OECONOMIA
COPERNICANA

VOLUME 14 ISSUE 3 SEPTEMBER 2023

p-ISSN 2083-1277, e-ISSN 2353-1827
www.oeconomia.pl

ORIGINAL ARTICLE

Citation: Tkacova, A., & Gavurova, B. (2023). Economic sentiment indicators and their prediction capabilities in business cycles of EU countries. *Oeconomia Copernicana*, *14*(3), 977–1008. doi: 10.24136/oc.2023.029

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Article history: Received: 13.06.2023; Accepted: 13.09.2023; Published online: 30.09.2023

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Economic sentiment indicators and their prediction capabilities in business cycles of EU countries

JEL Classification: *C53; E32; E37; G01*

Keywords: *business cycle; cross correlation; prediction; ESI; GDP; IIP*

Abstract

Research background: The post-World Financial Crisis period has showed us that an application of the qualitative data focused on the expectations of the enterprises and consumers in a combination with the quantitative data in the individual economy sectors is a good prerequisite for reliable prediction of the economic cycles.
Purpose of the paper: The main goal of the presented study was to test the ESI prediction capabilities and its components in a relation to the economic cycles of the EU countries in the individual time periods.
Methods: The time series for the period Q1 2000 to Q4 2022 and the three selected time periods were a subject to undergo the selection of the cyclical component applying the Hodrick-

Prescott filter and then, the relationship between the variables was determined employing the Pearson correlation coefficient with the time shifts. The relation of ESI and its components to GDP and the Index of Industrial Production (IIP), which represent the economic cycle, was analysed. The prediction volume and the cross-correlation values determined the nature of the observed cyclical variables.

Findings & value added: The results of the analysis point to the fact that ESI and its components are able to ensure a high-quality prediction of the economic cycle only in the selected EU countries. Regarding the components of the ESI, the Consumer confidence indicator, Construction and Industrial confidence indicators show the best predictive capabilities. The analytical outcomes show that the ESI size and lead period vary over time and after the 2008 crisis, the ESI showed better predictive capabilities in a relation to GDP and IIP than before the crisis. The Covid 19 pandemic had a significant negative impact on the ESI predictive capabilities.

Introduction

In the recent time, the economies of the European Union (EU) countries have been exposed to a broad range of a majority of the external factors that have a negative impact on their business cycles development. The 2008 world economic crisis, the Covid 19 pandemic and the war in Ukraine caused the EU countries issues with the growth of unemployment, inflation, public debts, and a decrease in economic growth. For a long period, the issue of high-quality forecasting has come to the forefront and according to it, it would be possible to identify the negative changes continuously and thus, to obtain a sufficiently long period to make decisions at the country as well as at the level of the private sector (Androniceanu, 2020; Wang *et al.* 2021).

Currently, a number of indicators are available that have the potential to provide a high-quality prediction (Škare & Stjepanović, 2016). More and more emphasis is placed on the data with qualitative characteristics represented by business or customer surveys. In some cases, information from the business partners can increase the accuracy of forecasts by up to 50% (Garnitz *et al.*, 2019). The importance of an application of the qualitative variables in the economic cycles prediction, especially after the crisis in 2008, was also confirmed in the studies such as by Rzoza-Brzezina and Kotlowski (2018), Claveria *et al.* (2016), and so on. A high-quality indicator is the Economic sentiment indicator (ESI) that was constructed by the European Commission in order to predict the economic cycles of the EU countries. The ESI belongs to the group of the composite indicators of business activity, providing information in the lead period before the GDP calcula-

tion based on simple questionnaire data collection — according the assessments and the expectations of the economic actors in the five BCS sectors (industry, retail, services, construction, and consumer sector). Early nature and high synchronous correlation with the reference statistics are key advantages of ESI (Lipkind *et al.*, 2019).

The existing studies confirm that ESI has predictive power regarding GDP growth and many other economic variables (Antipa *et al*., 2012; Cizmesija & Skrinjaric, 2021). Nevertheless, research, which is also available, has identified mutual effects between sentiment and GDP growth. ESI is not only employed for an explanation and forecast of economic growth. Its usefulness has been demonstrated in an observation of the life quality in the EU member countries (Skikiewicz & Blonski, 2018) as an important variable in the analysis of direct foreign investments (Badea *et al.*, 2018), stock market growth, forecasting tourist demand (Altin & Uysal, 2014) and so forth.

The mentioned studies evaluate the ESI predictive impact as an overall composite indicator. Nevertheless, ESI components and their predictive capabilities are also important. The sentiment indicators homogeneity is more pronounced at a higher aggregation level. The differences are observed by the country and not at the level of the EU as a whole (Lemmens *et al.*, 2007). There are few studies such as Clar *et al.* (2007) or Lemmens *et al.* (2005) that would evaluate the predictive capabilities of all the ESI components in a relation to the business cycle of the individual EU countries and at the same time, they are able to monitor changes in the prediction quality that may occur in the case of ESI throughout the explored period. The added value of the study is also tracking the ESI to a different reference series that can represent the economic cycle — namely, to the classic GDP or the less employed Index of Industrial Production (IIP), whose relationship with the ESI was monitored, for instance, in Germany by Hüfner and Schroder (2002).

The main goal of the presented study is to examine the ESI predictive capabilities and its components in the individual EU countries regarding the possible changes in the prediction quality throughout the examined period. The reason is an objective quality assessment of the provided predictions for the purpose of quantifying the lead time that the country and the private sector have to take timely steps. In the case of the country, these should be steps aimed at managing the volume of public expenditures and the possible regulation of tax rates. In the case of the private sector, it is

about managing the need for human capital, stock levels and investment activity that are closely linked to the expected future development of the economic cycle.

The significance of the presented study also has another important dimension in the prediction of the economic cycles, namely the identification of the ESI sub-components for the purpose of creating a composite leading indicator (CLI) for the individual EU countries. The ESI components (not the ESI as a comprehensive indicator) have long been applied as the CLI components that were constructed by the OECD for the individual EU countries. The OECD CLIs were also applied for a short-term prediction of the business cycles and determination of the turnover points, although they combine qualitative and quantitative data, which can be considered their great advantage. Nevertheless, their disadvantage was the long-term use of the same CLI composition for the particular country over the period that led to their prediction quality decrease. Ojo *et al.* (2023) confirmed that CLI OECD exhibited poor performance regarding GDP growth. Since January 2023, the OECD creates a CLI only for France, Germany, and Spain. This means that there is currently no institution that would ensure the creation and testing of new CLIs for the other EU countries, which the ESI components had a significant presence in. The outcomes of the presented study should thus constitute the first step towards the creation of a new CLI for all the EU countries and also offer a methodological framework to examine the advance capabilities of the other indicators. This is also the future research intention of the authors of this study.

This paper is organised as follows. Section 2 offers the theoretical background and the hypotheses' development. Section 3 describes the research methodology. The fourth section provides the empirical results. Finally, the fifth section provides conclusions, discussion, identifies limitations and opportunities for further research.

Literature review

ESI is a widely employed indicator in the empirical analysis of the business cycle. According to the questionnaire research, the evaluations and the expectations of managers and consumers are aggregated and expressed as the differences between the percentages of positive and negative answers. These are seasonally adjusted successively and applied in order to calculate

the composite indicators in the five economic sectors (as mentioned above). This approach is based on monitoring approximately 12,500 enterprises and 40,000 consumers interviewed in monthly periodicity. The fifteen variables expressed as seasonally adjusted balances are selected as the ESI components. According to the harmonised EU ESI calculation methodology, the sector weights for industry is 0.4, for services 0.3, for consumers 0.2, for construction 0.05, and for retail 0.05 (Cizmesija & Skrinjaric, 2021). The subsequent interpretation of the ESI is that if the ESI value is over 100, the economic sentiment in the national economy is above average and if the ESI is below 100, the economic sentiment is below average.

ESI predictive capabilities and its components in a relation to the selected economic indicators

The recent studies analyse the relationship between the different forms of the economic sentiment and real GDP growth (Soric, 2018; Mazurek & Mielcová, 2017). All of them demonstrate the similar conclusions, meaning, the consumer confidence indicators that are applied to predict the business cycles themselves or in a group with the other indicators, can be employed to predict the GDP changes three to six months in advance. ESI is usually applied strictly for the short-term GDP prediction and thus, it is suitable for forecasting only the change direction and not their volume. These facts are empirically confirmed in many significant studies such as by Claveria *et al.* (2016), Soric *et al.* (2016), Kolková and Ključnikov (2022).

The relationship between the sentiment indicators and the business cycle is tracked employing static or dynamic modelling. These forms, such as static modelling is more common and it is applied in the studies such as by Raoufina (2016), Dritsaki (2015). A large number of the studies evaluate the ESI relationship to the business cycle through the Granger causality and the correlation coefficient (Lipkind *et al.*, 2019; Cizmesija & Skrinjaric, 2021). Dynamic modelling is applied by Soric (2018) and it includes the VAR models primarily. The scientists, who know the ESI importance, continue to work on the methodological improvements and new areas of application to contribute to the methodological progress and a better understanding of the economic sentiment phenomenon (Soric *et al*., 2016).

The ESI importance in the GDP prediction was confirmed at the national level primarily. Through the VAR model, Cizmesija and Soric (2010) confirm that the ESI has the potential to be a part of the complex indicators

applied in order to predict the Croatian cycle. Adamowicz and Walczyk (2013) analyse the relationship between the confidence indicators in the various economic sectors and GDP, private consumption, industrial production, construction production, and retail sales during and after the recession in the Eurozone countries and some new EU member countries. The authors empirically confirm that the recession strongly determines the sentiment of the economic subjects that is shifted into pessimism in their evaluation and expectations for the future. Hüfner and Schroder (2002) employed the four indicators of the economic sentiment, including ESI for Germany and thus, they compared the relationships of these indicators to the German industrial production growth rate. It was proved that ESI can predict industrial production just a month in advance. Clar *et al.* (2007) examined ESI and its components at the Eurozone level. Lemmens *et al*. (2005) also explored the same data for the twelve EU member countries and they employed a multivariate simultaneous approach to test the causality of these indicators at the output level. The statistically significant Granger causality was found in the seven EU countries.

According to the observed studies, the following hypotheses were determined:

H1: *ESI shows a statistically high-quality level of prediction before the business cycle development that represents the GDP or IIP real growth only for the selected EU countries.*

H2: *The ESI components have the different predictive capabilities for GDP and IIP depending on the EU country.*

Post-crisis changes in ESI predictive capabilities

The studies published after 2008 have confirmed that economic sentiment measured in the particular country can spill over the national economy borders (Rzoza-Brzezina & Kotlowski, 2018). The available studies examine the performance of the survey-based composite indicators including ESI during the recessions and the crises at both the European and country level. Biau and D'Elia (2011) point to the change in the relationship between the ESI and GDP growth in the European countries before and after the 2008 crisis and thus, they conclude that further investigation of this relationship is needed. Claveria *et al.* (2016) confirmed that the capacity of

the agents' expectations to predict economic growth in the most European economies improved after the crisis. The European studies demonstrate that ESI dynamics after the crisis show an even higher correlation with the yearly GDP growth. Astolfi *et al.* (2016) confirm the leading characteristics based on the dated breakpoints for the OECD composite indicators compared to the indicators based on the national accounts during the Great Recession. Cesaroni and Iezzi (2017) remind the high statistical capability of the indicators based on the qualitative research in order to predict the macroeconomic alteration in the short term. Cizmesija and Skrinjaric (2021) confirm that ESI has found itself as a strong predictor of the economic activity. Michis (2021) determined that the ESI predictive influence varies considerably between the EU member countries in the short time period. Conversely, several similarities emerge when the associations are found throughout the longer period. These similarities tend to be related to the countries that are geographically close or the ones that performed similarly regarding the economic behaviour before the euro adoption.

The economic sentiment indicators were also examined in a relation to the Covid-19 pandemic. Nevertheless, these were mainly studies that focused on the impact velocity of the pandemic on the consumer surveys, the GDP dynamics, and the goods and services production, the import and export volumes, the industrial indicators, the changes in the global value chains, unemployment, financial markets, and the other areas (Jorda *et al*., 2020; Fernandes, 2020; Bonadio *et al.,* 2020; Guerrieri *et al.,* 2020; Lee, 2020; Kanapickienė *et al*., 2020; Olkiewicz, 2022). Zervoyianni *et al.* (2023) concluded that the pandemic caused significant downward sentiment among the economic agents in Europe through the economy slowdown due to the imposed restrictions on movement and the other controls. In this case, it means a rapidly occurring economic shock caused changes in ESI and not the other way around. The existence of the opposite causality direction was also confirmed in the past by Ferreira *et al*. (2008).

The results of the study by Teresiene *et al.* (2021) showed a relatively rapid and robust short-term effect of COVID-19 on the Eurozone, the United States, and China, but the longer-term results depended on the region and were not so unanimous. In the case of the Eurozone, the spread of the COVID-19 pandemic did not affect the Consumer Confidence Index (CCI that is involved in ESI. This means that ESI could not subsequently predict even changes in the economic cycle of the countries. Zhang *et al.* (2021) monitored the changes in the selected sentiment indicators under the influ-

ence of the pandemic in the 36 countries of the world monthly. After the outbreak of the Covid-19 pandemic, the economic sentiment fluctuated considerably and even turned pessimistic. The pandemic had a significantly negative effect on economic sentiment, but a substantial positive effect on consumer confidence, a substantial negative effect on industrial confidence, and no significant effect on confidence in the services. Simionescu and Raišienė (2021) claim that the sentiment indicators tend to better reflect social tensions caused by the Covid-19 pandemic, which they confirmed by identifying a negative impact on the labour market. Aguilar *et al.* (2021) tested the ESI capabilities during pandemic in Spain. They determined that ESI was only able to forecast a recession with a very low probability and that ESI was not able to catch this kind of crisis early enough even when it was an analysis based on the daily and monthly data.

According to these studies, the following hypotheses were formulated:

H3: *ESI shows better predictive power after the 2008 crisis than before it.*

H4: *The Covid-19 pandemic had a negative impact on the ESI predictive capabilities against the economic cycles of the EU countries.*

Research methods

The main goal of the presented study was to test the ESI predictive capabilities and its components in a relation to the economic cycles of the EU countries in the individual time periods. For the sake of the analysis, it was important to choose the right reference series that will represent the economic cycle of the EU countries. Based on the recommendations of Eurostat, the OECD as well as economists who observe the business cycles at the national level, it was necessary to choose the GDP indicator at the constant prices as the reference series, which has the ability to cover the entire economy and thus, to identify the turning points that indicate economic growth or economic decline (Pawęta, 2018). The GDP disadvantage is its time availability. Currently, it is presented in the form of the quarterly data and it is accessible with a delay of one or even two quarters that creates an issue especially in the case of predictions of the cyclical behaviour of the selected economy. From the year 2012 to the end of the year 2022, the OECD also reported GDP monthly, but there was a change and from the EU countries

in January 2023, monthly GDP is only available for countries such as France, Germany, Italy, and Spain. An alternative to GDP is the industrial production index (IIP) that is available on a monthly basis and shows long-term positive correlations in a relation to GDP (Erkisi & Tekin, 2019).

The quarterly data observation bears the disadvantage of information leakage in the case of the indicators whose predictive capabilities are at the level of one to two months. The analysis based on the quarterly data evaluates these indicators as concurrent. On the other hand, the quarterly data will capture the group of the indicators whose lead period before the GDP development is long enough for a high-quality prediction of the business cycle and thus, to provide the business sector and the country with enough time to take the necessary economic steps.

The fundamental database for exploration of the time series was by the European Commission. Initially, the analysis was performed on the time series Q1 2000–Q4 2022, which was the longest time series for the most EU countries except for Croatia, Malta, and Cyprus. The ESI predictive capabilities and its components were also tested on the shorter time periods, particularly 2000–2007, 2008–2022, and 2018–2022.

In the studies analysing the cyclical behaviour of the selected indicators to the business cycle, only their cyclical component is applied, which is obtained after removing the seasonal, trend, and random components (Astolfi *et al.,* 2016).

Christiano Fitzgerald (CF) filter, Hodrick-Prescott (HP) filter or the Phase-Average-Trend (PAT) method are among the most common methods employed to remove the trend and the seasonal component. The methods differ from each other, they have their advantages and disadvantages (Everts, 2006). In the study, the trend is removed from seasonally adjusted data by the European Commission database applying the Hodrick-Prescott filter (HP filter). The HP filter is a commonly applied tool for the detrending process. It is a most favourable trend extractor, which is stochastic, but moves smoothly over the period, and is uncorrelated with the cycle (Kovacic & Vilotic, 2017). For t=1,2,3… the trend component Y* is computed and λ is selected to minimise:

$$\sum_{t=1}^{T}(Y_t - Y_t^*)^2 + \lambda \sum_{t=2}^{T-1}[(Y_{t+1}^* - Y_t^*) - (Y_t^* - Y_{t-1}^*)]^2 \qquad (1)$$

To get optimal results for detrending, it has been suggested to choose λ=1600 for quarterly data and λ =14 400 for monthly data (Schilcht, 2005).

An advantage of the HP method is that no restriction on the length of time series is imposed. Nevertheless, there is a requirement that before proceed with HP filter one should seasonally adjusted each series. The trend itself is not very interesting in the analysis of cyclical behaviour. Therefore, the rest of study was done with cyclical components of each series (Nilsson & Brunet, 2006).

The cross-correlation (Pearson's correlation coefficient) with the five forward shifts and five backward shifts is applied in order to determine the relationship between the variables. According to the value of the correlation coefficient and the lead period, it is possible to identify the type of cyclical behaviour of the indicator according to the pattern in Table 1. The leading indicator must keep the lead period of at least one quarter, the minimum value of the cross-correlation during the lead period has to be higher than 0.55 and the second highest value at least at a level of 0.5. The indicator predictive capabilities quality was restricted by the assessment of the lead period and the cross-correlation values during the lead period. When evaluating the ESI quality or its components, the assessment of data time availability is omitted, since the data are published in the European Commission database with monthly periodicity at approximately the same time for all the EU countries. Thus, this criterion would not affect the evaluation results in any way.

In order to test the change in the ESI predictive capabilities and its components throughout the time period, the procedure will be repeated for the data of the periods 2000–2007, 2008–2017, and 2018–2023. The assumption is that depending on the selected length of the time series, the prediction quality will be different as the available studies confirm that the ESI prediction quality improved after the crisis (Biau & D'Elia, 2011; Michis, 2021).

Results

The ESI prediction capabilities in the economic cycle of the EU countries

When exploring the business cycles, it is crucial to select an appropriate reference series that represents the particular business cycle. The theory recommends GDP or IIP. Nevertheless, there is a need to identify the relationship between these variables at the national level. Table 2 shows the results of cross-correlations between the cyclical components of GDP and

PPI, which were obtained with the help of the HP filter for the period Q1 2000–Q4 2022. The results indicate a strong convergence between GDP and IIP in the most EU countries, which confirms the possibility of the variables being interchangeable during monitoring economic cycles. Only in the case of Malta was the cyclical relationship between the variables not confirmed. In the case of Latvia and Lithuania, the IIP represents even the leading indicator. The cross-correlation value for Latvia was at the level of 0.71 at the time period t-2, which means the lead period reliability at a level of approximately 71% by the two quarters in advance. Except for Latvia, Lithuania, and Malta, it can be argued that the IIP can also be applied to observe the economic cycles for the other EU member countries. This finding is important mainly because the IIP is reported in the databases on a monthly basis and ahead of GDP. Nevertheless, it is worth mentioning that IIP shows more false signals than GDP. Also, the importance of IIP prediction applying ESI is significant for the industrially oriented economies, which can thus obtain a notification about the possible future development of production in the industry.

The relationship between the ESI cyclical component and the GDP and IIP cyclical components were established again through the cross-correlations and the shifts of the quarterly data by the five periods forward and backward. The time series originated in the period Q1 2000–Q4 2020. Table 3 demonstrates the results, while the significant findings were only in the periods t to t-3.

H1 can be confirmed in the case of a cyclical relationship between ESI and GDP, ESI and IIP: ESI demonstrates a statistically high-quality prediction before the business cycle development, which represents real GDP or IIP growth only in the selected EU countries. According to Table 3, it is possible to identify the ESI predictive capabilities for GDP in the nine countries and in the case of IIP in the six countries. In the case of GDP, it was two quarters in advance from the countries such as Denmark, Germany, Estonia, Lithuania, the Netherlands, Austria, Finland, and Sweden, with a prediction significance of 0.595 (Austria) to 0.719 (Lithuania). The lead period of three quarters was recorded only in the case of Latvia (0.633). For the other nine EU countries, ESI showed coincidence with the development of GDP at the correlation level from 0.620 (France) to 0.737 (Portugal). In the countries such as Luxembourg, Romania and Slovakia, the cross-correlation value was so low that, according to the set criteria, ESI did not show a cyclical nature.

The relationship between ESI and IIP was of comparable features. The countries where the ESI showed the attribute of the leading indicator were at the level of one quarter Germany (0.720) and Estonia (0.735). A two-quarter-lead was recorded in Denmark (0.558), Austria (0.675), Finland (0.690) and Sweden (0.629). As many as twelve EU countries showed overlap between ESI and IIP and the cross-correlation values were higher than in the case of ESI on GDP. From these results, it can be concluded that there is a stronger relationship between ESI and IIP in the EU countries, but ESI can predict the business cycles of the selected EU countries if the reference series is represented by GDP. A large number of the countries showing convergence, which may mean that the ESI prediction capability is limited to a period of one or two months, so it is only the short-term prediction that does not provide enough time to take the necessary steps, which confirms the conclusions of many scientific studies.

The quality of prediction according to the criteria set out in Table 1 is processed into the results demonstrated in Table 4. Among the high-quality leading indicators, ESI was included only in a relation to GDP in the cases of Latvia, Lithuania, and Sweden. The prediction size and strength allow ESI in these countries to provide the high-quality prediction about the possible future economy development with enough time to take the necessary steps at the level of the public or private sector. The medium prediction quality can be observed for the six countries in the case of GDP and IIP, while these countries are different. The most represented are the concurrent indicators with a high correlation value at the time period t, which do not provide any or only the minimum lead period within one quarter.

ESI can offer the best predictions from the point of view of the lead time period length in the case of Latvia, which is also illustrated in Figure 1. In the case of this country, it is possible to see the lead period of ESI before GDP and IIP Latvia most significantly in the years 2007 to 2011, which means that ESI was able to predict the effects of this crisis to the business cycle. The size of the advance was more pronounced in relation to GDP than to IIP. Figure 1 rather shows the simultaneous development of all the three indicators in the case of the Covid-19 pandemic. In the case of this country, it is possible to conclude that the type of crisis affects the ESI prediction capabilities that is a subject to further investigation.

ESI components prediction capabilities in the economic cycle of the EU countries

ESI performs as a composite indicator that includes the qualitative data from the five areas of the economy. Industry (0.4), services (0.3) and consumers (0.2) possess the higher weight, construction (0.05) and retail (0.05) the lowest. Despite the different economic orientation of the countries, ESI has the same composition and weights for all the EU member countries. Table 5 demonstrates the results of the cross-correlations between the cyclical component of the ESI and GDP components. Only the highest achieved cross-correlation values throughout the period are shown.

The results demonstrate that the ESI components have significantly different predictive capabilities in the individual EU countries observed in the time series Q1 2000–Q4 2022. In the case of industry, which has the higher weight, the industrial confidence indicator has the predictive capabilities for the eight countries that are primarily industrially oriented. In the case of the consumer confidence indicator with a weight of 0.2, a lead period was identified in as many as the twelve countries. This ESI component is applied in the creation of the composite lead indicators for the selected member countries of OECD. The Construction confidence indicator with a weight of 0.05 had predictive capabilities in the case of the six countries and the Retail confidence indicator with the same weight of 0.05 predicted the GDP of the five member countries. The Services confidence indicator with a weight of 0.2 showed a convergence or a non-cyclical relationship in the monitored period. The largest number of ESI components in the number of the three and four showed the capability to predict the development of GDP in the case of Denmark, Estonia, Latvia, Lithuania, and Finland. The quality of the predictive capabilities of ESI and its components in the case of Finland can also be seen in Figure 2.

The same procedure was applied when testing the ESI components and the cyclic component of the IIP shown in Table 6. The highest level of correlation was achieved by IIP with the Industrial confidence indicator that is a logical conclusion. The industrial component of ESI was able to predict the development of IIP in the nine countries. For the other countries, there was a strong level of correlation at the simultaneous time period. The construction confidence indicator predicted IIP development in the eight countries, The Retail confidence indicator in the five countries and the Consumer confidence indicator in the two countries. The Services confidence indicator was able to predict the development of IIP only in the case of Finland.

The highest predictive ability of the ESI components at the level of the three or four components against IIP was in Germany, Estonia, Latvia and Finland.

From the outcomes of Tables 5 and Table 6, it is possible to conclude that the individual components have a significantly different ability to qualitatively predict the development of the economic cycle represented by either GDP or IIP. Thus, it is possible to confirm H2: The ESI components have different predictive capabilities for GDP and IIP, depending on the EU country. These findings should possess an impact on the change in the composition of ESI, which, due to the weak components, reduces the overall predictive capability of ESI in the case of the most EU countries. Another conclusion is the need to reconsider the use of the same system for determining the weights of the particular ESI components for the EU countries or the approach of aggregating the components into ESI. Gelper and Croux (2010) came to the conclusion that the method of aggregating components into the ESI can actually improve the ESI predictive capabilities, especially in a relation to GDP. It has been shown that the strong predictive capabilities possessing the potential to estimate future economic developments vary across the countries.

Changes in the ESI prediction capabilities influenced by the crises

The examined literature review has demonstrated the findings that after the 2008 crisis, the cross-correlation data in a relation to GDP have increased. This insight was also verified in the presented study in a relation to GDP and IIP. The three time periods of the quarterly data were monitored: 2000–2007, 2008–2017, and 2018–2022. The last five-year period tested the ESI capability to detect and to predict the Covid-19 pandemic outbreak. The results are shown in Table 7.

In the period before the crisis, for example, the period 2000–2007, ESI had the ability to predict GDP in the thirteen countries and IIP in the fifteen countries. In the period 2008–2017, it was up to the twenty countries for GDP and the seventeen countries for IIP. For GDP, ESI improved the cross-correlation values in the sixteen countries from 0.751 to 0.780 on average and the lead period was improved by at least one quarter in the ten countries. For IIP, the cross-correlation values improved after the crisis in the thirteen cases on average, from 0.761 to 0.776, and the improvement in prediction quality by at least one quarter occurred in the six cases. These

results allow us to confirm H3: ESI demonstrates the better predictive capabilities after the crisis than before the 2008 crisis.

A different case occurred in testing the prediction capabilities of ESI in the period 2018–2022. During this time period, ESI showed a strong coincidence with the development of GDP and IIP for a majority of the monitored countries. On average, this value was at the level of 0.803 for GDP and 0.792 for IIP, but at the time of the convergence. An important finding was that in the case of the ten countries for GDP and the nine countries for IIP, ESI was lagged naturally. This means that GDP and IIP developed ahead of time and ESI only responded by changing the expectations of businesses and consumers. Thus, it is the opposite causal relationship that is expected from ESI. Evidence of the existence of the opposite causal relationship was confirmed in the study by Ferreira *et al.* (2008) on the example of the selected European countries. It is possible that ESI could show a lead period of one or two months that the quarterly data analysis is unable to capture. Overall, it can be concluded that the ESI was able to predict the 2008 crisis outbreak and the cross-correlation value improved after the crisis that is in a line with the theory. In the case of the Covid-19 pandemic, there was a change and ESI was not able to draw an attention to this type of the crisis well in advance. These results confirm H4: The crisis type has an impact on the ESI predictive capabilities for the economic cycles of the EU countries.

Testing in the different time periods also took place at the level of the ESI components. A summary of the results is provided in Table 8. The results of the analysis show that the predictive capabilities of the ESI components change throughout the time period in the individual countries. The predictive capabilities of the components in the terms of the number of the countries were best in the post-crisis period that is again consistent with theory. From the point of view of the time period, the lowest predictive capabilities were recorded in the time after 2018. The weakest predictive indicator in the quarterly data monitoring is represented by the Services confidence indicator, which, nevertheless, was the only one able to predict the effects of the Covid-19 pandemic in the four countries.

Discussion

The study analysed the ESI predictive capabilities and its components for the economic cycles of the selected EU countries that were represented by either GDP or IIP for the period Q1 2000 to Q4 2022. Due to the length of the time series and the availability of the time series data in the European Commission database, the countries such as Malta, Cyprus, and Croatia were excluded from the analysis. The results of the study are as follows.

ESI shows a statistically high-quality prediction level before the development of the business cycle, which represents the GDP or IIP real growth only for the selected EU countries making it possible to accept H1. The prediction statistical quality meant that the ESI had to predict GDP or IIP with at least a quarterly lead period at a cross-correlation level above 0.55 (the second highest cross-correlation value has to be higher than 0.5). In the terms of GDP, this was confirmed in the case of Denmark, Germany, Estonia, Latvia, Lithuania, the Netherlands, Austria, Finland, and Sweden. Regarding IIP, these were the countries like Denmark, Germany, Estonia, Austria, Finland, and Sweden (Table 3). This confirmed already the existing studies on the ESI different predictive capabilities for GDP and IIP in the various European countries (Antipa *et al*., 2012; Cizmesija & Skrinjaric, 2021; Hüfner & Schroder, 2002). In the case of the other countries, a simultaneous relationship with the development of the business cycle was recorded, which means that they develop in the same way or the lead period of the ESI prediction before the economic cycle of these countries is shorter than one quarter. Nonetheless, this is a very short time period to make decisions for both the country and the private sector. From this point of view, ESI does not meet the criteria of the quality prediction that were set in the study. In the case of Ireland, ESI was evaluated as a non-cyclical indicator.

The study has showed that the ESI components have different predictive capabilities for GDP and IIP depending on the EU country that confirms the acceptance of H2. The findings correspond with the results of the studies by Clar *et al.* (2007) or Lemmens *et al.* (2005, 2007). When evaluating the predictive capabilities of the ESI components for the period 2000–2022, it was found that the Consumer confidence indicator (the twelve countries) can predict the GDP in the largest number of the countries, followed by the Construction confidence indicator (the six countries) and the Industrial confidence indicator (the eight countries). The retail confidence indicator

was significant only in the countries such as Estonia, Latvia, Lithuania, Slovakia, and Finland, but it performed the high correlation values and the lead period over one quarter (see Table 5). In these countries, it would be desirable to increase the weight of the given indicator in ESI. On the other hand, the Services confidence indicator has showed no predictive capabilities, even in some countries it behaved non-cyclically. In the case of IIP, it was demonstrated that the Industrial confidence indicator (the nine countries) and the Construction confidence indicator (the eight countries) have predictive capabilities for the largest number of the countries among the ESI components (see Table 6). The results of Tables 5 and 6 point to the need to respect the economic specifics of the country and their economic cycles in order to achieve the best possible composite lead indicators.

The studies published so far, such as the ones by Rzoza-Brzezina and Kotlowski (2018), Claveria *et al.* (2016), Adamowicz and Walczyk (2013), and the others confirmed that the 2008 crisis had an impact on the ESI prediction capabilities quality in the selected European countries. Definitely, the time series of the quarterly data of the periods 2000–2007 and 2008–2017 were compared in a way that the impact of the Covid-19 pandemic was not captured. In the presented study, it was confirmed that ESI shows the better prediction capabilities after the crisis than before the crisis in 2008 (see Table 7). The improvement was noted both in an increase of the cross-correlation value and in an increase in the lead period to two or three quarters. For GDP, the sixteen countries improved from 0.751 to 0.780 on average and the lead period improved by at least one quarter in the ten countries. Specifically, there was an improvement in ESI against GDP from 0.603 to 0.867 two quarters in advance in Germany, while in Sweden, from 0.741 at the time period t-1 to 0.873 at the time period t-2 after the crisis. For IIP, the cross-correlation values improved after the crisis in the thirteen cases on average, numerically from 0.761 to 0.776. The improvement in the prediction quality by at least one quarter occurred in the six cases. The most significant improvement compared to the IIP occurred in the Czech Republic from 0.672 at the time period t-1 to 0.880 at the time period t-2 after the crisis. For Denmark, there was a prediction improvement by up to two quarters.

From the point of view of the benefits of the presented study, the H4 confirmation, which says that the Covid-19 pandemic has a negative impact on the ESI predictive capabilities for the economic cycles of the EU countries, can be considered a significant finding. The results in Table 7,

when comparing the three time periods, have showed the fact that in the period 2018–2022 ESI was unable to capture the arising Covid-19 pandemic. On the contrary, the business and consumer surveys were only affected by the pandemic outbreak subsequently that is also confirmed by the studies' outcomes on the impact of the pandemic on ESI (Lee, 2020; Kanapickienė *et al.,* 2020; Olkiewicz, 2022; Zervoyianni *et al.*, 2023). Nevertheless, the presented study pointed to the opposite causal relationship between ESI and the economic cycle of the EU countries such as Belgium, Bulgaria, Estonia, France, Hungary, Poland, and Romania. Only in the case of Denmark and Finland ESI retain its predictive capability. In the case of the other countries (except for Ireland) the high cross-correlation value was achieved at the simultaneous time and the second highest value at the time period t+1 meaning that even in the case of these countries the ESI behaved lately, but only with a lag of up to one quarter.

Conclusions

The tempestuous progress of the economic cycles of the EU countries constantly shows the need for the high-quality prediction mechanisms. For a long time period, the economic sentiment indicator, which is constructed by the European Commission, is considered an important predictive indicator. ESI is applied independently for the short-term prediction of the economic cycles or its components are employed by economists and international institutions to construct their own national leading composite indicators. The main goal of the presented study was to test the ESI predictive capabilities and its components in a relation to the economic cycles of the EU countries in the individual time periods. The presented hypotheses were also aimed at confirmation or rejection of the expected changes in the ESI predictive capabilities after the 2008 crisis and after the Covid-19 pandemic.

The main conclusion of the study is that ESI can be applied for the high-quality short-term forecasting of the economic cycles of the EU countries, but only in the selected ones. This knowledge cannot be generalised for all the countries explored. This would lead to an application of ESI, where it shows no information for the business cycle development with a considerable lead period or it provides faulty information even. While ESI can be recommended for the high-quality short-term prediction of more than one

quarter in the case of Denmark, Germany, Estonia, Latvia, Lithuania, the Netherlands, Austria, Finland, and Sweden, for the other countries the lead period prediction is minimal or zero. Nevertheless, it should be noted that the given conclusion was reached during the quarterly data analysis, mainly due to the GDP data accessibility only on a quarterly basis can that be considered the main study limitation. The study also reached the same results in a relation to IIP. Regarding this, it can be confirmed that the ESI has very similar predictive capabilities for the main macroeconomic indicator as well as for the fundamental industry indicator. In the case of IIP, it is possible to examine the relationship between ESI and IIP also monthly, but the results would identify the countries where the lead period length is only one or two months, which is a short period in order to take the steps that could mitigate the negative effects of the coming recession at the public sector level and the private sector.

The study also provided an overview of the specific ESI components that are most suitable for the particular country as the components of the composite lead indicators. The recommendation is also a re-evaluation of the aggregation of the components into ESI by the European Commission, mainly in the area of determining the weights of the variables that would respect the peculiarities of the particular economy and thus they would not possess a uniform form for every EU country.

A significant finding of the study is that ESI can respond differently to the type of an incoming crisis. After the 2008 crisis, a substantial improvement in the lead period and the cross-correlation value was noted in a majority of the EU countries that was confirmed by the already existing studies. In many countries, the 2008 crisis was only an imported crisis meaning that their impact was expected for businesses and consumers of these countries with some advance due to the openness of the country economy. It is about the so-called spillover effect, which is explored in the studies such as by Rzoza-Brzezina and Kotlowski, (2018) or Plakandaras *et al.* (2019). Nonetheless, this issue is beyond the scope of the presented study and it represents the possible future challenges in the further research.

It was confirmed that the ESI reacted to the changes caused by the crisis only ex-post and the rapid changes in GDP and IIP which occurred were processed by the business and consumer surveys with a lag of several months or the quarters respectively in the case of the Covid 19 pandemic. This is related to the high level of uncertainty that resulted from the previ-

ously unexpected robust steps of the country, which came in some cases during the night literally.

From the above-mentioned, the global economic crises as well as crises associated with a high level of uncertainty lead to a change in the ESI prediction capabilities. To analyse the changes in the ESI predictive capabilities, testing is also needed in the post-pandemic period that embodies the opportunities for further research.

The continuation of the research on the ESI predictive possibilities is planned on the two levels. The first level's aim will be to improve the ESI prediction itself. The second level's aim will be the ESI use as one of the components in the creation of the complex leading indicators based on a combination of qualitative and quantitative data.

In a case of the ESI prediction improvement, it will be necessary to establish a new system of weights of the individual components for the needs of every country. The outcomes of this study provide a valuable platform for this. An impact analysis of the selected ESI components on the economic cycle of the different countries is also a challenge for future research. At first, in a case of the small and open economies, it is necessary to pay attention, for instance, to the status of orders on the buyer's market. New orders are directly related to the importer's market expectations. The existence of the ESI predictive capabilities and its components on the economic cycles of the supplier countries would thus represent a further research direction.

An important added value of the study is the use of the knowledge gained about ESI to predict the business cycles through the CLI, which, as mentioned in the introduction, the OECD stopped to observe for a majority of the EU countries in January 2023. The findings achieved in the presented study allow us to reveal the first CLI components, which in the selected countries had the ability to predict the economic cycle. The benefit of the study is also that it evaluates the predictive capabilities both in a relation to GDP and in a relation to the IIP, which the OECD has long used as a reference series representing the business cycle. By continuation of the investigation of the cyclical relationship and the other indicators, new research challenges arise aimed at the CLI construction for the EU countries according to a uniform methodology. Many of the EU countries are currently creating their own CLIs at the national level of the statistical offices, but they differ mainly in the construction methodology. CLI constructed applying a uniform methodology through the high-quality ESI components in a combination with the leading indicators would thus significantly con-

tribute to the prediction of the specific economic cycle of the selected country. This approach has been absent since the year 2023.

In the case of the presented study, it is possible to see the limits of the research on several levels. The first one is represented by the data itself, which, especially in the case of GDP, is only available on a quarterly basis, leading to the possibility of erroneous evaluation of the ESI components as concurrent, even if they could demonstrate an advance of one or two months. In this context, the OECD developed a methodology for converting GDP to monthly data through the linear interpolation method in the year 2012 (Gyomai & Guidetti, 2012), which was applied to create the CLI, but currently the OECD no longer reports monthly GDP for the EU countries. In relation to the data, there is also a limitation in the time availability of the ESI components, which can lead to a delayed signal about future economic developments. Another limitation of the study is the methodological framework itself, which could improve its quality in the future, for instance, through the application of the more sophisticated methods of demonstrating the relationships among the cyclical components. A possibility is to replace the Pearson correlation coefficient with another approach, for instance the cross-spectral methods that allow us a more detailed analysis and draw more comprehensive conclusions. The limitation of the research is also the determination of the time periods, which the ESI predictive ability is determined in. If the ESI components were to be considered as the CLI components in the future, it is disputable how to evaluate the ESI components quality either according to the outcomes of Q1 2000–Q4 2022 or according to the sub-periods in a relation to the existing crises.

From the outcomes of the presented study, as well as from the definition of the future research challenges, it follows that the monitoring and prediction of the economic cycles is still a current topic and there is a space for achieving new scientific knowledge.

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Acknowledgements

This work was supported by the Slovak Research and Development Agency under the Contract No. APVV-21-0188: Development of concepts of strategic investment and development packages for regions of Slovakia with a causal link to the creation of methodology for quantifying their effectiveness and efficiency.

Ministry of Education and Science
Republic of Poland

The journal is co-financed in the years 2022–2024 by the Ministry of Education and Science of the Republic of Poland in the framework of the ministerial programme "Development of Scientific Journals" (RCN) on the basis of contract no. RCN/SN/0697/2021/1 concluded on 29 September 2022 and being in force until 28 September 2024.

Annex

Table 1. Criteria for identification of cyclical behaviour of the indicators and their prediction quality evaluation

Cyclical behaviour in a relation to GDP cyclical component		Maximum cross-correlation value	Maximum cross-correlation value period	Indicator quality evaluation
Cyclical*	Lead	0,55-0,70	t-1	+
		0,71-0,85		++
		0,85-1		++
		0,55-0,70	t-2	++
		0,71-0,85		+++
		0,85-1		+++
		0,55-0,70	t-3 to t-5	+++
		0,71-0,85		+++
		0,85-1		+++
	Lagged	> 0,55	t+1 to t+5	-
	Concurrent	> 0,55	t	0
Noncyclical		< 0,55	not important	x

Note: *The condition for the group of the cyclical indicators. the second highest cross-correlation value has to be higher than 0.5.

Table 2. Results of cross-correlation between GDP and IIP in the period Q1 2000–Q4 2020

Country	t-5	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4	t+5
Belgium	-0,14	-0,06	-0,06	0,31	0,48	**0,67**	0,43	0,13	0,15	-0,06	-0,14
Bulgaria	0,10	0,28	0,28	0,59	0,69	**0,74**	0,55	0,28	0,45	0,28	0,10
Czechia	0,12	0,28	0,28	0,57	0,66	**0,80**	0,44	0,17	0,47	0,28	0,12
Denmark	-0,14	-0,01	-0,01	0,43	0,62	**0,77**	0,72	0,61	0,18	-0,01	-0,14
Germany	-0,07	0,11	0,11	0,50	0,64	**0,92**	0,63	0,33	0,35	0,11	-0,07
Estonia	0,15	0,35	0,35	0,69	0,78	**0,85**	0,67	0,44	0,54	0,35	0,15
Ireland	0,25	0,29	0,29	0,40	0,46	**0,60**	0,38	0,22	0,37	0,29	0,25
Greece	0,43	0,52	0,52	0,64	0,63	**0,65**	0,47	0,28	0,55	0,52	0,43
Spain	0,12	0,24	0,24	0,42	0,51	**0,73**	0,35	0,10	0,36	0,24	0,12
France	-0,15	0,00	0,00	0,26	0,42	**0,86**	0,47	0,15	0,15	0,00	-0,15
Croatia	0,11	0,22	0,22	0,52	0,67	**0,73**	0,42	0,27	0,33	0,22	0,11
Italy	-0,12	0,09	0,09	0,43	0,63	**0,86**	0,51	0,25	0,27	0,09	-0,12
Cyprus	0,26	0,36	0,36	0,56	0,71	**0,82**	0,53	0,37	0,45	0,36	0,26
Latvia	0,55	0,63	0,63	**0,71**	0,69	0,62	0,40	0,17	0,69	0,63	0,55
Lithuania	0,17	0,21	0,21	0,45	**0,56**	0,55	0,39	0,25	0,31	0,21	0,17
Luxembourg	0,04	0,04	0,04	0,28	0,44	**0,62**	0,36	0,18	0,12	0,04	0,04
Hungary	-0,10	0,03	0,03	0,38	0,52	**0,84**	0,32	0,14	0,22	0,03	-0,10
Malta	-0,09	-0,09	-0,09	-0,07	0,04	0,24	0,16	0,04	-0,13	-0,09	-0,09

Table 2. Continued

Country	t-5	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4	t+5
Netherlands	-0,09	0,10	0,10	0,42	0,49	**0,61**	0,37	0,13	0,28	0,10	-0,09
Austria	-0,12	0,20	0,20	0,61	0,62	**0,87**	0,55	0,28	0,48	0,20	-0,12
Poland	-0,01	0,16	0,16	0,47	0,54	**0,78**	0,28	0,08	0,35	0,16	-0,01
Portugal	0,10	0,17	0,17	0,24	0,30	**0,66**	0,19	0,00	0,31	0,17	0,10
Romania	0,26	0,34	0,34	0,56	0,64	**0,66**	0,18	-0,02	0,48	0,34	0,26
Slovenia	0,00	0,19	0,19	0,57	0,65	**0,88**	0,59	0,25	0,39	0,19	0,00
Slovakia	-0,20	-0,12	-0,12	0,37	0,51	**0,79**	0,49	0,20	0,23	-0,12	-0,20
Finland	-0,13	0,05	0,05	0,55	0,77	**0,90**	0,75	0,54	0,30	0,05	-0,13
Sweden	-0,30	-0,08	-0,08	0,41	0,58	**0,87**	0,66	0,50	0,14	-0,08	-0,30

Table 3. Results of cross-correlation between ESI, GDP, and IIP in the period Q1 2000–Q4 2022

Country	ESI-HDP				ESI-IIP			
	t-3	t-2	t-1	t	t-3	t-2	t-1	t
Belgium	0,277	0,482	0,447	**0,628**	0,110	0,541	0,680	**0,700**
Bulgaria	0,186	0,428	0,579	**0,722**	0,098	0,402	0,576	**0,735**
Czechia	0,361	0,529	0,583	**0,686**	0,216	0,423	0,559	**0,813**
Denmark	0,425	**0,569**	0,509	0,501	0,553	**0,558**	0,432	0,206
Germany	0,453	**0,623**	0,584	0,600	0,432	0,664	**0,720**	0,700
Estonia	0,541	**0,648**	0,610	0,534	0,455	0,723	**0,735**	0,672
Ireland	0,274	0,517	0,380	0,495	0,078	0,119	0,264	0,250
Greece	0,258	0,320	0,532	**0,542**	0,124	0,314	0,537	**0,572**
Spain	0,338	0,447	0,409	0,550	0,418	0,567	0,587	**0,709**
France	0,212	0,356	0,327	**0,620**	0,320	0,502	0,557	**0,711**
Italy	0,373	0,556	0,561	**0,663**	0,333	0,506	0,542	**0,647**
Latvia	**0,633**	0,600	0,513	0,399	0,385	0,696	0,786	**0,826**
Lithuania	0,606	**0,719**	0,695	0,581	0,188	0,479	0,558	**0,576**
Luxembourg	0,083	0,280	0,349	0,471	0,173	0,471	0,585	**0,660**
Hungary	0,210	0,412	0,474	**0,647**	0,200	0,287	0,335	0,524
Netherlands	0,436	**0,624**	0,583	0,610	0,123	0,449	0,543	**0,592**
Austria	0,464	**0,595**	0,516	0,558	0,456	**0,675**	0,675	0,670
Poland	0,185	0,500	0,524	**0,702**	0,007	0,339	0,486	**0,818**
Portugal	0,235	0,460	0,488	**0,737**	0,199	0,257	0,287	0,649
Romania	0,323	0,370	0,433	0,505	0,008	0,044	0,581	**0,615**
Slovenia	0,375	0,565	0,527	**0,623**	0,318	0,530	0,608	**0,714**
Slovakia	0,319	0,399	0,509	**0,580**	0,255	0,261	0,502	**0,589**
Finland	0,538	**0,697**	0,642	0,528	0,514	**0,690**	0,653	0,458
Sweden	0,456	**0,709**	0,667	0,662	0,474	**0,629**	0,608	0,555
Average	**0,357**	**0,517**	**0,510**	**0,589**	**0,268**	**0,464**	**0,529**	**0,623**

Note: Malta, Cyprus, and Croatia offer no data for this time period.

Table 4. ESI cyclical behaviour klické in the EU countries and prediction quality determination in the period 2000–2022

Cyclical behaviour		ESI and HDP	ESI and IIP
Lead	**High quality (+++)**	Latvia, Lithuania, Sweden	
	Medium quality(++) Low quality(+)	Germany, Estonia, Nertherlands, Denmark, Finland, Austria	Austria, Germany, Estonia, Denmark, Finland, Sweden
Concurrent (0)		Belgium, Bulgaria, Czechia, France, Italy, Hungary, Poland, Portugal, Slovenia,	Belgium, Bulgaria, Czechia, Spain, France, Italy, Latvia, Lithuania, Luxembourg, Nertherlands, Poland, Slovenia
Lagged (-)			
Noncyclical (x)		Ireland, Greece, Spain, Luxembourg, Romania, Slovakia	Greece, Portugal, Romania, Slovakia

Table 5. Results of cross-correlation for the GDP cyclical components and the ESI components

Country	Construction confidence indicator	Industrial confidence indicator	Retail confidence indicator	Consumer confidence indicator	Services confidence indicator
Belgium	t (0,646)	t (0,575)	t (0,604)	**t-2 (0,561)**	t (0,744)
Bulgaria	t (0,619)	t (0,708)	t (0,694)	No data	No data
Czechia	t (0,574)	t-1 (0,516)	t (0,552)	**t-2 (0,624)**	No data
Denmark	**t-1 (0,693)**	**t-1 (0,554)**	No data	**t-2 (0,612)**	No data
Germany	t (0,627)	**t-2 (0,682)**	t-2 (0,487)	**t-2 (0,607)**	t (0,476)
Estonia	**t-2 (0,713)**	**t-2 (0,682)**	**t-2 (0,735)**	**t-2 (0,571)**	No data
Ireland	t-2 (0,284)	t-2 (0,454)	t-2 (0,484)	t-2 (0,532)	t (0,391)
Greece	t-3 (0,482)	t (0,440)	t (0,629)	t (0,409)	t (0,505)
Spain	t (0,367)	t (0,504)	t (0,582)	**t-1 (0,596)**	t (0,397)
France	t (0,563)	t (0,561)	t (0,594)	**t-2 (0,669)**	t (0,684)
Italy	t (0,747)	t (0,677)	t (0,527)	**t-1 (0,652)**	t (0,652)
Latvia	**t-3 (0,769)**	**t-3 (0,649)**	**t-3 (0,617)**	No data	No data
Lithuania	**t-3 (0,749)**	**t-2 (0,718)**	**t-2 (0,718)**	No data	No data
Luxembourg	t (0,357)	t (0,500)	No data	No data	No data
Hungary	t (0,639)	t (0,662)	t (0,584)	t (0,294)	No data
Netherlands	t (0,719)	t (0,670)	t (0,646)	**t-2 (0,592)**	t (0,624)
Austria	t (0,631)	**t-2 (0,625)**	t (0,439)	**t-2 (0,635)**	t (0,645)
Poland	t (0,567)	t (0,605)	t (0,749)	No data	No data
Portugal	t (0,451)	t (0,623)	t (0,673)	t (0,490)	t (0,729)
Romania	t (0,522)	t-3 (0,364)	t (0,521)	No data	No data
Slovenia	t (0,572)	**t-2 (0,604)**	t (0,705)	t (0,479)	No data
Slovakia	**t-1 (0,572)**	t-2 (0,422)	**t -1 (0,614)**	t (0,544)	No data
Finland	**t-1 (0,736)**	**t-2 (0,734)**	**t-1 (0,711)**	**t-3 (0,555)**	t (0,595)
Sweden	t (0,780)	t (0,690)	t-2 (0,537)	**t-2 (0,591)**	t (0,684)

Notes: Malta, Cyprus, and Croatia offer no data for the time period 2000–2022.

Table 6. Results of cross-correlation for the IIP cyclical components and the ESI components in the period 2000–2022

Country	Construction confidence indicator	Industrial confidence indicator	Retail confidence indicator	Consumer confidence indicator	Services confidence indicator
Belgium	**t-1 (0,662)**	**t-1 (0,660)**	t (0,545)	t-2 (0,463)	t (0,772)
Bulgaria	t (0,807)	t (0,813)	t (0,792)	No data	No data
Czechia	t (0,780)	t (0,782)	t (0,564)	t-3 (0,271)	No data
Denmark	**t-2 (0,587)**	**t-2 (0,582)**	No data	t-3 (0,546)	No data
Germany	**t-1 (0,786)**	**t-1 (0,789)**	**t-1 (0,558)**	**t-2 (0,640)**	t (0,586)
Estonia	**t-2 (0,737)**	**t-1 (0,742)**	**t-1 (0,805)**	**t-1 (0,581)**	No data
Ireland	t-1 (0,200)	t-1 (0,195)	t-1 (0,288)	t-1 (0,306)	t (0,304)
Greece	t (0,585)	t (0,583)	t (0,611)	t (0,041)	t (0,560)
Spain	t (0,797)	t (0,798)	t (0,455)	t-2 (0,519)	t (0,659)
France	t (0,714)	t (0,715)	**t-1 (0,701)**	t-3 (0,393)	t (0,802)
Italy	t (0,762)	t (0,763)	t (0,414)	t-2 (0,275)	t (0,648)
Latvia	**t-1 (0,794)**	**t -1 (0,796)**	**t (0,764)**	No data	No data
Lithuania	t (0,571)	**t-1 (0,561)**	**t-1 (0,469)**	No data	No data
Luxembourg	t (0,700)	t (0,701)	No data	No data	No data
Hungary	t (0,662)	t (0,662)	t (0,531)	t (0,155)	No data
Netherlands	t (0,676)	t (0,675)	t (0,500)	t-2 (0,370)	t (0,604)
Austria	**t-1 (0,743)**	**t-1 (0,743)**	t-2 (0,449)	t-2 (0,527)	t (0,760)
Poland	t (0,798)	t (0,793)	t (0,832)	No data	No data
Portugal	t (0,665)	t (0,665)	t (0,535)	t (0,362)	t (0,619)
Romania	t (0,646)	t (0,644)	t (0,600)	No data	No data
Slovenia	t (0,656)	t (0,657)	t (0,746)	t (0,458)	No data
Slovakia	t (0,511)	t (0,513)	t (0,523)	t (0,358)	No data
Finland	**t-2 (0,732)**	**t-2 (0,734)**	**t-1 (0,670)**	t-3 (0,509)	**t-1 (0,561)**
Sweden	**t-2 (0,615)**	**t-2 (0,616)**	t-3 (0,461)	t-3 (0,502)	t (0,612)

Notes: Malta, Cyprus, and Croatia offer no data for the time period 2000-2022.

Table 7. Change in the ESI prediction capabilities for GDP and IIP throughout the explored periods

Country	2000–2007		2008–2017		2018–2022	
	ESI-GDP	**ESI -IIP**	**GDP-ESI**	**IIP-ESI**	**GDP-ESI**	**IIP-ESI**
Belgium	**t-1 (0,850)**	**t-2 (0,751)**	**t-1 (0,764)**	**t-1 (0,798)**	t+1 (0,721)	t+1 (0,899)
Bulgaria	t-3 (0,405)	**t -1 (0,681)**	**t-1 (0,716)**	t (0,947)	t +1 (0,923)	t+1(0,817)
Czechia	**t-1 (0,674)**	**t-2 (0,672)**	**t-1 (0,675)**	**t-2 (0,880)**	t (0,889)	t (0,874)
Denmark	t (0,647)	**t-1 (0,818)**	**t-3 (0,684)**	**t-3 (0,641)**	t (0,746)	**t-2 (0,673)**
Germany	**t-2 (0,603)**	**t-2 (0,819)**	**t-2 (0,864)**	**t-1 (0,870)**	t (0,722)	t (0,776)
Estonia	**t-2 (0,641)**	**t-2 (0,712)**	**t-3 (0,875)**	**t-2 (0,918)**	t+1 (0,949)	t+1 (0,810)
Ireland	t (0,494)	**t-1 (0,834)**	t-2 (0,387)	t-2 (0,441)	t (0,614)	t+1 (0,300)
Greece	t (0,836)	**t-1 (0,898)**	t (0,547)	t (0,535)	t (0,819)	t (0,610)
Spain	**t-3 (0,831)**	**t-2 (0,886)**	t-2 (0,506)	**t-2 (0,800)**	t (0,791)	t (0,811)
France	**t-1 (0,774)**	**t-1 (0,705)**	**t-2 (0,762)**	**t-1 (0,844)**	t+1 (0,831)	t+1 (0,789)
Italy	**t-3 (0,817)**	**t-2 (0,825)**	**t-2 (0,770)**	**t-2 (0,692)**	t (0,804)	t (0,829)
Latvia	**t-1 (0,726)**	**t-2 (0,618)**	**t-3 (0,769)**	**t-1 (0,892)**	t+1 (0,889)	t+1 (0,836)

Table 7. Continued

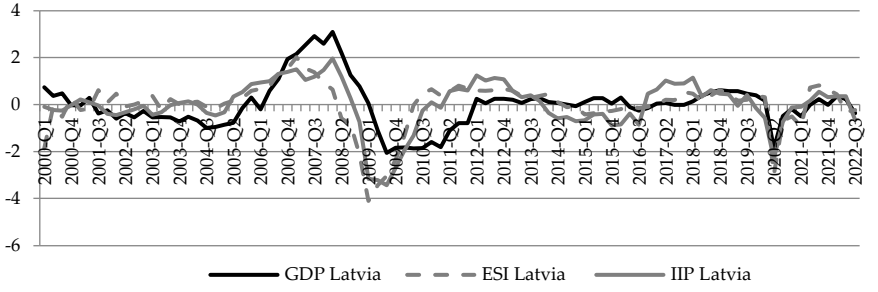
Country	2000–2007		2008–2017		2018–2022	
	ESI-GDP	ESI -IIP	GDP-ESI	IIP-ESI	GDP-ESI	IIP-ESI
Luxembourg	t (0,448)	t (0,711)	t-1 (0,444)	t (0,737)	t (0,641)	t (0,719)
Hungary	t (0,773)	t (0,619)	**t-3 (0,665)**	**t-1 (0,675)**	t+1 (0,864)	t +1(0,678)
Netherlands	**t-3 (0,889)**	t (0,561)	**t-2 (0,671)**	**t-1 (0,648)**	t (0,793)	t (0,838)
Austria	**t-2 (0,744)**	**t-2 (0,824)**	**t-2 (0,779)**	**t-2 (0,854)**	t (0,670)	t (0,755)
Poland	**t-2 (0,722)**	t (0,908)	**t-2 (0,770)**	t (0,805)	t+1 (0,893)	t +1(0,852)
Portugal	t (0,809)	t (0,767)	**t-1 (0,658)**	t (0,730)	t (0,916)	t (0,783)
Romania	t (0,714)	t (0,693)	**t-2 (0,659)**	t (0,618)	t+1(0,844)	t+1 (0,784)
Slovenia	t (0,779)	t (0,772)	**t-2 (0,664)**	**t-1 (0,742)**	t+1 (0,878)	t (0,936)
Slovakia	t (0,720)	t (0,755)	**t-1 (0,657)**	**t-1 (0,660)**	t (0,809)	t (0,806)
Finland	t (0,734)	**t-1 (0,713)**	**t-2 (0,831)**	**t-2 (0,776)**	t (0,703)	**t-2 (0,741)**
Sweden	**t-1 (0,741)**	**t-2 (0,662)**	**t-2 (0,873)**	**t-2 (0,780)**	t (0,704)	t (0,629)

Table 8. Prediction capabilities of the ESI components in the EU countries and their alteration in a timely way in a relation to GDP

	Construction confidence indicator	Industrial confidence indicator	Retail confidence indicator	Consumer confidence indicator	Services confidence indicator
Q1 2000-Q4 2022	LV, EE, LT, FI, DK, SK	LV, FI, LT, DE, AT, SI, EE, DK	LV, LT, FI	BE, CZ, DK, DE, EE, ES, FR , IT, NL, FI, DE, EE	
Q1 2000-Q4 2007	BE, BG, CZ, DE, EE, IE, EL, ES, IT, LV, LT, NL, AT, PT, SI, SK, FI	BE, BG, CZ, DE, EE, IE, ES, IT, LV LT, AT, SI, SK, FI	BE, DE, EE, IE, EL, ES, LV, LT, NL, SI, SE	BE, CZ, DK, DE, EE, EL, ES, NL, AT, PT	
Q1 2008-Q4 2017	BE, BG, CZ, DK, DE, EE, FR, IT, LV, LT, HU, NL, AT, SI, FI, SE	BE, BG, CZ, DK, DE, EE, FR, IT, LV, LT, HU, NL, AT, SI, SK, FI, SE	BE, BG, DE, EE, ES, FR, IT, LV, LT, HU, NL, PT, SI, FI, SE	DE, EE, ES, LV, LT, HU, NL, AT, PT, FI, SE	LT, LV, NL
Q1 2018-Q4 2022	AT	DE, AT	FI	LV	BE, FR, IT, NL

Note: Abbreviations represent the common international country codes.

Figure 1. GDP cyclical components development and ESI



Note: time serieses are normalised (Standardisation method according to OECD (2008) is applied in order to normalise the data).

Figure 2. GDP and ESI and their components for Finland

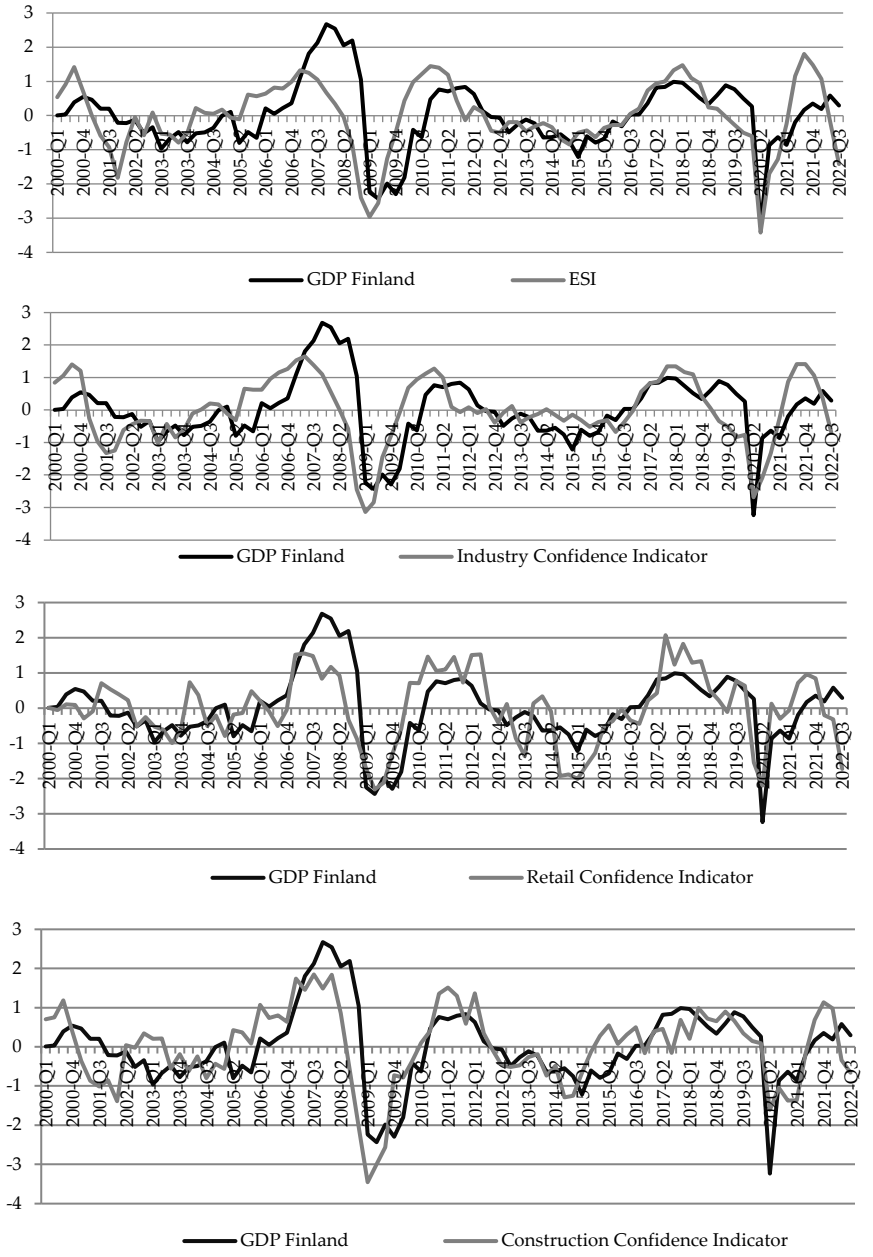


Figure 2. Continued