firlej et al., 2023).

The breakthrough event in the process of synchronization of indicators was the Global Financial Crisis, which impacted not only national economies but also the global financial system causing its synchronization, through the occurrence of intensified systemic financial risk. Particularly global risk shocks and the domino effect on financial markets were key in strengthening the synchronization of financial cycles across different markets (Cha, 2012). Additionally, the impact of market volatility and information during the crisis played a significant role, where volatility often overshadowed the impact of information on market correlations. However, as the crisis progressed, the impact of information became increasingly clear, indicating a dynamic interaction between these factors (Mun, Brooks, 2012). Moreover, domino effects, especially from the USA to global markets, were characterized by significant synchronization during the GFC, highlighted by the transmission mechanisms among international banks (Mollah et al., 2016). This highlights the complex mechanisms of risk transmission and market behaviors, which contribute to the global synchronization of financial markets during times of economic crisis.

Cyclical measurements of macroeconomic indicators are crucial for understanding the real effective exchange rate (REER) as they highlight turning points in the economy, which are essential for policy adjustment and strategic planning. Cyclical fluctuations in REER reflect changes in a country's economic competitiveness, influenced by performance, labor costs, and economic policies. REER appreciation during periods of economic growth may indicate improved competitiveness or higher inflation rates compared to trading partners, while depreciation during downturns may suggest the opposite. The cyclicity, which both influences and responds to global economic dynamics, is essential for making informed decisions regarding trade, monetary policy, and international market strategies, thereby supporting economic stability and growth.

3. Materials & Methods

The article aimed to determine the possibility of a cyclical component in the shaping of the behavior patterns of the real effective exchange rate (REER), as well as to study the impact of the financial crisis (GFC) on its European synchronization and the subsequent emergence of a new cyclical path in the period between crises (GFC and the post-pandemic crisis) as a result of changes implemented in global financial systems, by identifying economies with similar fluctuations of the index during this period. The analysis was conducted using the Fourier Transform (Maruyama, 2018; Pollock, 2009), which allows for the extraction of cyclical behaviors of a time series for stationary series (to confirm the stationarity of the series, the Dickey-Fuller and Philips-Perron tests were used (commonly applied in the field, including by Leybourne & Newbold (Leybourne, Newbold, 1999; Wolters & Hassler (Wolters, Hassler, 2006)). To determine the synchronization of the lengths of fluctuations in the cyclicality of individual series, the spectral density index was used, which offers a more detailed view of the power distribution of the signal at different frequencies. The values of this index enabled the comparison of the similarity of structures of individual cycles, for which a measure of the correlation between individual time series was used.

The study utilized monthly data from January 2000 to January 2024, for 24 European countries (Austria, Belgium, Bulgaria, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, United Kingdom, Greece, Croatia, Hungary, Italy, Lithuania, Latvia, Netherlands, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia) and the eurozone (a group of countries that share the euro as their common currency), sourced from the Bank for International Settlements database (BIS, https://data.bis.org/topics/EER/data).

4. Result and discussion

Defining cycles in the structures of individual time series of the REER index began with determining the time intervals of individual phases: I. REER Cycle Phase, which covered the time from the beginning of the study to the Global Financial Crisis (GFC), and II. REER Cycle Phase, after the GFC period. Based on the literature, it was assumed that the GFC period ranged from the beginning of 2007 to the end of 2010 (Merrouche, Nier, 2010; Shahrokhi, 2011; Tekin, 2020; Olbrys, 2021). Additionally, it was indicated that the post-pandemic crisis, which contributed to changes in the cyclical structure of the REER index, began in 2021 (Bank of Greece & Catiforis, 2022; Prokopowicz, 2022). This is related to the occurrence of global inflation caused by rising commodity prices and changes in monetary policy. During the crisis, stimulus packages were introduced to support the liquidity of economic entities disrupted by rising production prices and to maintain aggregate supply at the pre-crisis level. International organizations launched financial programs such as the European Regional Development Fund, the European Social Fund+ and the Fund for a Just Transition to support the global financial system and economic recovery (Massetti, Exadaktylos, 2022).
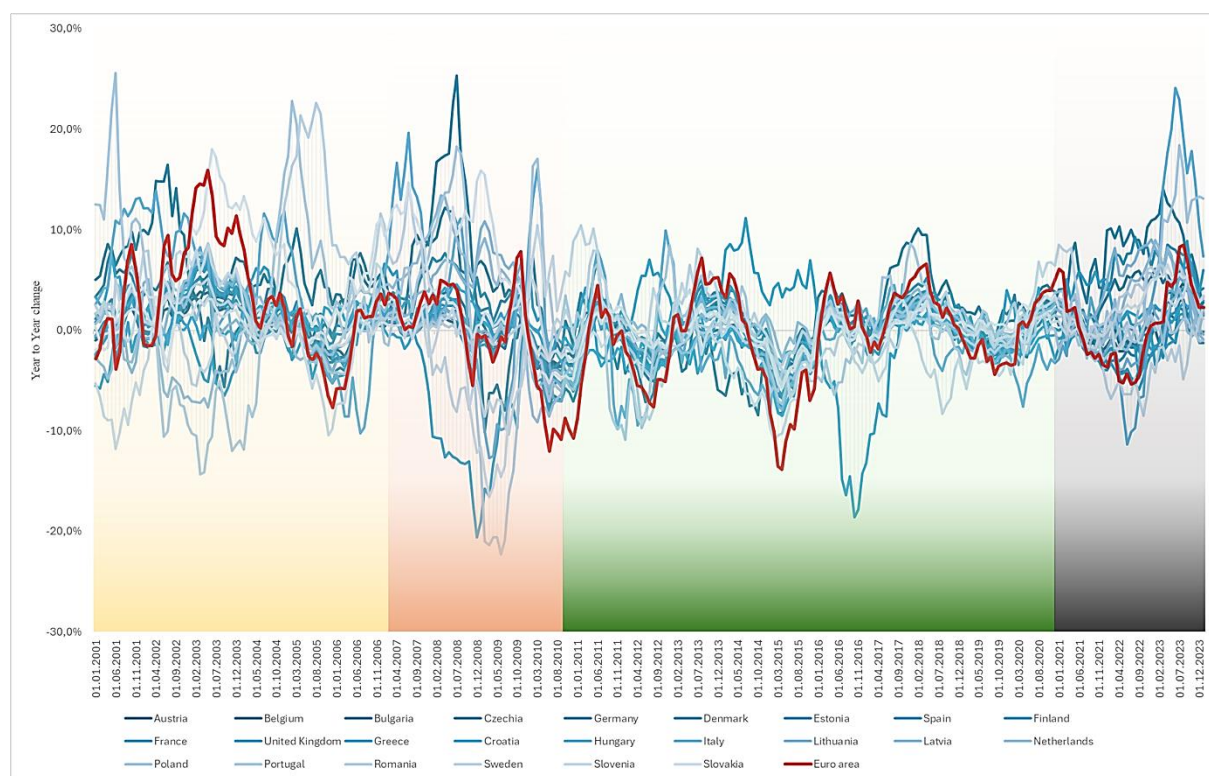
Figure 1. Development of the real effective exchange rate values in European countries, indicating the REER Cycle Phases.

Source: own study based on BIS data.

For each phase (in figure 1: Phase I of the REER Cycle in yellow; Phase II of the REER Cycle in green), series were isolated for examination of basic statistics, followed by determination of cyclical structures using the Fourier Transform (Figure 1 also marks the GFC period and the post-pandemic crisis). Preliminary results of the variance (dispersion of values around the mean, with an increase indicating greater dispersion and a decrease indicating less, thereby increasing consistency) for the REER index during Phases I and II of the REER Cycle indicated a change of approximately 42.34 pp in Phase I and 12.55 pp in Phase II. Before the GFC, the range between the highest value (Slovakia – 235.77) and the lowest (Slovenia – 3.91) was 232.76, while after the crisis it was 49.40. The highest REER value was recorded for the Czech Republic (51.27) and the lowest for Slovenia (1.87). Between the phases, an average decrease of 29.80 pp was observed, indicating the impact of the GFC on reducing the variability of the REER index. Only for three of the countries studied was an increase in variance noted between periods, namely Sweden, Lithuania, and the United Kingdom. After the GFC, the variance decreased, meaning it reduced differences in currency rate volatility among countries, thereby increasing the synchronization of the REER index among the countries studied.
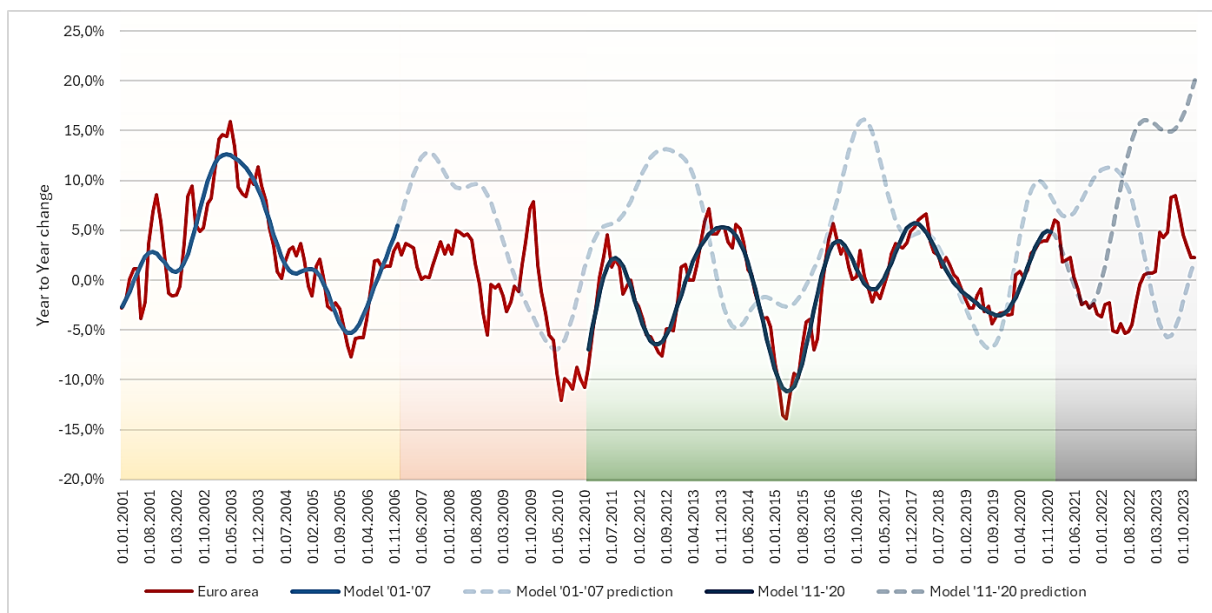
Figure 2. Development of the REER index for the Euro area with markings of cyclical components. Source: own study based on BIS data.

Based on the series of changes in the REER index value (year-over-year) for the Euro area and the results of the cycle structure analysis in the respective Phases, two models describing the cyclical parameter of the index were determined. The equations describing these models (where t denotes successive observations over time) took the form:

$$y_{01-07} = 0.04 - 3.34(0.02\cos(0.11t) - 0.005\sin(0.11t))$$
$$- 2.65(-0.0001\cos(0.12t) + 0.008\sin(0.12t))$$
$$- 6.2(0.003\cos(0.27t) - 0.004\sin(0.27t)) \tag{1}$$
$$+ 3.85(-0.001\cos(0.29t) - 0.0003\sin(0.29t))$$
$$- 14.31(-0.002\cos(0.44t) - 0.002\sin(0.44t))$$

$$y_{11-20} = -0.0026 + 4.46(-0.006\cos(0.141t) - 0.003\sin(0.141t))$$
$$+ 25.5(-0.002\cos(0.225t) - 0.006\sin(0.225t))$$
$$+ 1.8(-0.002\cos(0.216t) + 0.001\sin(0.216t))$$
$$+ 6.7(-0.002\cos(0.108t) - 0.002\sin(0.108t))$$
$$+ 9.7(0.026\cos(0.025t) - 0.017\sin(0.025t)) \tag{2}$$
$$+ 5.8(-0.002\cos(0.325t) - 0.001\sin(0.325t))$$
$$- 9.68(0.001\cos(0.208t) - 0.001\sin(0.208t))$$
$$- 934(-0.0007\cos(0.158t) - 0.004\sin(0.158t))$$
$$- 44.79(-0.02\cos(0.041t) - 0.007\sin(0.041t))$$

The described models illustrate the change in the share of the cyclical factor in the dynamics of the NEER index in the Euro area (the model fit for Phase I is measured by the determination coefficient R2 = 0.83, while for Phase II, following the GFC, it is R2 = 0.92). Thus, the models indicate not only a change in the temporal dynamics of the index (changes in the contributions of various cycle lengths) but also greater synchronization over time (a decrease in residuals resulting from the mismatch to the cycle). Consequently, the consequence of the policies implemented in the financial space was an improvement in the predictability of the NEER index formation after the crisis.

Similarly, for the individual time series of individual countries' NEER indices, a cycle decomposition was conducted for periods of Phase I and Phase II, followed by a comparison of the spectral density index (which describes the contribution of various cycle lengths to the dynamics of the entire series) between countries using Ward's categorization method.
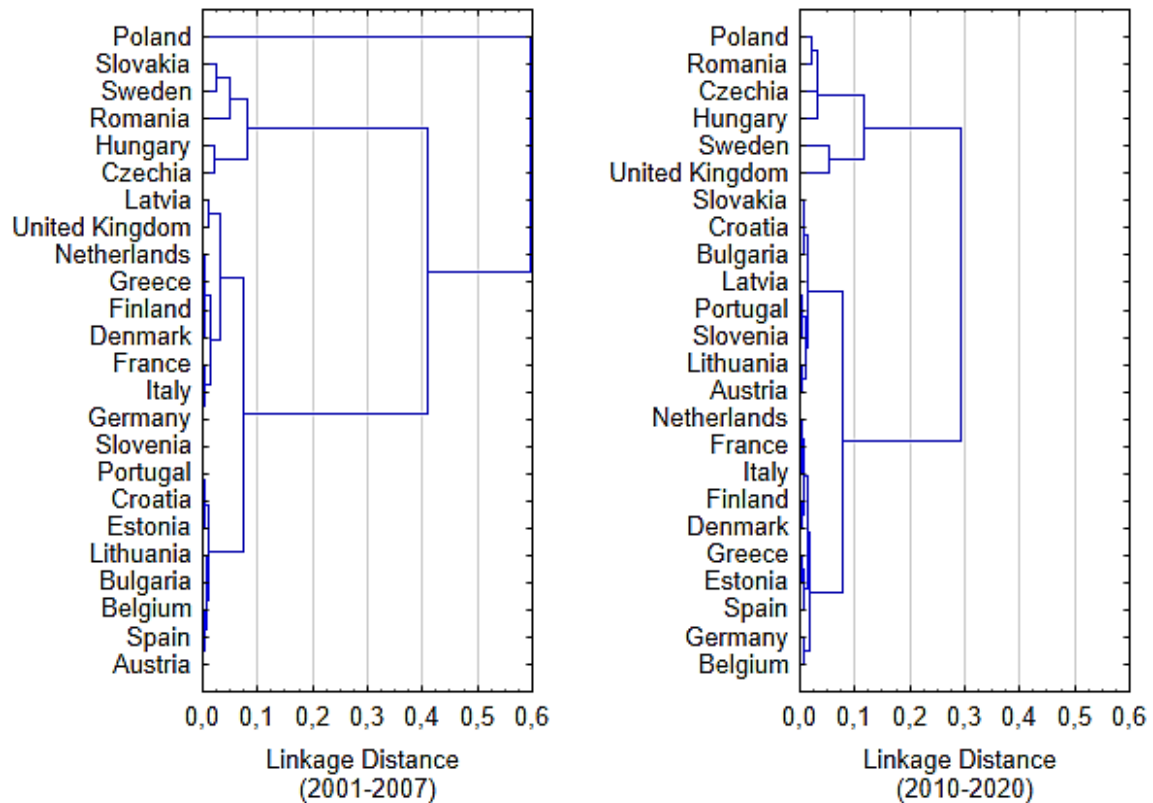
Figure 3. Classification of countries based on the cyclical structure of the NEER index during Phases I and II.
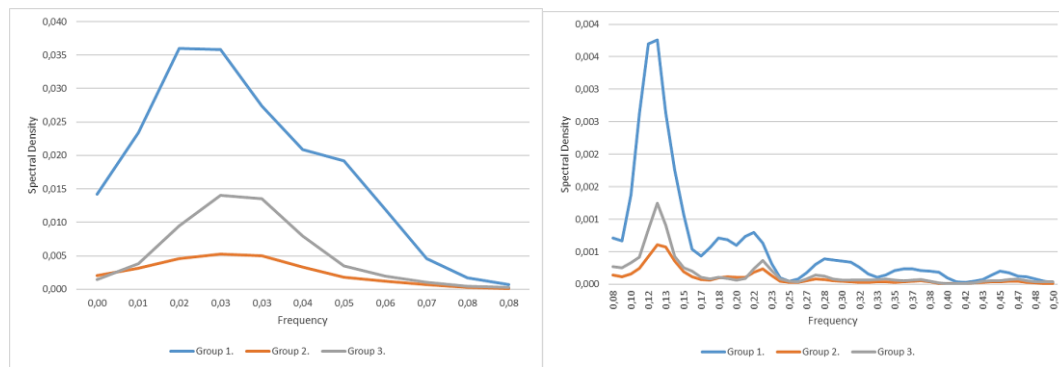
Source: own study based on BIS data.

As a result, countries were grouped based on similar characteristics of the cyclical element in the dynamics of the REER index during Phases I and II (as shown in figure 3 above). In the pre-crisis period, four distinct groups of countries with similar cycle characteristics can be identified: 1. Poland; 2. Slovakia, Sweden, Romania, Hungary, Czechia; 3. Latvia, United Kingdom, Netherlands, Greece, Finland, Denmark, France, Italy, Germany; 4. others. In the categorization of countries in Phase II, there is a reduction in the number of groups (three distinct groups of countries with similar structures of the cyclical element can be identified), as well as a decrease in the Euclidean distance between the groups of countries, which indicates not only a convergence of cyclical dynamics within the groups but also between the groups.
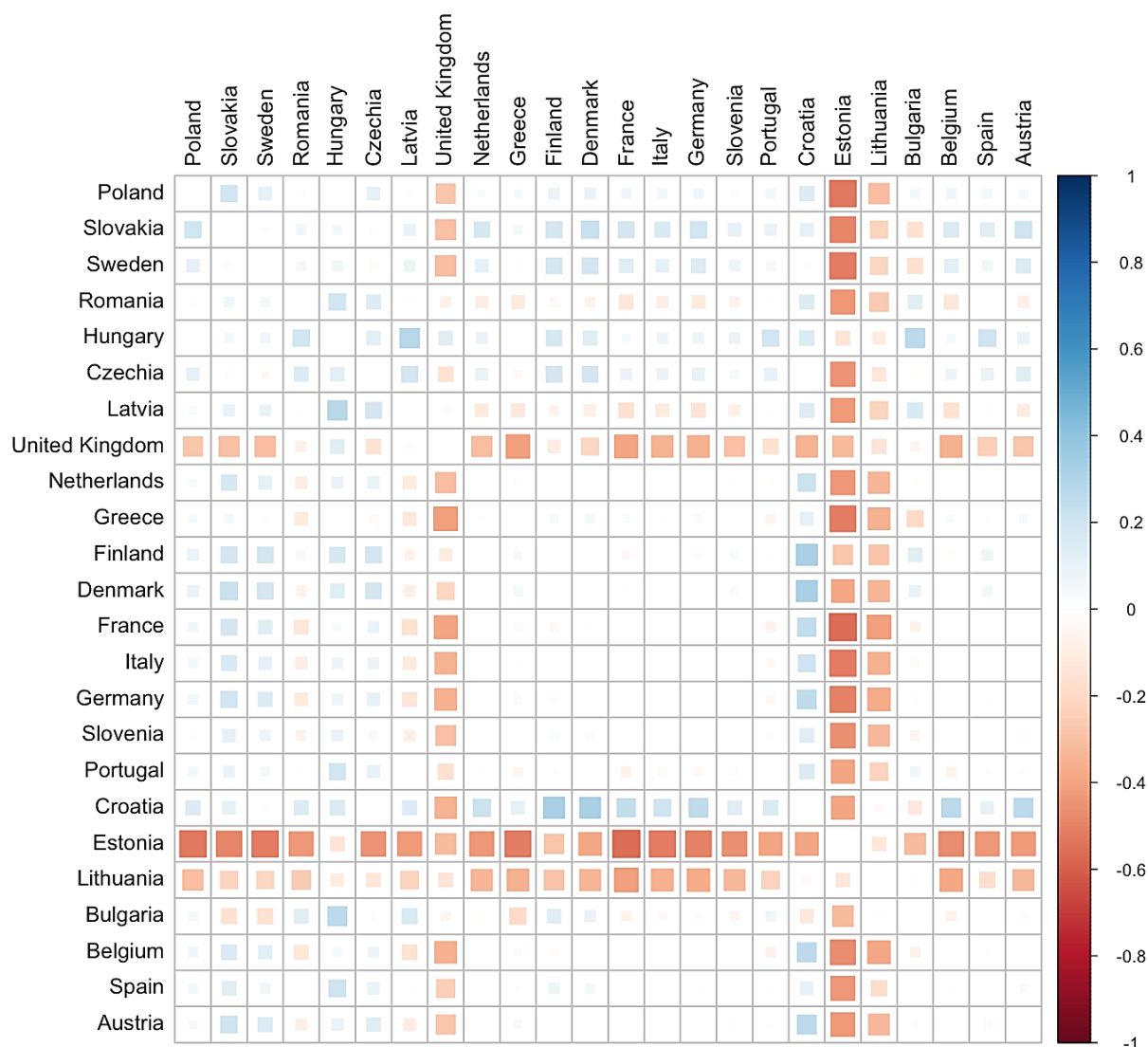
Figure 4. Differences in correlation structure between the spectral density indices of the REER index for individual countries during Phases I and II.

Source: own study based on BIS data.

As presented in Chart 4 the changes in the correlation structure (that indicates the extent to which two variables move concerning each other and how it contributes to participation) REER indices of various countries are correlated across two distinct periods, highlighting that during Phase I, there is a broader range of correlation values indicating more variability in the cyclical behaviors and economic interactions among the countries, while in Phase II, there is a noticeable shift towards stronger and more consistent positive correlations, as evidenced by the clustering of blue squares, suggesting that post-crisis economic conditions and policies have led to greater synchronization and alignment of REER fluctuations across these nations. However, some countries still exhibit unique or negative correlations for example Estonia, Lithuania, United Kingdom, reflecting divergent economic conditions or responses to global economic events.

Chart 5. Average values of the spectral density of the REER index in individual country groups during Phase 2.

Source: own study based on BIS data.

In Phase II, the cycle structure in the three country groups was primarily based on a long-term cycle (frequencies of 0.02-0.03, corresponding to approximately four-year cycles) and three short cycle lengths (less than a year). These are the frequencies: 0.12 (eight-month cycles), 0.22 (four-month cycles), and 0.28 (quarterly cycles). At the same time, it can be noted that the strongest impact of the cyclical component on the dynamics of the observed series is found in the first group of countries, indicating that these are the countries with the most predictable dynamics of the REER index behaviors during the studied period.

5. Conclusion

The study presented in this article focuses on analyzing the impact of the Global Financial Crisis (GFC) on the synchronization of the real effective exchange rate (REER) and on identifying cyclical changes in its behavior in the context of global financial integration. A detailed assessment of REER dynamics indicates increased synchronization and predictability of the index in response to global and regional events. The analysis results clearly show that the GFC significantly impacted the structure and dynamics of REER, enhancing its synchronization on a European scale. The variance between Phase I and Phase II decreased by 29.80 percentage points, and the correlation between countries increased by 3.60 percentage points. In Phase II, the cycle structure in the three country groups was primarily based on a long-term cycle with frequencies of four-year cycles, and three shorter cycle lengths of less than a year. As a result of the crisis the first group of countries showed the strongest cyclical impact, indicating the most predictable REER index dynamics during the period studied.

Based on the grouping of countries according to similarities in the dynamics of REER, it was found that after the GFC, there was a convergence of economic cyclicality among different economies, suggesting that policies introduced in response to the crisis contributed to increasing global economic cohesion. At the same time, it was indicated that due to the crisis,

there was a change in the cyclical structure of individual time series describing the REER index, which has also been evolving since 2021. This observation indicates that the post-pandemic crisis may have a real impact on the dynamics of the formation of the real effective exchange rate index, leading to the creation of a new dynamic structure and REER levels after the crisis ends, leading to a new, Phase III of the REER Cycle. Based on the research results, it can be concluded that the Global Financial Crisis (GFC) and the COVID-19 pandemic have indeed shortened the cyclical periods in REER movements, confirming H1. Additionally, there has been a noticeable improvement in the synchronization of REER movements post-GFC, suggesting that economies are converging in their responses to global shocks, thereby confirming H2. Furthermore, the synchronization of REER indices among European countries has increased, indicating a stabilization of exchange rate movements in response to coordinated monetary policies, thus confirming H3.

While this research provides significant insights into the behavior of REER during major global crises, it is important to acknowledge its limitations and weaknesses. Firstly, the study is constrained by the availability and quality of data, which may affect the accuracy of the findings. The reliance on spectral analysis, although innovative, may also introduce biases, especially if the underlying assumptions of stationarity are not fully met. Additionally, the focus on European countries limits the generalizability of the results to other regions with different economic structures and policy responses. Despite these limitations, the research offers valuable new knowledge and several key lessons. It demonstrates that global crises, such as the GFC and the COVID-19 pandemic, have a significant impact on the synchronization and cyclicality of REER. The study's findings suggest that post-GFC, there is a noticeable improvement in the synchronization of REER movements, indicating that economies are increasingly converging in their responses to global economic shocks. This convergence implies a potential stabilization of exchange rate movements, which is crucial for policymakers and financial market participants. The importance of this research lies in its contribution to understanding the dynamics of exchange rates in response to global crises. By highlighting the increased synchronization of REER movements, the study provides a basis for more coordinated monetary policies among European countries. This coordination can lead to more effective and consistent policy actions at the supranational level, enhancing the stability of the entire region. The findings have practical implications for financial industry stakeholders, including better-informed decisions regarding hedging strategies against currency exchange rate fluctuations and improved forecasting of future exchange rate trends. The theoretical implications extend to the broader field of international economics, where this research fills a critical gap in understanding the interplay between global crises and exchange rate dynamics. The information obtained from this study can be further used to explore the impact of other types of economic shocks on REER and examine REER's synchronization in other regions. Future research could also investigate the long-term effects of coordinated monetary policies on the stability and predictability of exchange rates. Additionally, the methodology and findings

could be applied to other economic indicators to assess their cyclicality and synchronization in response to global events.

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