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Prediction of business cycle of Poland

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Abstract. The paper is focused on the construction of a new composite indicator intended to predict the economic cycle of Poland and its comparison with the existing CLI used by international institutions such as OECD and Eurostat. In part, this research is also dedicated to monitoring the partial advance cyclical indicators that make up the CLI components and their changes over time. The paper explores 62 qualitative and quantitative economic indicators of Poland and their relationship to the development of monthly GDP at constant prices in three different time periods: 2005 to 2021, 2010 to 2021, and 2016 to 2021. A modified OECD method is used to select the cyclical component of time series using the Hodrick-Prescott filter and subsequently employ cross-correlation of the variables with the cyclical component of GDP. The constructed CLI can predict the evolution of the CLI one month ahead with a cross-correlation level of 0.879 under equal weights and 0.877 under different weights. Research has shown that

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there is no significant change in the composition of the CLI for the prediction of the economic cycle of Poland when using the established methodology.

Keywords: Business Cycle, Composite Leading Indicator (CLI), GDP, Cross-correlation, Prediction.

JEL Classification: E32, E37.

1. INTRODUCTION

Monitoring of the business cycle has been at the forefront of economic research since the 1920s, mainly due to the instability of the economy and the subsequent Great Depression in the 1930s. In the 1950s and the 1960s, the business cycle seemed to be "dead", but the 1970s and the oil crises brought it back into the spotlight and new economic theories came along trying to explain the causes of its origin (Berge, 2011). A new wave of interest in observation and prediction of the economic cycle occurred at the time in the 21st century that will go down in history as a period full of significant economic shocks that often could not be reliably predicted. The deep negative effects of the financial crisis in 2008, the subsequent wave of the extreme public debts of the European countries, the unexpected global onset of the coronavirus pandemic in 2019, and the war in Ukraine have raised the question of whether and to what extent we are able to predict the possible future development of national economies.

Currently, there are various approaches to predicting business cycles using econometric models (Clark & Ravazzolo, 2015; Ferrara, 2015; Barhoumi, 2016; Bjørnland, 2017; Pawęta, 2018; Kliuchnikava, 2022). Some authors use specific general indexes (Gawel & Glodowska, 2021; Wachira, 2022; Bartos et al. 2021, 2022), however, globally the attention is focused on predictions with the help of composite leading indicators (CLIs). A Composite Leading Indicator (CLI) is an index that aggregates the time series summarising information contained in a number of key short-term economic indicators known to be associated with the business cycle (Zalewski, 2008). The economic cycle is represented by the development of GDP, industrial production index or Composite Coincident Indicator (CCI) (Arnoštová et al., 2011; Bacarić et al., 2016). CLI provides qualitative data on short-term economic movements. CLI draws much attention because it should be able to predict the future states of economic activity – when the economy is going to switch from the expansion phase into the contraction phase or vice versa (Vraná, 2008). Determination of turning points is one of the main benefits of using CLI (Bakarić et al, 2016). It is important to note that CLIs offer information about the expected development of the economy, and thus open a debate on the implementation of decisions in the public or private sector (Monni et al. 2017; Fabuš, 2017). This is a short-term estimate of the future economic situation, but it can point to important economic changes that are the turning points of the economic cycle (Kramoliš, 2015; Mazur, 2017, Döpke et al. 2017). In addition to the prediction itself, CLI can also be used to analyse the performance of economies and thus, to compare their performance within different groups (Saltelli, 2006).

The composite leading indicators also possess own disadvantages and limits that are visible in their practical use that is common for the composite indicators (see Djogo & Stanišić, 2016; Roszko-Wójtowicz & Białek, 2016; Šegota et al., 2017). Among the fundamental issues, it is possible to consider the incorrect selection of the reference series or an insufficiently large group of sub-indicators. When using CLI, it is mainly about the availability of the false signals and misinterpretation of the results (Saisana & Tarantola, 2002; Eurostat, 2017).

For the economic policy measures derived from the CLI prediction, it is necessary to be cautious and to take into account the impact of several factors, such as the development of CLI partial indicators, the

overall nature of the economy, the causes of negative developments (problems of the banking sector, public finances, developments in the credit market, the quality of business environment, economic developments in the other countries depending on the openness of the economy, and the other aspects. (Travkina, 2015; Janto-Drozdowska & Majewska, 2016; Fuinhas et al., 2016; Sachpazidu-Wójcicka, 2017; Dobeš et al. 2017; Korsakienė et al. 2017). One of the most important factors that can shift significantly prediction results is the high share of informal economy (Digdowiseiso & Sugiyanto, 2021; Jovovic, 2021; Mishchuk et al., 2018) as well as uncertainty in innovations and knowledge-based activities development (Ebong & Babu, 2020; Oliinyk et al., 2021; Wasiluk & Ginevičius, 2020). It is equally important that some fiscal policy decisions can only be positive for the economy in the short term, but in the long run, they may be counterproductive (Korsakienė et al. 2015; Ciegis et al., 2015; Lajtkepová, 2016; Vochozka et al. 2020, 2021).

Due to the advantages of CLI, the national statistical offices, the national banks, as well as the specific enterprises, primarily with an industry orientation, are devoted to explore their construction and subsequently, to analyse these points. CLI possesses an important position in the short-term economic forecasts of the European countries, the United States of America, and Japan. At the international level, the organisations such as the OECD and Eurostat pay a significant attention to them. They prefer a different CLI design approach and hence, they use mainly the same CLI composition for the selected country for a long time. This results in quality prediction capabilities of CLI not being achieved for some economies. For this reason, it is necessary to verify the predictive capabilities of existing CLIs and, if necessary, create new composite pre-heat indicators. For economies, which have undergone the significant changes in the past, it can be assumed that the composition of their CLI will change over time. The transitional economies can be considered such countries. For the purposes of this paper, Poland was selected as the country under study due to the insufficient predictive ability of CLI by the OECD and Eurostat and this is analysed in more detail in the given paper. The aim of the present contribution is to create an own composite leading indicator for the business cycle of Poland and compare it with the existing CLIs. The research question is also raised whether there really is a change in the composition of the CLI in the case of Poland over time.

2. LITERATURE REVIEW

The economists at the national and international level are engaged in the construction of the CLI for the economic cycle of Poland. The best-known international methodologies for the construction of Poland's CLI are represented by the OECD and Eurostat procedures. Their modifications can be seen in the studies of the authors such as Bandholz (2005), Zalewski (2009), Jakubíková et al. (2014), and Vraná (2018).

The methodology of the OECD and Eurostat is based on the growth cycle, while the time series can be divided into the random, trend, seasonal, and cyclical components (Trimbut, 2006). For further investigation, the cyclical component is selected from the time series. The first important step is the selection of a reference series that represents the economic cycle of the given economy. The studies offer several options for a selection of the reference series for Poland. The monthly index of the industrial production (or manufacturing production) is the most commonly used measure of economic activity (Bandholz, 2005). The first reason is that it is available promptly and on a monthly basis in contrast to GDP. Secondly, it constitutes the most cyclical subset of the whole economy. Moreover, for many countries it was found that cyclical profiles of GDP and IIP are strongly related. An obvious disadvantage of employing GDP instead of IIP is that GDP is very often revised by the Central Statistical Office and it is a subject to significant changes (OECD, 2006). According to the OECD methodology, the IIP was applied to construct CLI until 2012 for Poland and from 2012 it was a monthly time series of GDP at constant prices (Fulop & Gyomai, 2012). GDP is also preferred by Eurostat (2017), Bandholz (2005), Zalewski (2008), and Jakubíková et al. (2014). On the other hand, authors such as Artis et al. (2004) and Vraná (2018) prefer the use of IIP. In

their opinion, GDP for Poland shows too little cyclical variation and is thus not the appropriate measure for monitoring business cycle fluctuations.

A brief comparison of the elementary differences in the construction of the OECD CLI and Eurostat composite indicators is presented in Table 1.

Table 1

Comparison of international methodologies for CLI construction

Criteria	Eurostat	OECD
Type of business cycle	Grow cycle	Grow cycle
Countries	Chosen countries of European Union, Eurozone	Members of OECD, a few nonmember countries
Trend determination	Hodrick Prescott Filter	Christiano Fitzgerald Filter
Reference series	GDP	Index of industrial production (to 2012) GDP (since 2012)
Relationship between reference series and indicators	Cross correlation	Cross correlation
Type of data	Qualitative data	Quantitative and qualitative data
Period of data	Monthly data	Monthly data
Wages of components	Diggerent wages for all components	Same wages for all components

Source: Authors' results.

The prediction possibilities for the cyclical development of Poland's economy are discussed in the studies by Drozdowicz-Bieć (2001), Matkowski (2002), Nilsson (2006), Garczarczyk & Skikiewicz (2011), Lenart et al. (2016) or Mazur (2017). Another author Bandholz (2005) applies GDP as the reference series and thus, he creates the CLI for Poland and Hungary from quarterly data for the period 1994 to 2004. Employing the linear and non-linear dynamic factor modelling approaches, he finds for the both countries that a parsimonious specification that combines the national business cycle indicators, the series reflecting trade volumes, and the supranational business expectations making for the most reliable business cycle leaders. The composite leading indicators significantly cause a GDP growth, while the estimated Markov-switching probabilities of being in a recessionary state agree well with a priori determined cycle chronologies. The resulting CLI for Poland is composed of a system of the equal and different weights and it contains the six components.

Zalewski (2009) applies the modified form of the OECD methodology and thus, he chooses monthly IIP data for the period 1992 to 2007 as the reference series. Based on the analysis of the 15 economic indicators of Poland, he compiles the CLI, which consists of six resulting components. He compares the constructed CLI with the development of ESI and Matkowski (2002), evaluating that his constructed CLI indicates fewer false signals and therefore, it provides a better short-term prediction.

Jakubíkova et al. (2014) explored the development of the economic cycle of the V4 countries with a reference series of GDP at constant prices. Using the analysis of the quarterly data for the period 2005 to 2011, they pointed out the shortcomings in the OECD predictive ability for Poland. In the explored period, the highest value of the OECD CLI cross-correlation was 0.489, while Eurostat ESI stood at a level of 0.798. Subsequently, according to the modified OECD methodology, a CLI was compiled for Poland too, and it consisted of the six components also. For the V4 countries, the CLI has been shown to have a different composition for each country.

Vraná (2018) applied an innovative approach to the construction of the CLI, which consists in including variables from other countries among the selected cyclical indicators. To compile CLI of Poland, it follows the development of indicators in Austria, Germany, the Czech Republic and Slovakia for the period 1996 to 2016 with the reference series of GDP. He argues that the economies of some countries are

small and their economic situation is often related to the development of the business cycle in other countries. According to her study, the resulting CLI of Poland actually achieves the best predictive capabilities when incorporating indicators from the monitored countries.

The available CLIs for Poland were compared based on selected criteria such as a CLI composition, lead size and CLI cross-correlation value (Table 2).

Table 2

Comparison of the construction of the composite indicators for Poland

Author	Observed period	Indicator construction	Time period advance	Cross-correlation value
Bandholz (2005)	1994-2004 (quarterly data)	CLI (reference series GDP): Describes demand tendency in manufacturing, Nominal effective exchange rate, Business expectations for Western Europe	1 Q	0.75
Zalewski (2009)	1992-2007 (monthly data)	CLI (reference series IPP): Narrow Money (M1) Index 2000=100 SA, Manufacturing industry (Selling prices, Future tendency), Manufacturing industry (Production Tendency), Short-term interest rates, Manufacturing industry (Production, Future Tendency), Net trade in goods (value) in billions of US dollars SA	-	0.788
Jakubíková et al. (2014)	2005-2011 (quarterly data)	CLI (reference series GDP): Production in manufacturing industry, 2005 = 100 Monetary aggregate M1, 2005 = 100 Warszawski Indeks Gieldowy, 2005 = 100, Industry turnover, (intermediate product and capital goods), domestic market, 2005 = 100 Indicator of confidence in the construction industry	2 Q	0.886
Vraná (2018)	1996-2016 (monthly data)	CLI (reference series GDP): 9 international components (Austria, Czech Republic, Germany, Slovakia) and 6 national components: Business tendency surveys (construction), Share Prices, Business tendency surveys (manufacturing), International Trade (Imports, goods), Business tendency surveys (services- business situation), Business tendency surveys (services - confidence indicators)	3 M	0.790
OECD* (2022)	2005-2021 2010-2021 2016-2021 (monthly data)	CLI (reference series GDP): Real effective exchange rates - CPI Based (2015=100) inverted 3-month WIBOR (% per annum) inverted Manufacturing - Production: tendency (% balance) Job vacancies: unfilled (number) Production of coal (tonnes)	10 M 9 M 9 M	0.442 0.578 0.588
Eurostat* (2022)	2005-2021 2010-2021 2016-2021 (monthly data)	CLI (reference series GDP): Confidence indicator in industry, Confidence indicator in the service, Consumer confidence indicator, Confidence indicator in construction, Confidence indicator in retail	1 M 0 M 0 M	0.756 0.811 0.921

Note: * own calculations
Source: Authors' results

In the case of CLI OECD and ESI Eurostat, the values were calculated by the authors of the paper. By comparing the observed studies, the difference in the predictive abilities of CLI is noticeable. The reason is mainly differences in the CLI calculation methodology, but also in the type and periodicity of monitored variables and the length of the time series. The predictive capabilities of the OECD and Eurostat CLIs, which were calculated by the authors of this study from three different length time series with unchanged CLI composition, are interesting. In the case of the OECD, a prediction period of up to 9 or 10 months was found, but with a low cross-correlation value of 0.442 to 0.588. This means that with this composition, the CLI gives many false signals about the changes in the Polish business cycle. On the contrary, the ESI showed a high correlation value from 0.756 to 0.921, but at the time of the coincidence or a month in advance.

3. METHODOLOGY

The main goal of the paper is the construction of a new composite leading indicator (CLI) designed to predict the development of the business cycle in Poland. A partial objective is to determine whether the length of the time series significantly affects the groups of the cyclical leading indicators that can form CLIs. For creation of CLI, a modified OECD methodology is employed. It is based on a construction with the growth cycle (De Vroey & Pensieroso, 2006). This is more appropriate to apply in the case of the transitional economies such as Poland (Czesaný et al., 2007). The monthly GDP indicator at constant prices is selected as the reference series that is generally considered the broadest indicator of economic activity (Czesány & Jeřábková, 2009a). Only its cyclical component is used in the analyses (Czesány & Jeřábková, 2009b; Astolfi et al., 2016).

The indicators, whose relation to GDP is monitored include, the 62 quantitative and qualitative indicators from the fields of industry, services, retail, construction, foreign trade, labor market, monetary aggregates, stock indices, confidence indicators, consumer expectations as well as the GDP components themselves. The data sources are the databases of the OECD, Eurostat and the Polish Statistical Office. All the available time series from January 2005 to November 2021 with monthly periodicity are included in the analysis. The relationship of the variables to GDP in the periods 2005 to 2021, 2010 to 2021, and 2016 to 2021 is monitored. The reason is the results of the published research for Slovakia, which confirmed there is a change in the composition of the CLI over time or that the length of the observed period affects the composition of the CLI. The recommendation is to monitor changes in the composition of the CLI at least at the five-year intervals, or after major economic changes in the country and thereby, to minimise the number of the false signals (Tkáčová & Kišová, 2018).

The time series is initially seasonally adjusted by the method of balancing employing the seasonal indices and then, the trend is removed applying the Hodrick-Prescott filter (HP filter). The HP filter is a commonly employed tool for detrending. It is a most favourable extractor of a trend that is stochastic but moves smoothly over time and is uncorrelated with the cycle (Kovacic & Vilotic, 2017). For t=1,2,3… the trend component Y* is computed, and λ is chosen to minimise:

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

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 the 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 in a way of the Pearson's correlation coefficient with the two forward shifts and the five backward shifts is applied in order to determine the relationship between the variables. According to the value of the correlation coefficient and the size of the advance, it is possible to create groups of cyclical and anticyclical indicators according to the pattern of Table 3.

Table 3

Criteria for identification of the cyclical behaviour of the indicators for Poland

Indicator type		**The highest absolute cross-correlation value**	**Time to reach the highest absolute cross-correlation value**
Cyclic	Early	> 0,55	(t+1, t+2)
	Overdue	> 0,55	(t-5, t-1)
	Concurrent	> 0,55	t
Anticyclical		≤ 0,55	not significant

Source: Kľúčik, Haluška (2008).

A group of the leading indicators is a subject to a more detailed analysis for the compilation of Poland's CLI. Subsequently, the selection and scoring method is applied, which economic and statistical significance and statistical quality are evaluated according to. The maximum number of the points that the variables can reach is given in Table 4.

Table 4

Scoring criteria for the selection of the leading cyclical indicators

Economic significance (maximum 10 points)		**Statistical significance (maximum 30 points)**		**Statistical quality (maximum 10 points)**	
Economic interpretation in relation to the business cycle	10 points	Pearson's correlation coefficient	15 points	Time availability	5 points
		Number of advance months	15 points	Update	5 points

Source: Authors' results

Due to the different units of the partial indicators, their normalised values obtained by using the standardization method (OECD, 2008) are used in the composition of the CLI. A system of the equal and different weights is employed. The relationship for calculating equal weights looks like as follows:

$$\omega_i = \frac{1}{n} \tag{2}$$

where *i* stands for the weight of *i*th component a *n* is the number of the partial indicators entering the CLI. The absolute values of the correlation coefficients are applied in order to determine the different weights.

The relationship for calculation of the different weights is expressed subsequently:

$$\omega_i = \frac{r_i}{\sum_{i=1}^{n} r_i} \tag{3}$$

where *i* stands for the weight of *i*th component, *r* is the absolute value of the correlation coefficient of *i*th component at the time of advance and *n* is the number of the partial indicators entering the CLI.

The sum of the normalised values multiplied by the weights creates the basement for construction of the CLI assembly equation.

$$CLI_t = \sum_{i=1}^{n} \omega_i * y_{i,t} \tag{4}$$

ω – a variable weight value,

y – a value of the normalised cyclic component of the variable at *t* time,

n – a number of the partial indicators entering the CLI.

4. EMPIRICAL RESULTS AND DISCUSSION

The basic step for the creation of CLI for Poland is characterised by the selection of a reference series that represents the economic cycle. Through the analysis of the relationship between the cyclical component of GDP and PPI, it was demonstrated that PPI shows a month advance with a cross-correlation value of 0.789 for the period 2005 to 2021 and 0.827 for the period 2016 to 2021. This means that the PPI represents the leading indicator of GDP and thus, it is able to form one of the components of the CLI. It is not appropriate to select it as a reference line. In the case of Poland, it is more suitable to use the cyclical component of GDP.

Selection of the cyclical indicators for Poland

According to the described methodology, the cyclical relationship of all the 62 selected variables to GDP was analysed. Through calculation of the cross-correlations of the cyclical components associated with the variables of the cyclical component of GDP, the 17 indicators were selected that demonstrated the properties of the leading cyclical indicators according to the definition given in the methodological part of the paper. The highest cross-correlation value was achieved to the left side of t and at the same time, the second highest cross-correlation value was greater than 0.55. Table 5 demonstrates the results.

Table 5

Advance indicators

Indicator	2005–2021		2010–2021		2016–2021	
	advance	correlation	advance	correlation	advance	correlation
Industrial production index	1 M	0.798	1 M	0.802	1 M	0.827
Stock price index	2 M	0.524	2 M	0.533	1 M	0.664
Total industry production index	1 M	0.807	1 M	0.813	1 M	0.838
Total production in the processing industry index	1 M	0.775	1 M	0.774	1 M	0.796
Total production in the processing industry index – intermediate product	1 M	0.732	1 M	0.756	1 M	0.761
Total investment goods production index	1 M	0.745	1 M	0.751	1 M	0.757
Total retail volume index	1 M	0.595	1 M	0.622	1 M	0.745
Production in the processing industry	1 M	0.667	1 M	0.723	1 M	0.813
Consumer industry employment	1 M	0.599	1 M	0.665	1 M	0.747
Processing industry confidence indicator	1 M	0.714	0 M	0.786*	0 M	0.857*
Construction industry employment	1 M	0.619	1 M	0.719	1 M	0.796
Retail business situation	1 M	0.706	1 M	0.750	1 M	0.801
Retail employment	1 M	0.702	1 M	0.805	1 M	0.834
Order intention or demand in retail	1 M	0.708	1 M	0.760	1 M	0.811
Services – demand development	1 M	0.760	1 M	0.788	1 M	0.862
Services – employment	1 M	0.686	1 M	0.766	1 M	0.813
Dow Jones euro stoxx 50 Price Index	1 M	0.483*	1 M	0.479*	1 M	0.667

* the indicator is assigned to the advance indicators according to the advance period length and not the cross-correlation value

Source: Authors' results.

Three time periods were monitored in order to verify the assumption that there is a change in the leading cyclical indicators throughout the time that represent potential components of the CLI. In the case of Poland, only a small change in the nature of these indicators was confirmed. Out of the 62 variables, 17 indicators were included among the leading cyclical indicators. Subsequently, only the 2 out of the 17 indicators changed their nature as a leading cyclical indicator. The first one was an indicator of confidence in the manufacturing industry, which over time changed from a leading indicator to a concurrent indicator, and the second was the Dow Jones Euro Stoxx 50 price index that acquired the characteristics of a leading indicator over time. For the 15 indicators, it has been proven that they show a better quality lead with a shorter time period, and thus the value of their correlation coefficient increases. Overall, it can be assumed that in the case of Poland, there is no significant change over a time period in the group of the leading cyclical indicators. According to the established methodology, it is possible to compile a high-quality CLI therefore, whose composition would meet the prediction of the economic cycle of Poland even for several years. However, with shorter time periods, the value of the cross-correlation grew, which means that the selected indicators are suitable for creating a CLI for the current prediction. For this reason, the subsequent investigation is devoted to the time series for the 2016 to 2021 period.

For a detailed selection of the variables that create the CLI, a selection and a scoring method is applied for all the 17 lead indicators (Table 6), while the maximum value, which the indicator can reach, is 50 points (Kľúčik, 2009b). The variables from the same economic area, which achieved the highest number of points after an application of a selection and a scoring method, were eligible for further analysis. This reduced the selection down to the 10 leading cyclical indicators.

Table 6

Results of the selection and scoring method for the advance cyclical indicators

Indicator	**Maximum points**	**Indicator**	**Maximum points**
Total industry production index	45	Total retail volume index	40
Industrial production index	44	Retail employment	39
Total investment goods production index	43	Order intention or demand in retail	39
Stock price index	42	Processing industry confidence indicator employment	39
Total production in the processing industry index – intermediate product	42	Processing industry confidence indicator	38
Total production in the processing industry index	41	Services – demand development	38
Total production in the processing industry	41	Dow Jones euro stoxx 50 Price Index	38
Retail business situation	41	Processing industry confidence indicator	25
Services – employment	41		

Source: Authors' results

Construction of a composite lead indicator for Poland

During the construction of the CLI, there were the 7 options for the composition of the CLI with each additional possibility having one less indicator with the lowest number of the points. CLI 10 (at the same weights) or CLI A (at different weights) were composed of the 10 indicators and CLI 4 of the 4 indicators that represented the minimum number. CLI numerical designation is applied for the same indicator weights and a letter designation is used employed for the different CLI component weights. Table 7 demonstrates the results of the cross-correlations with the advance volume.

Table 7

Cross-correlation results for different CLI compositions for the period 2016 to 2021

CLI	Identical weights		Different weights	
	Advance	Cross-correlation value	Advance	Cross-correlation value
CLI 10 / A	1 M	0.712	1 M	0.709
CLI 9 / B	1 M	0.712	1 M	0.709
CLI 8 / C	1 M	0.723	1 M	0.719
CLI 7 / D	1 M	0.851	1 M	0.846
CLI 6 / E	0 M	0.881	0 M	0.885
CLI 5 / F	**1 M**	**0.879**	**1 M**	**0.877**
CLI 4 / G	0 M	0.879	0 M	0.883

Source: Authors' results.

The CLI 5 composition possesses the best predictive ability at the same weights or CLI E at the different weights. The equations for their calculation are as follows:

CLI 5 = 0.2 * Stock price index + 0.2 * Total industry production index + 0.2 * Total investment goods production index + 0.2 * Retail business situation + 0.2 * The services sector employment (5)

CLI F = 0.171 * Stock price index + 0.216 * Total industry production index + 0.195 * Total investment goods production index + 0.207 * Retail business situation + 0.210 * The services sector employment (6)

Figure 1 illustrates the predictive capabilities of CLI 5 and CLI F before the development of the cyclical component of Poland GDP for the period 2016 to 2021. Successively, the predictive ability of the compiled CLI 5/F was tested even for the longer time series as shown in Table 8.

Table 8

Prediction capabilities of CLI 5/F for the different length time series

CLI	2005–2021		2010–2021		2016–2021	
	Advance	Correlation	Advance	Correlation	Advance	Correlation
CLI 5	1 M	0.762	1 M	0.826	1 M	0.879
CLI F	1 M	0.729	1 M	0.812	1 M	0.877

Source: Authors' results

The results confirmed that the CLI 5/F composition is suitable for prediction of the business cycle of Poland in the long term. This claim is supported by the high cross-correlation values of 0.879 for the same weights and 0.877 for the different weights one month ahead for the period 2016 to 2021. As the time series is being reduced, the cross-correlation value increases too. This means that the CLI is suitable for the current short-term business cycle prediction for Poland.

5. DISCUSSION

Employing a modified OECD methodology, the new composite leading indicator for Poland was compiled that includes the stock index, the industry indicators, the retail sector, and the labour market. The other authors, who deal with the construction of CLI, such as Bandholz (2005), Zalewski (2009), Jakubíková et al. (2014), Vraná (2018), OECD (2022), and Eurostat (2022) observe the manufacturing indicators, the stock indices and the confidence indicators preferentially (see Table 2). It is desirable to compare the quality of the prediction created by the CLI with the available composite indicators. This is not possible in a case of all the available studies, mainly due to the application of the different methodology and the time period, which the CLIs were compiled from. A comparison with the correlation coefficients and the advance time

period length, which the authors of the studies mention during the time of the research, is not sufficient for the needs of the current comparison and hence, it did not lead to the relevant results. Nevertheless, it can be found that the CLI OECD and ESI time series in the freely available databases that allow us to compare the explored indicators with CLI 5/F. Table 9 demonstrates the results.

Whilst comparing the prediction capabilities of CLI on the monthly data of the period 2016 to 2021, it was demonstrated that CLI 5/F was ahead considerably. The highest value of the cross-correlation at the level of 0.879/0.877 was reached at one-month advance. The OECD CLI demonstrated the lead indicator properties with a large false-signal reporting rate at a cross-correlation value of 0.588. The ESI achieved strong correlation at the level of 0.921, but this indicator behaves in a parallel way with the development of GDP and therefore, it is not suitable to apply it in order to predict the Polish business cycle currently.

Figure 2 visualises the development of the observed indicators that confirms the fact expressing CLI 5 (similarly to CLI F) with the best ability to develop ahead of the cyclical component of Poland GDP among the monitored composite indicators.

Momentarily, the available CLIs captured a significant downturn in the economy at the onset of the coronavirus disease 2019 pandemic. The constructed CLI 5 demonstrates a change in the economic cycle of Poland even earlier than the OECD and Eurostat CLIs. The advance period, the value of the cross-correlation, as well as the graphical presentation of the results confirmed the ability of CLI 5 to predict the development of the economic cycle of Poland better than the currently internationally constructed CLIs.

6. CONCLUSION

The economy of Poland was under the influence of the significant external economic shocks like the other European countries in the recent period. Despite a high domestic demand, these external factors had an impact on the development of the Polish business cycle and they could not be reliably predicted. In particular, the sudden beginning of the coronavirus disease 2019 pandemic affected the normal economic activity so suddenly that even until then the reliable predictive indicators could not identify and to quantify these impacts in time.

The main goal of this paper was to propose a new composite leading indicator that could reliably describe the short-term future development of the business cycle of Poland. According to the applied methodology, it was possible to construct a CLI that is composed of the indicators such as the stock price index, the total industrial production, the total investment goods production index, retail business situation, and employment in the services sector. In order to ensure the best possible predictive capabilities of the CLI, the indicator was compiled based on the analysis of the monthly data from the period 2016 to 2021. The defined time period comprised the last five years deliberately and it did not include the 2008 financial crisis or the other fluctuations of the economy that occurred before the explored period. The assumption was that the past economic shocks could influence the selection of the leading cyclical indicators for the current CLI. Nonetheless, this was not confirmed in the case of Poland and it can be seen from the outcomes visible in Table 6 and Table 9. Table 6 shows that there was no significant change throughout the period in the leading cyclical indicators that serve to construct the Polish CLI. This means it is not necessary to analyse all the 62 input variables in the future, but it is possible to focus only on the development of the 17 selected indicators. Table 9 confirmed that even with the longer time series, CLI can achieve the high cross-correlation values whilst predicting one month.

Table 9

Comparison of the composition of the proposed CLI 5 with the CLI of OECD and Eurostat

CLI composition for the period 2016–2021		**Advance length**	**Cross-correlation value**
CLI 5/F	Stock price index Total industry production index Total investment goods production index Retail business situation Services – employment	1 M	0.879/ 0.877
ESI	Industry confidence indicator Consumer confidence indicator Construction industry confidence indicator Retail confidence indicator Services confidence indicator	0 M	0.921
CLI OECD	Real effective exchange rates - CPI Based (2015=100) inverted 3-month WIBOR (% per annum) inverted Manufacturing - Production: tendency sa (% balance) Job vacancies: unfilled sa (number) Production of coal (tonnes)	9 M	0.588

Source: Authors' result

Throughout the period, the strength of the correlation is being increased. This means that the CLI is suitable for the current short-term prediction of the Polish business cycle. When compared with the CLI of the OECD and the ESI, the compiled CLI was evaluated as the most suitable indicator intended to estimate the future development of the economic cycle of Poland. However, the advantages of CLI OECD and Eurostat should not be forgotten. According to Table 10, the OECD CLI has the largest cross-correlation value of 0.588 with a lead of nine months. Although, it gives a large number of the false signals, it is worthwhile to apply it as an auxiliary indicator. In the same way, ESI can determine the position of the economy in the business cycle through the high value of the cross-correlation at the same time. Due to the fact that it is compiled from the qualitative data, it is an important indicator. For the business sector and the economic policymakers, it is suitable to observe the development of all the three indicators.

Definition of the disadvantages associated with the applied CLI is also an important part of the paper. The first of them is that CLI can only predict the business cycles in the short term and this prediction describes only the direction of the business cycle – for instance, whether it will be an economic growth or a decline. The second issue is an advance period that takes one month, because it is insufficient. For the construction of the CLI, it is necessary to possess the values of the partial indicators in time. It is observed as the statistical quality of the data in the study. If these cannot be obtained in the appropriate advance period, the CLI will be constructed late itself and the signal of a change in the economic cycle will arrive late. A one-month advance period does not leave enough room for the possible issues with the availability of the input variables. In the case of Poland, this problem appears to be unsolvable as the data did not show a sufficiently long advance period generally. This is caused precisely by the speed and unpredictability of the external influences that are typical for the current economic shocks. The businesses and even the country do not have enough area to manoeuvre before an onset of an economic downturn that will cause more severe negative effects on the economy. When comparing with the studies such as by Bandholz (2005), Zalewski (2009), Jakubíková et al. (2014), or Vraná (2018), this issue can be considered temporary and associated precisely with an onset of the coronavirus disease 2019 pandemic. The advance of CLI achieved in these studies was at the level of one to two quarters that can already be considered a sufficiently long advance period. Thus, it would be appropriate to test the prediction capabilities of the created CLI in the future as well and to see whether the length of advance period is changed. Nevertheless, the war in Ukraine

represents another factor that can possess the opposite effect. For this reason, the business and public sector should supplement the information from the CLI with the predictions made according to the econometric models and the predictions of the national statistical offices that are not examined in this study. It is also necessary to observe the development of the economic cycles of the countries, which Poland cooperates economically with. Regarding a shorter advance period if the CLI is created from the national indicators, it would be appropriate to examine the predictive capabilities of the foreign variables as suggested by Vraná (2018). It would also be beneficial to investigate the accuracy of CLI when determining the turning points that is one of the basic features of CLI.

The issue of prediction of the countries' economic cycle has to be considered as relevant still. Reliable prediction also with the help of CLI allows economic policymakers to respond to the possible changes on the income and expenditure side of the budget associated with the development of GDP. In the same way, the business sector can anticipate these changes in the demand for its products and hence, to adjust the size of production accordingly, to manage inventory, and to hire new employees. The presented study confirmed that the constructed CLI can be considered as an indicator that in the case of Poland could become an important part of the complex studies aimed at short-term prediction of the business cycle.

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ANNEX

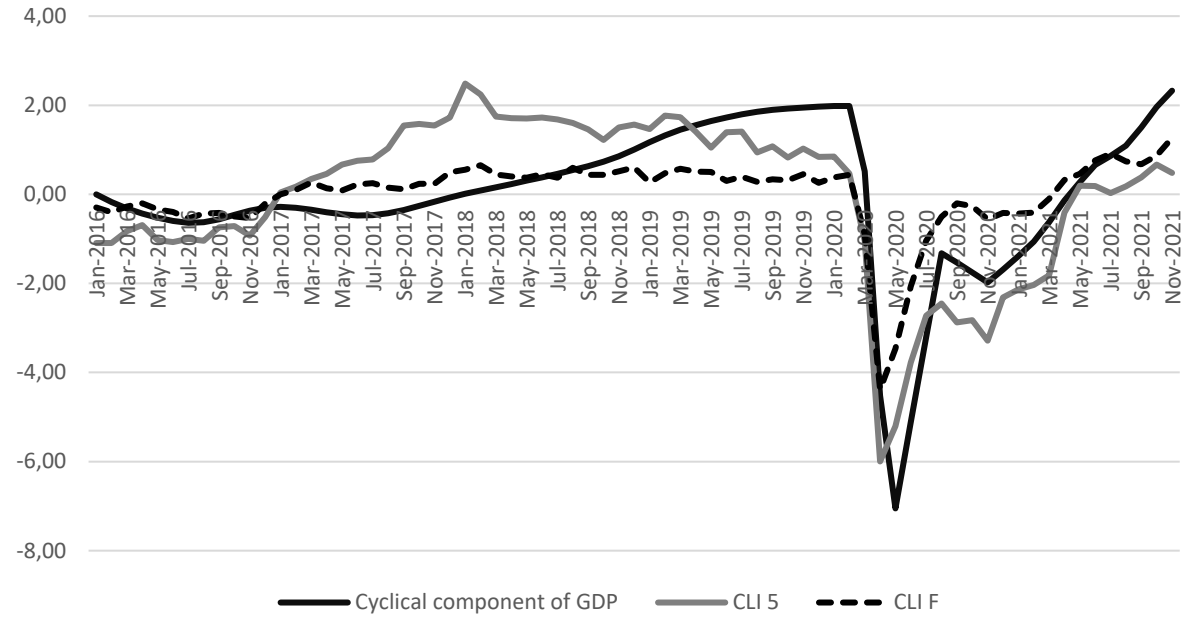

Figure 1. Development of the cyclical component of GDP and CLI with the equal and different weights
Source: Authors' results

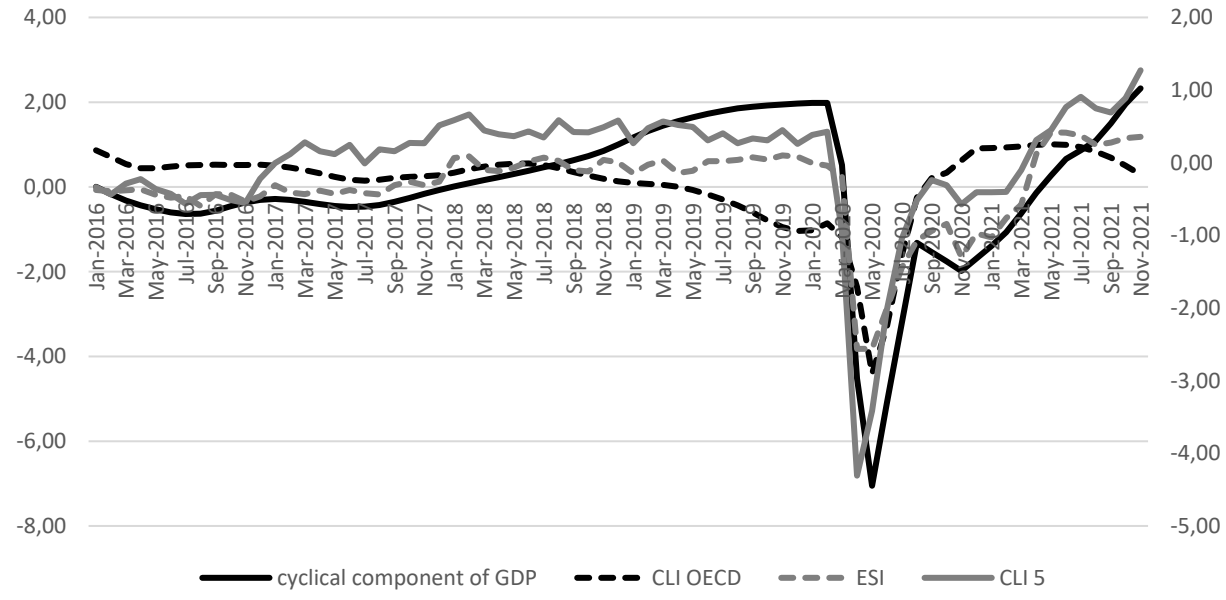

Figure 2. Comparison of the development of the cyclical component of GDP, CLI 5 (the equal weights), CLI OECD, ESI
Source: Authors' results