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The business cycles synchronization in three monetary unions: EMU, WAEMU and CAEMC

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International monetary cooperation is, according to theory, seen as the final stage of economic integration. The example of non-European unions shows that it is possible to function within a monetary union and derive benefits from it without first creating a common market or customs union. The aim of this paper is to assess the degree of synchronization of business cycles in three monetary unions: EMU, WAEMU and CAEMC. The study used annual time series illustrating the dynamics of real GDP, which were subjected to the decomposition procedure (Hodrick–Prescott filter). Cycle convergence was examined using spectral analysis. As a result of the conducted research, it can be concluded that the cycles of the EMU countries are more synchronized than the cycles of the WAEMU and CAEMC countries. Cooperation in monetary terms is not enough to achieve a relatively high level of cycle synchronization.

Keywords: monetary union, EMU, WAEMU, CAEMC, business cycles synchronization

1. Introduction

International monetary cooperation is, according to theory, seen as the final stage of economic integration. The example of non-European monetary unions, such as West African Economic and Monetary Union (WAEMU) and Central African Economic and Monetary Community (CAEMC), shows that it is possible to achieve benefits from using the same means of payment without first creating a common market or customs union.

African monetary unions are characterized by a different integration path, which results from historical conditions. Unlike the European economic integration process that preceded the creation of the European Monetary Union (EMU), the WAEMU and CAEMC countries operated for several decades without any formal mechanisms aimed at the convergence of economies and macroeconomic policies. Despite some benefits resulting from cooperation in the field of money, these unions struggle with many social and political problems, and the convergence criteria were formulated only in response to real threats to the integrity of the union.

In monetary unions, regardless of the economic integration path, the key element is the synchronization of business cycles, which determines the adequacy of the common monetary policy. It is also one of the indicators enabling the assessment of real convergence. For this reason, it is justified to assess the degree of synchronization of business cycles in three monetary unions: EMU, WAEMU and CAEMC. This is the aim of the research in this paper. The research question was formulated as follows: Does cooperation in the field of money without the prior creation of a customs union and a common market enable a high degree of synchronization of business cycles?

The present paper has the following structure. After this introduction, the business cycles synchronization as a part of Optimal Currency Area Theory is discussed, followed by an overview of the monetary integration of three monetary unions in practice. After

explaining the materials and methods, the results of research on business cycle synchronization for three monetary unions WAEMU, CAEMC and EMU, are presented. The article ends with the results and conclusions.

2. Optimal Currency Area Theory with a particular emphasis on business cycles synchronization

The theoretical basis for the creation of a monetary union is the concept of an optimal currency area. The Optimal Currency Area (OCA) Theory indicates the criteria that the economies of countries should meet in order for the monetary union they create to be optimal (Kotliński–Warżała 2020). The general criterion for assessing the ability of a given country to participate in the monetary union is the low susceptibility of the economy to asymmetric shocks and the development of appropriate mechanisms to absorb these shocks (Pronobis 2008).

The Theory of Optimal Currency Areas focuses on the possibility of asymmetric shocks occurring and on identifying mechanisms that allow for their absorption. The group of factors reducing the risk that the country will be affected by an asymmetric shock includes: the degree of production diversification, a similar level of inflation, convergence of business cycles and similarity of the structure of economies. Factors contributing to the absorption of shocks include: mobility of production factors, price and wage flexibility, and fiscal and financial integration (Markowski 2023, Drossart-Demond 2022, Nkwatoh 2019, Kotliński–Warżała 2013, Mognelli 2002).

Under the conditions of a single monetary policy within the monetary union, it is impossible to accommodate economic shocks through exchange rate adjustments or adjustments to national interest rates (Markowski–Warżała 2023). Therefore, the asymmetry of economic shocks is perceived as a key obstacle to the creation of a monetary union by a given group of countries. The asymmetry of disruptions is manifested primarily in the uneven course of business cycles in individual countries (Wojnicka 2002).

Losing monetary policy autonomy is more costly if there is a risk of cyclical inconsistency. The common monetary policy may be inappropriate in relation to the needs of a given country if the business cycle of this economy is shifted in relation to other countries included in the monetary union. In this case, the potential costs of participating in the monetary union are related to the possibility of procyclicality of the common monetary policy. The risk of inappropriateness of the cyclical common monetary policy does not exist when business cycles are synchronized. In addition to shifting the business cycle, the frequency of business fluctuations, the type of shocks affecting the economy, different reactions to shocks and different depths of the cycle phases are also important (Kotliński–Warżała 2013).

On the other hand, differences in economic conditions in individual partner countries may be a countercyclical factor. This will be the case when domestic demand and exports are substitute components of aggregate demand. In the event of a domestic recession and a simultaneous improvement in the economic situation in the partner country, the decline in domestic demand could be replaced by exports.

Thus, the decline in domestic production would be mitigated and exports would act as a stabilizer of the economic situation.

In the 1990s, attention was drawn to the fact that joining the currency area itself could trigger a significant impulse for trade expansion, which in turn could result in more correlated business cycles. This means that a given country may be more willing to meet the criteria for a currency area ex post rather than ex ante. This concept was called the endogeneity hypothesis, and the whole trend clearly reduces the importance of costs and emphasizing the benefits of monetary integration – the New Optimal Currency Area Theory (Markowski 2023). The benefits of a currency union can be obtained in the way that the distances between countries could be narrowed down by lowering transaction costs, removing market segmentation, eliminating exchange rate volatility, and rising price transparency. It thereby promotes trade among monetary union members. The benefits also involve the insulation from speculation bubbles (Nguyen et al. 2020). Therefore, the very fact of creating a single-currency area triggers processes that automatically create an optimal currency area in the economic sense (Frankel–Rose 1998). Even if the countries were not an optimal currency area at the time of joining the monetary union, business cycles are synchronized during its duration.

In this perspective, international integration processes are even motivated by the desire to protect countries against the unfavorable impact of economic fluctuations and crises. According to these arguments, over time, the synchronization of business cycles among monetary union members should increase.

3. Monetary integration in practice

This section of the paper discusses the three monetary unions under consideration (EMU, WAEMU, and CAEMC/CEMAC) regarding their members, history, rules, institutions, and monetary policy, with particular emphasis on different integration paths, and differences among them.

3.1. European Economic and Monetary Union

The European Economic and Monetary Union (EMU) represents the third and final stage of full economic and monetary union for the member states of the European Union (EU), including Austria, Belgium, Croatia, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain[1].

The process of monetary integration in Europe was preceded by trade integration and the construction of a common market. In the 1950s, after the successful liberalization of trade on the coal, steel and iron markets, the member countries decided to deepen economic cooperation, which was inaugurated with the signing of the Treaties of Rome (1957), establishing the European Economic

[1] Only 20 of the 27 members of the European Union have adopted the common currency and pursue a common monetary policy.

Community (EEC) and the European Atomic Energy Community (Euratom). The basis for European cooperation was to be the customs union, which was finally created in 1968. These events initiated the process of economic interpenetration and merging of European countries, which resulted in increased dependence also in other areas. In the 1970s, after the period called "Eurosclerosis", consideration began to be given to how to incorporate confederal thought into the idea of a "practical federation", which was based on the gradual achievement of legal and political connections. The European Community began to be perceived as a unique structure combining the federal trend with intergovernmental cooperation (Zielińska-Głębocka 1999). As a result of these observations, new initiatives were launched to promote economic integration in Europe. In terms of monetary integration, the European Monetary System (EMS) was created in 1978, based on the European Monetary Unit (ECU). This mechanism facilitated further integration initiatives. In 1985, the European Commission was obliged to prepare a calendar of projects aimed at creating a common market. The basis for its establishment was the Single European Act, signed in 1986. The common market, enabling the free movement of capital, goods and services, became a reality at the beginning of 1993.

The monetary union in Europe is the successor to the above-mentioned European Monetary System. The legal, institutional, and monetary parts of European integration were established in the Maastricht Treaty (1992), following the recommendations of the Delors Report (1989), as highlighted by Eichengreen et al. (1993) and Haug et al. (2000).

Moreover, as part of the Maastricht Treaty (1992), four "nominal convergence" requirements were established for the monetary and fiscal components, which a member state had to fulfill to be eligible to join the EMU. These were: (a) no currency devaluation in the two years before union entry; (b) inflation rate no more than 1.5 percentage point above the average of the three lowest-inflation countries; (c) long-term interest rate no more than 2 percentage point above the average of the three lowest-inflation countries; and (d) government debt and deficits not more than 3% and 60% of GDP, respectively. Further, the EMU, also known as the Eurozone, is a wide umbrella that has implemented several policies targeted at free trade and economic convergence among its member nations. Three stages went into creating the EMU, the third of which started the transition from previous national currencies to the shared euro currency (Hodson et al. 2022). All of the original EU member states have finished this, except Denmark and the United Kingdom, which chose not to accept the euro. After the Brexit referendum in 2020, the United Kingdom subsequently departed the European Union.

It can be emphasized that the EMU is based on the idea of convergence, which refers to both the convergence of European countries to preserve the distinctive European model and the convergence of member states toward the highest levels of wealth (Juncker et al. 2015). According to Juncker et al. (2015), important aspects of economic policy continue to be national, even while monetary policy is centralized in the EMU. Ensuring that citizens and businesses can adjust to and benefit from changing demands, trends, and difficulties, as well as modernizing economic structures and welfare systems, are all in the common and self-interest of all members. Every member has an equal stake in the others moving at a comparable pace. This is

especially important in the European Monetary Union (EMU), where labor mobility is restricted and large-scale fiscal transfers between member states are not anticipated.

It can be indicated that EMU is administered by some designated institutions which include the European Central Bank (ECB), the European System of Central Banks (ESCB), the Economic and Financial Committee, the Eurogroup, and the Economic and Financial Affairs Council (Ecofin) (Jost 2023). These institutions are largely responsible for establishing the European monetary policy, rules governing the issuing of the euro, and price stability in the EU. Furthermore, the EMU is governed by a set of rules and regulations that are established to ensure economic stability, convergence, and coordination among its member states. These comprise the following:

1. Treaty on the functioning of the European Union (TFEU): The TFEU is one of the primary treaties governing the European Union (EU) and provides the legal framework for the EMU. It sets out the objectives, principles, and institutional framework of the EMU.
2. Maastricht Treaty: The Maastricht Treaty, formally known as the Treaty on the European Union (TEU), established the EMU in 1992. It laid down the conditions and criteria for the adoption of the euro as a common currency and the formation of the European Central Bank (ECB). The Maastricht Treaty also established convergence criteria, known as the "Maastricht criteria," which member states must meet to join the EMU.
3. Stability and growth pact (SGP): The SGP is a set of rules aimed at ensuring fiscal discipline and coordination among member states. It sets limits on government deficits and debt levels to promote fiscal stability. The SGP requires member states to maintain their budget deficits below 3% of GDP and their public debt below 60% of GDP.
4. European semester: The European Semester is an annual cycle of economic policy coordination among EU member states. It aims to ensure the coordination of economic policies, fiscal policies, and structural reforms to strengthen economic performance and convergence. The European Semester involves the monitoring, assessment, and coordination of member states' economic and fiscal policies by the European Commission and the Council of the European Union.
5. Macroeconomic imbalance procedure (MIP): The MIP is a framework established to identify and address macroeconomic imbalances within the euro area. It aims to prevent and correct imbalances that could pose risks to the stability and functioning of the EMU. The MIP monitors indicators such as current account balances, housing prices, private and public debt, and unemployment rates to identify potential imbalances and trigger corrective actions.
6. Banking union: The banking union is a framework established to ensure the stability of the banking sector within the euro area. It consists of three pillars: a Single Supervisory Mechanism (SSM), a Single Resolution Mechanism (SRM), and a common deposit insurance scheme (EDIS). The SSM, operated by the ECB, oversees the prudential supervision of banks.

The SRM provides a framework for the orderly resolution of failing banks, and EDIS aims to establish a common deposit insurance scheme to protect depositors.

It is worth emphasizing that monetary policy plays a crucial role in shaping the economic performance of countries. In the context of the European Economic and Monetary Union (EMU), a common monetary policy is followed and this monetary policy is formulated and implemented by the European Central Bank (ECB) for the euro area member states (Ardakani et al. 2024, The European Central Bank 2021). The EMU aims to promote economic integration and stability among its member countries. However, the integration paths among member states have varied, leading to different challenges and dynamics in the implementation of monetary policy (Pagliari–Young 2014). It is important to explore the different integration paths within the EMU and their implications for monetary policy.

It should be noted that the functioning monetary policy is predicated on maintaining the equality of interest rates in the EMU interbank market, which is a uniform position throughout the monetary union. The formulation of monetary policy has been centralized in this instance, leading to the harmonization of instruments and techniques and the uniformity of monetary policy signals across nations (Enoch–Quintyn 1996). This has also created enough opportunities for arbitrage across the EMU, allowing for the rapid and uniform transmission of interest rate changes throughout the monetary union. Additionally, the integration paths among members of the EMU have varied, leading to different challenges for the implementation of monetary policy. The core-periphery divide, varying degrees of economic convergence, and differences in the effectiveness of monetary policy transmission channels have all shaped the dynamics of monetary policy within the euro area. The ECB has responded to these challenges through unconventional measures and initiatives such as the Banking Union and the Capital Markets Union. As the EMU continues to evolve, addressing these integration paths and challenges will remain important for ensuring the stability and effectiveness of monetary policy.

3.2. West African Economic and Monetary Union (WAEMU)

The West African Economic and Monetary Union (WAEMU) is a regional organization that seeks to promote economic integration and monetary cooperation among its member states.

The currency grouping in West Africa was created as an economic consequence of French colonialism. In the second half of the 20th century, the colonial franc was established there as the currency in monetary circulation. The CFA franc was created by the French colonial authorities in December 1945 following France's ratification of the Bretton Woods Accords. According to the declarations of the French authorities, the creation of a new currency was a kind of act of magnanimity in order to spare the French colonies from the strong devaluation that the French franc was subjected to.

Dating back to 1962, WAEMU is one of the oldest sub-regional unions and also one of the currency unions in the world today (Kebalo–Zouri 2022, Kireyev

2015). The WAEMU consists of eight low-income countries, namely, Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo. WAEMU was established in 1994, through the signing of the Treaty of Dakar. However, its origins can be traced back to the West African Monetary Union (WAMU), which aimed to promote economic integration among its member states through the establishment of a common currency and a central bank. Over time, WAMU evolved into WAEMU, with a broader mandate to foster economic and monetary cooperation (Hernández-Catá–François 1998). Thus, WAEMU shares a common currency, the CFA franc, which is pegged to the euro. The CFA franc is issued by the Central Bank of West African States (BCEAO), which is the central bank of the WAEMU.

Moreover, the WAEMU operates based on a set of rules and institutions designed to facilitate economic integration and monetary cooperation and the members are required to abide by these rules. The main institutions responsible for running the affairs of the union are the following: The West African Monetary Union Commission (WAMU Commission), which is the executive body of WAEMU and is responsible for implementing the decisions of the Council of Ministers and the WAEMU Heads of State; The Council of Ministers, which is the highest decision-making body of WAEMU and consists of the ministers in charge of economic and financial affairs from each member state; The central bank of WAEMU (BCEAO), responsible for issuing the CFA franc, pegged to the euro at a fixed exchange rate, conducting a single regional monetary policy, pooling foreign exchange reserves of members, supervising the banking system, and maintaining price stability; and The Convergence, Stability, Growth, and Solidarity Pact, which sets out the fiscal and monetary policy framework for member states (Diop 2010). The pact includes convergence criteria related to budget deficits, public debt, inflation, and external reserves, which member states are expected to meet.

Further, as indicated early on, WAEMU has a common monetary policy managed by the BCEAO and for that matter, the monetary policy decisions are made by the Monetary Policy Committee, which consists of representatives from the BCEAO and the national central banks of member states. The BCEAO uses various instruments, such as open market operations and reserve requirements, to manage liquidity and stabilize the CFA franc (Hernández-Catá–François 1998). It can be stated that members of WAEMU have diverse integration paths and these paths can be broadly categorized into two groups: (a) Francophone countries, including Benin, Burkina Faso, Côte d'Ivoire, Mali, Niger, Senegal, and Togo, which have a deeper level of integration within WAEMU and a common currency, the CFA franc, as well as adhere closely to the rules and institutions of the union; and (b) Guinea-Bissau, a former Portuguese colony which joined WAEMU in 1997 but has not fully adopted the CFA franc as its currency and maintains its own currency, the West African peso. Guinea-Bissau has a more limited level of integration within the WAEMU compared to the francophone countries.

3.3. Central African Economic and Monetary Community (CAEMC/CEMAC)

The Central African Economic and Monetary Union (CAEMC), also known as the Economic and Monetary Community of Central Africa (CEMAC), is also a regional

organization in Central Africa that has the aim of promoting economic integration and monetary cooperation among its member states. Like WAEMU, its roots can be traced to French colonialism and the creation of the franc zone in Africa. The CAEMC is made up of six member states, namely, Cameroon, Central African Republic, Chad, Republic of Congo, Equatorial Guinea, and Gabon. These countries also share a common currency, the Central African CFA franc, which is pegged to the euro at a fixed exchange rate. Moreover, CAEMC was established in 1994, with the signing of the Treaty of N'Djamena. This organization was created as a successor to the Central African Customs and Economic Union (UDEAC), which was established in 1964 to promote economic cooperation among its member states (Melo–Ngwenya 2018).

Later, UDEAC grew into CAEMC with a broader mandate to foster economic and monetary integration. Just like WAEMU, CAEMC/CEMAC is governed by rules and some designated institutions. These institutions include the Conference of Heads of State and Government, which is the highest decision-making body of CAEMC and consists of the heads of state and government of member countries; The Commission of the Economic and Monetary Community of Central Africa (CEMAC Commission), which is the executive body of CAEMC, responsible for implementing the decisions of the Conference of Heads of State and Government; The Central African States Development Bank (BDEAC), which plays a crucial role in financing development projects within the CAEMC region; and The Bank of Central African States (BEAC) also known as the Banque des États de l'Afrique Centrale (Manu 2016). The BEAC is the central bank of CAEMC and is responsible for issuing and managing the Central African CFA franc, conducting monetary policy, and maintaining price stability. In addition, the BEAC is granted the authority to establish a common monetary policy, keep and oversee member states' foreign reserves, and issue a single currency, the CFA franc (de Zamaróczy et al. 2018).

Within the CFA franc zone, there are no restrictions on capital flows and CEMAC works under a fixed exchange rate regime. The CFA franc is freely convertible at the set exchange rate and is fixed to the euro. Here, the BEAC makes monetary policy decisions through the Monetary Policy Committee, which includes representatives from the BEAC and the national central banks of member states. The BEAC uses various instruments, such as open market operations and reserve requirements, to manage liquidity and stabilize the Central African CFA franc. However, it can be indicated that the monetary policy of member countries is influenced by the monetary policy of the Eurozone, as the CEMAC countries do not have control over their monetary policy. It can be emphasized that CAEMC member states have followed different paths of integration within the union as was seen in the case of WAEMU. These paths can be said to be in two directions:

(a) Francophone countries such as Cameroon, Central African Republic, Chad, and the Republic of Congo have a deeper level of integration within CAEMC. Thus, these countries have adopted the Central African CFA franc as their currency and adhere closely to the rules and institutions of the union;
(b) Equatorial Guinea and Gabon, which were former Portuguese and French colonies, respectively, have a more limited level of integration within

CAEMC. These countries have not fully adopted the Central African CFA franc and maintain their currencies, the Central African ekwele and the Central African franc, respectively. Also, these countries have their monetary policies and a different level of adherence to the rules and institutions of CAEMC.

To sum up, it can be indicated that these three monetary unions have some level of similarities in terms of the conduct of monetary policy. Due to the use of a single currency among the member states within the respective unions, monetary authorities from the national central banks surrender their control to the central banks of the unions – that is, the unions' central banks that are in charge of the chosen currency receive complete control over monetary policy and exchange rates from the monetary authorities. Also, even though WAEMU and CAEMC use the CFA franc, it is pegged to the euro. Here, it can be stressed that the use of the CFA franc and euro by WAEMU and CAEMC probably occurred due to historical ties to former colonial masters or a currency reform intended to restore macroeconomic stability (van Riet 2024, Staehr 2015).

However, there are differences associated with them. At the integration level, the EMU has a higher level of economic and monetary integration among its member states which involves coordination of fiscal, monetary, and economic policies and a unified central bank. In the case of WAEMU, the member states have different integration paths and it aims to achieve economic integration and monetary stability within the West African region through the use of a common currency and coordination of monetary policies. The CAEMC/CEMAC also has a disparate way of integration.

It can be concluded that African monetary unions are characterized by a different integration path, which results from historical conditions. Unlike the European economic integration process that preceded the creation of the European Monetary Union (EMU), the WAEMU and CAEMC countries operated for several decades without any formal mechanisms aimed at the convergence of economies and macroeconomic policies. Despite some benefits resulting from cooperation in the monetary field, these unions struggle with many social and political problems. Moreover, the convergence criteria were formulated only in response to real threats to the integrity of the union (Młodkowski 2007).

These differences constitute an argument for empirical verification of the degree of synchronization of business cycles in the countries belonging to the three mentioned unions. An interesting issue is the answer to the question whether cooperation in the field of money without the support of formal mechanisms aimed at economic convergence allows to achieve a relatively high level of synchronization of fluctuations in economic activity, such as in the European monetary union

4. Materials and methods

This study assumes the annual dynamics of real GDP as the raw time series. The selected concept of separating the cyclical component is the growth method, and the identification of the growth cycles combines "cyclical" and "growth" aspects of

dynamics (Hübner et al. 1994, pp. 18-20). It allows to identify cyclical fluctuations even when the economy is characterized by a long period of uninterrupted growth.

Due to the use of annual data, the seasonal adjustment procedure was not necessary[2]. The cyclical component was extracted from the time series using the Hodrick–Prescott filter (1997). It is a high-pass filter, which means that it "passes" fluctuations with frequencies higher than those selected by the researcher (Adamowicz et al. 2008, p. 18; Łuczyński 2013, p. 270). Although this filter was created within the new classical economics and methodologically corresponds to the interpretation of the Lucas cycle (Beck 2017, p. 6), it should not be treated as a theory, but as a universal tool and a standard econometric procedure (Kasperowicz 2010, p. 69).

The starting point in using the HP filter is the assumption that the time series consists of two components: a trend and a cyclical component. The filter takes the form of the sum of squares of the time series increments. The trend is estimated by solving the following function (Kufel et al., 2014: 42; Beck, 2017: 7):

$$min\left[\sum_{t=1}^{T}(y_t - g_t)^2 + \lambda \sum_{t=3}^{T}(\Delta^2 g_t)^2\right]$$

Where: g_t is a trend and λ is the so-called smoothing parameter.

The only component of the equation that must be determined by the researcher is parameter λ (Beck 2017, p. 7). The smoothing parameter was set according to the suggestion of M.O. Ravn and H. Uhlig (2001, p. 1), who proposed that this value of annual data should be 100.

The reference series were business cycles of entire monetary unions, to which the variability of national cycles was related. The convergence of fluctuations was measured using spectral analysis – the coherence coefficient and cross-correlations. The coherence coefficient allows to determine the strength of convergence between time series within a predetermined fluctuation range. The value of this coefficient indicates the extent to which cyclical fluctuations of the empirical series of variable X are able to explain cyclical fluctuations of the reference series:

$$K_{yx}^2 = \frac{c_{yx}(\omega)^2 + q_{yx}(\omega)^2}{f_x(\omega) * f_y(\omega)}$$

$$0 \leq K_{yx}^2(\omega) \leq 1 \ \ for \ \ \omega \in [-\pi;\ \pi].$$

[2] Typically, higher-frequency data is preferred when examining business cycle synchronization. However, such data are difficult to access for African countries or are incomplete. Another solution is to carry out the disaggregation procedure of annual data. However, this raises doubts regarding the comparability of estimated data (for WAEMU and CAEMC) with real data (for EMU). Therefore, it was decided to use long time series representing annual data in this work.

Where: $c_{yx}(\omega)$is a co-spectrum (real part cross-spectrum), $q_{yx}(\omega)$ is quadrature spectrum (negative imaginary part of the cross-spectrum), and $\omega = 2\pi/N$ is a frequency of harmonic components.

Coherence is therefore a measure of the R^2 fit in a regression of the dependent variable against the independent variable for a given frequency. The value of the coefficient ranges from 0 to 1. The closer the coherence value is to unity, the more interdependent the series under study (Burzała 2009).

Cross-correlation, on the other hand, is a function of the value of the Pearson correlation coefficient of two time series shifted by Δt relative to each other depending on the value of Δt. The study also calculated the number of additional cycles of a given country relative to the reference series.

The time range of the research is 1981–2022. The starting date results from the implementation of the ECU (European Currency Unit), i.e. the accounting unit in the European Monetary System, which replaced the European Unit of Account (EUA) and which preceded the introduction of the euro in 1999. It was therefore a time of tightening integration in the sphere of money, supported by the already functioning customs union and the development of rules for the functioning of the common market. It is worth emphasizing that cooperation in the field of common money has already existed in African countries[3].

The following countries belonging to individual monetary unions were included in the research:

- EMU: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain.
- WAEMU: Benin, Burkina Faso, Cote d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, Togo.
- CAEMC: Cameroon, Central African Republic, Chad, Congo Rep., Equatorial Guinea, Gabon.

The selection of countries (in the case of EMU) was dictated by the length of participation in the grouping.[4] Most countries participated in the integration process for the vast majority of the research period. Moreover, all 12 countries adopted the common currency, the euro, in 1999.

[3] Moreover, previous data for African unions was incomplete.
[4] Croatia, Cyprus, Estonia, Italy, Latvia, Malta, Slovakia and Slovenia are excluded from the study.

5. Results

The study of cycle synchronization was carried out using spectral analysis. The research results for three monetary unions – WAEMU, CAEMC and EMU – are presented in Tables 1, 2 and 3[5].

Table 1. Cyclical factor statistics of real GDP dynamics in relation to the reference series (WAEMU)

Country	Coherence	Number of additional cycles with respect to the reference series	Cross-correlation		
			r_0	r_{max}	t_{max}
Benin	0.18	-3	0.26	0.32	1
Burkina Faso	0.37	0	0.57	0.57	0
Cote d'Ivoire	0.81	0	0.90	0.90	0
Guinea-Bissau	0.05	-2	0.21	0.21	1
Mali	0.17	0	0.37	0.37	0
Niger	0.32	-1	0.47	0.47	0
Senegal	0.25	-1	0.48	0.48	0
Togo	0.17	-2	0.43	0.43	1

Source: results of own research

The coherence coefficient determines the extent to which changes in economic fluctuations of the entire monetary union affect the fluctuations of a given country. Based on the research results, we can conclude that in the case of WAEMU countries this is a small impact. The exception is Cote d'Ivoire, whose dependence of fluctuations can be assessed as high. It can also be concluded from the data in the table that most countries are characterized by fewer business cycles than the entire group. Assessing the synchronization of cycles based on the correlation coefficient, it should be concluded that it is weak or moderate. The high convergence of Cote d'Ivoire cyclical fluctuations is confirmed. There is moderate synchronization for Burkina Faso, Senegal, Niger, and Mali. This is also confirmed by the values of the correlation coefficient with the shift (in these countries, synchronization is the highest without the shift). However, the low values of the coherence coefficient do not allow formulating a conclusion about a moderate correlation of cyclical fluctuations of the WAEMU countries because the cycles of individual countries are weakly dependent on the cycle of the entire union. It seems that the convergence of cyclical fluctuations in African countries is influenced by the specificity of events of different importance for these economies or different impact strengths.

[5] Due to the end-point instability of the HP filter, as a robustness check, the spectral analysis was also performed with the removal of the first and last two datapoints from the time series. The results did not differ significantly from the original data and this did not affect the conclusions.

Similar conclusions can be drawn when analyzing CAEMC (Table 2).

Table 2. Cyclical factor statistics of real GDP dynamics in relation to the reference series (CAEMC)

Country	Coherence	Number of additional cycles with respect to the reference series	Cross-correlation		
			r_0	r_{max}	t_{max}
Cameroon	0.42	-1	0.62	0.62	0
Central African Republic	0.13	-1	0.22	0.26	3
Chad	0.37	-2	0.59	0.59	0
Congo, Rep.	0.04	-1	0.17	-0.25	-3
Equatorial Guinea	0.16	-2	0.42	0.42	0
Gabon	0.25	-3	0.41	0.41	0

Source: results of own research

The coherence coefficient indicates a moderate dependence of Cameroon and Chad fluctuations on the fluctuations of the entire monetary union. In other countries this relationship is weak. No single CAEMC country has the same number of cycles as the entire grouping. The correlation coefficient confirms the relatively stronger cyclical convergence of the Cameroon and Chad economies.
In the case of EMU, the situation is different (Table 3).

Table 3. Cyclical factor statistics of real GDP dynamics in relation to the reference series (EMU)

Country	Coherence	Number of additional cycles with respect to the reference series	Cross-correlation		
			r_0	r_{max}	t_{max}
Austria	0.85	0	0.89	0.89	0
Belgium	0.89	-1	0.91	0.91	0
Finland	0.50	1	0.66	0.66	0
France	0.91	-1	0.92	0.92	0
Germany	0.79	-1	0.86	0.86	0
Greece	0.52	0	0.67	0.67	0
Ireland	0.23	0	0.46	0.46	0
Italy	0.95	0	0.94	0.94	0
Luxembourg	0.39	-1	0.61	0.61	0
Netherlands	0.88	1	0.90	0.90	0
Portugal	0.72	0	0.81	0.81	0
Spain	0.85	-1	0.89	0.89	0

Source: results of own research

First of all, in almost all countries, the coherence coefficient is very high. This proves the strong interdependence and integration of European economies. Therefore,

economic fluctuations in these countries are interdependent, and economic phenomena have an impact on other member countries. It should also be emphasized that there are countries with relatively weaker synchronization, such as Ireland, Luxembourg and Finland. This is, to some extent, determined by the specificity of these economies (Luxembourg), connections with American capital (Ireland) or the trade structure (Finland). The difference in the number of cycles between individual countries and the entire EU does not exceed 1, which also distinguishes EMU from WAEMU and CAEMC. The correlation coefficients for EMU countries are also significantly high in most cases. It is worth emphasizing that they reach the highest value without the leads/lags of the time series.

The analysis shows that the synchronization of business cycles in the European monetary union is much higher than in African unions. In order to illustrate the scale of the difference between unions using one value, average values of correlation coefficients were calculated for each union. The results are presented in Table 4.

Table 4. Average correlation coefficient of countries included in individual monetary unions

Union	Average correlation coefficient of countries[6]
WAEMU	0.30
CAEMC	0.20
EMU	0.87

Source: results of own research

The calculations confirm that the countries of the European Monetary Union are characterized by the highest degree of business cycle synchronization. WAEMU can be ranked second and CAEMC third.

6. Conclusion

The empirical research reported on here achieved the research goal. This allowed us to draw the following conclusions:

- The cycles of the EMU countries are more synchronized than the cycles of the WAEMU and CAEMC countries, which is confirmed by the values of the correlation coefficient. High values of the coherence coefficient prove the strong interdependence and integration of European economies. The values of the cross-correlation coefficient also indicate better synchronization of the cycles of European countries than those of African countries.

[6] Since correlation coefficients are not additive, Fisher's transformation was used to calculate mean values.

- It seems that the convergence of cyclical fluctuations in African countries is influenced by the specificity of events of different importance for these economies or different impact strengths.
- Cooperation on money is not enough to achieve a relatively high level of cycle synchronization. To some extent, this contradicts the endogeneity theory. Projects aimed at coordinating macroeconomic policies and creating formal mechanisms aimed at the convergence of economies also seem necessary.
- African countries included in WAEMU and CEAMC are likely to experience permanent inadequacy (cyclical and structural) of the single monetary policy.
- This may partly stem from their different integration paths.

The conducted research, like any empirical analysis, is based on certain assumptions and is not free from limitations. The research should be extended to include time series with a different frequency, e.g. quarterly. However, due to the rather unambiguous results, the authors do not expect that such a change would result in a correction of the conclusions. Another modification may be to use a different statistical data filtering procedure or to extend the time series. Other areas of convergence identified by OCA theory can be considered future research directions, including: inflation or trade structure.

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