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ASSESSMENT OF LEADING PROPERTIES OF SHORT-TERM ECONOMIC INDICATORS OF KAZAKHSTAN

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Annotation

In this study, the predictive properties of the leading indicators of the Kazakh economy were evaluated using ten combinations of paired series with the application of economic theories, statistical tests and Vector Error Correction Model (VECM).

The quality of the VECM models is verified by diagnostic tests: serial correlation, normal distribution and heteroscedasticity of residues.

Unidirectional positive cause-and-effect relationships between business activity subindexes in construction and production, as well as in mining and construction have been identified. Production sector supplies construction sector with the necessary materials. Construction companies produce capital goods and services for the mining industry.

The calculated functions of impulse responses indicated a positive effect of the impact of these subindexes on future changes in the turning points of phases of the economic cycle.

Decomposition of variances established the share of the impact of their own innovation shocks and shocks of other influencing sectors of the economy.

The existence of long-term co-integration relations between business activity subindexes in production, construction and mining is revealed.

Keywords: *composite leading indicator, business activity subindex, production, services, construction, mining industry, co-integration, VECM.*

JEL-classification: *C01, C32, C51, C52, E32.*

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1. Introduction

Leading short–term economic indicators include business activity subindexes (BAS) and composite leading indicator (CLI). Their main property is predictive, providing signals about future and prospective changes in the business cycle before these changes occur in reality.

The NBK calculates the BAS and CLI based on surveys of enterprises in the real sector of the economy using methodology of international specialized organizations.

The BAS is calculated on a monthly basis separately for the industries of production, services, construction and mining, as well as aggregated for the entire sample by weighing specific equity of industries in GDP. A value of more than 50 points indicates an increase in the activity of the sector compared to the previous month, and vice versa, a value of less than 50 points indicates a slowdown in economic activity. The number of BAS respondents[2] is as follows: in production – 150, services – 223, construction – 77 and mining – 66.

The calculation of CLI is carried out on a quarterly basis for the entire real sector of the economy: mining, production, construction, trade, transport and warehousing, agriculture and other enterprises. CLI is used to determine the turning points of the business cycle and provides qualitative information about the state and direction of the dynamics of economic activity. CLI reflects a generalized assessment of the current and expected situation at enterprises and has the property of outpacing the dynamics of real GDP by 1-2 quarters. The construction of the CLI is based on the OECD methodology[3]. The number of CLI respondents[4] is 3362 enterprises of the real sector (mining – 209, production – 743, construction - 325, trade – 954, transport and warehousing – 265, agriculture – 197 and others – 669). A value of more than 100 points indicates an increase in the activity of the sector compared to the previous quarter, and vice versa, a value of less than 100 points indicates a slowdown in economic activity.

The novelty of this study lies in the fact that an attempt has been made to evaluate the predictive property of leading indicators using economic theories and the vector error correction model (VECM).

The purpose of this study is to quantify and construct empirical VECM models of the relationship between leading indicators for the economy of Kazakhstan.

The objects of research are the BAS of four sectors of the economy (production, services, construction, mining) and CLI. Research period: from September 2016 to April 2023.

The information base was compiled from official data from the NBK, scientific literature sourced from the Web of Science platform, and other references.

[2] For August 2023
[3] OECD System of Composite Leading Indicators, Methodology Guideline, OECD 2012
[4] For the 2nd quarter of 2023

2. Literature review

The literature review was carried out on the main components of our research: leading indicators, cointegration, the VECM model.

A. Leading indicators appeared for the first time in the USA around the 20-30s of the XX century. Due to the frequent crises, there was a need to indicate business activity at the macro level in order to show, assess the state and dynamics within the economic cycle.

The essence, evolution of economic indicators, their role, significance, types, and practice of application in different countries were described in the works of following scientists: Kopp (2022); Reiff (2023); Loseva O.V. et al. (2015); Tkacova et al. (2017); Bogdanova A.L. (2018); Egiyan K.A., Pogorelskaya T.A. (2014); Kruk D., Korshun A. (2010), etc.

When describing the turning points of the phases of cyclic activity, the key criteria of leading indicators and their interpretations presented by scientists were used: Kopp (2022); Reiff (2023); Loseva O.V. et al. (2015). Thus, the values of the indicators fluctuate in the range of 0-50, where 50 points is the norm, the "golden mean", characterizes the turning point, the absence of changes; more than 50 points indicates activation of the sector compared to the previous month; a value of less than 50 points indicates a slowdown in economic activity, predicts a recession (Kopp, 2022; Reiff, 2023); the level of 44 points is a drop, below 44 points predicts an absolute decline in economic activity (Loseva O.V. et al., 2015).

The scientific basis for the study of leading indicators is comprised of interconnected theories: economic development, economic growth, economic cycles (business cycles), and the real business cycle theory. Economic theories are reflected in the works of scientists Schumpeter (1939), Schumpeter J.A. (2008); Kydland and Prescott (1982); Altonji (1982); Long and Plosser (1983); Tupchienko V.A., Krivtsova M.K. (2014); Silina Y.P. et al. (2019).

In his research, Schumpeter (1939) wrote that "the real world is always dynamic".

Describing economic development as "a substantially new use of labor and land services", J.A. Schumpeter (2008) was able to formulate the following thesis: "the implementation of new combinations occurs by removing these services from their former spheres of application"; "economic development... occurs in the form of the implementation of new combinations of existing goods.”

The founders of the theory of the real business cycle (Kydland and Prescott, 1982; Altonji, 1982; Long and Plosser, 1983) in their models explain the economic fluctuations of real variables by the variation of exogenous stochastic components (shocks) caused by the action of real factors such as changes in production technologies, investment tax benefits, technological progress, disruptions in oil and food supplies, and other similar shocks.

Silin Ya.P. et al. (2019) focus on the fact that the following categories allow us to understand the changes taking place in the economy: economic growth, economic development, economic cycle, economic situation, which complement each other. Economic development and economic growth occur due to a “constant dynamic characteristic of a market economy,” called the “cycle.”

The levels and rates of change in macroeconomic indicators, the existing proportions of production, distribution, exchange and consumption in the economy form the economic situation. According to Tupchienko V.A., Krivtsova M.K. (2014), "the theory of economic cycles is also called the theory of economic conjuncture. Despite fluctuations, the general trend of economic development is characterized by growth".

Loseva O.V. et al. (2015) conducted a quantitative assessment of leading indexes and their correlation with indicators of development of the national stock market using the example of Russian practice.

Authors Tkacova et al. (2017) proposed and tested a new composite, generated leading indicator for monitoring and forecasting the German economy using 18 indicators, and also calculated the cross-sectional correlation between GDP and the index of industrial production.

Kruk D., Korshun A. (2010) were the first to use a composite leading indicator consisting of 14 variables for Belarus. The indicator of the cyclical component of GDP has demonstrated high predictive properties for 3 months ahead for the Belarusian economy.

Schumpeter (1939) considered business cycles and economic growth as interrelated, because introduction of new technology affects long-term productivity growth and short-term fluctuations in production volume.

Long and Plosser (1983) wrote that the behavior of economic agents is conditioned by the business cycle and many characteristics are usually associated with business cycles.

In scientific studies, the authors give approximately similar definitions of the “economic cycle” as: “an interval (segment) of time in the development of the economy, which reflects the ups and downs of production volumes, goods and services” (Silin Y.P. et al., 2019); “periodic fluctuations in the economic activity of society, the period of time from the beginning of one crisis to the beginning of another” (Tupchienko V.A., Krivtsova M.K., 2014); “the period of time between two identical states of economic conditions” (Tupchienko V.A., Krivtsova M.K., 2014). The economic cycle is characterized by such features as: a certain periodicity and repeatability of the same type of relationships, forms of manifestation.

J.A. Schumpeter (2008) argued: "the main movement of the economy occurs intermittently and restlessly", ... "undulating". According to Silin Ya.P. et al. (2019)the waves are “long and ultra-long cycles that absorb shorter cycles of different durations, with different amplitudes and depths.” They admit that "waves are a technical (statistical) concept."

B. Cointegration manifests itself when time series can be linked by some long-term relationship, from which these time series may deviate in the short term, but to which they should return in the long term.

The concept of cointegration applies only to series with a single root. The idea of cointegration is that two or more variables can change synchronously so that their linear combination is a stationary process (Artamonov N. V. et al., 2021).

C. The Vector Error Correction Model (VECM)representation of Engle and Granger (1987) is one of the most widely used time series models in empirical practice. This model allows us to better understand the long-term dynamics, consisting of short-term and long-term changes. In the model, short-term changes are adjusted depending on the deviation of the long-term dependence between variables, thereby maintaining a long-term equilibrium.

The predominant estimation method for VECM is the low-rank regression method introduced by Johansen (1988, 1991, 1995).

The VECM equation has the form (Naveed and Mahmood, 2017):

$$\Delta Z_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \, \Delta Z_{t-i} + \Pi Z_{t-1} + \varepsilon_t \qquad (1),$$

where μ is the deterministic component representing the intersection point (absence of trend) in both CE and VAR;

Π – represents a long-term cointegrating matrix, and contains information about long-term relationships;

the matrix Π can be decomposed into Π = αβ', where β' is the long–term matrix of coefficients, and α is the speed of adjustment to the equilibrium state;

parameter Γ – shows VAR coefficients or short-term coefficients explaining short-term relationships between model variables;

k is the optimal lag length of the VAR model.

The main stages of building the VECM model are (Maulia et al., 2018):

1. Checking series for stationarity.
2. Checking series for cointegration.
3. If the series are cointegrated with each other, then you can use VECM (otherwise - VAR).
4. Checking series for causal dependence by Granger.
5. Choosing the optimal lag.
6. Creating a VECM model.
7. Verification of the VECM model for quality by tests of serial correlation, heteroscedasticity and normal distribution of residues.
8. Forecast assessment based on the VECM model.

The Granger causality test is a statistical method for determining whether one time series is useful for predicting another. The Granger causality test can only be applied to pairs of variables and can produce erroneous results when the true relationship involves three or more variables. Granger stated that the concept of causality does not imply a causal relationship, but rather is based only on "predictability" or the ability to "predict" (Granger, 1969).

In the context of VECM evaluation, paired Granger causality tests and impulse response function analysis can be used to evaluate economic policy (Setyowati, 2019).

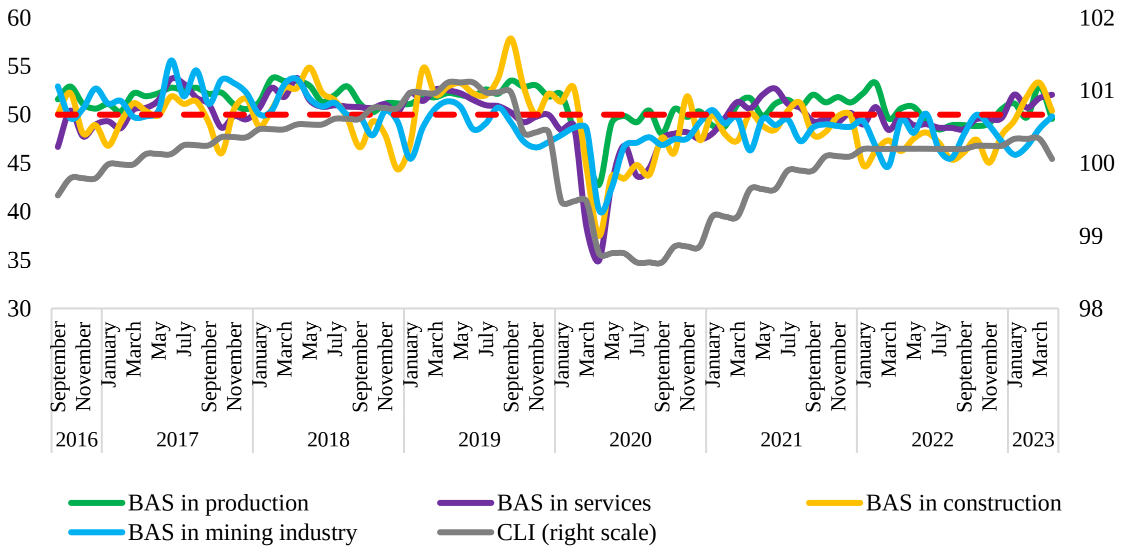
The Impulse response function (IRF) is a graphical illustration of forecasting that quantifies the impact of each variable over time. The study of the behavior of one variable due to a change in another variable is the main function of the IRF (Shabbir et al., 2019).

The variance decomposition method measures the percentage of variance of the prediction error of a variable explained by other aspects. More precisely, it indicates the relative influence of one variable on another. In addition, it provides information on how the variable of interest reacts to shocks or innovations in other variables (Majid and Kassim, 2015).

3. Analysis of leading indicators

Data visualization clearly demonstrates cyclical fluctuations over the period under review (Graph 1).

Graph 1. Dynamics of BAS in the sectors of production, services, construction and mining industry, as well as CLI



Source: NBRK
Note: CLI data for April 2023 are based on enterprise expectations

Depending on the amplitude of the fluctuations, there is a change in the phase shifts of economic cycles, successively alternating with each other with a new repetition. Economic cycles of recovery (values over 50 or 100) are replaced over time by recessive ones, which after a certain period of time are replaced by depressive ones (values less than 50 or 100).

Thus, in production sector, the revival of business activity can be traced from September 2016 to January 2020. Since February 2020, there has been a decrease in the BAS (48.5) with a slight recovery by May 2021 (49.9). Then a new rise in business activity from June 2021 to February 2022, followed by a downward reversal from March 2022 to April 2023.

Attention is drawn to production sector, where the number of positive variables dominates with values of BAS over 50, determining the activation of business activity: 75.0% (60 out of 80).

Trends in the services sector are about the same as in production sector, with some shifts in the months that replace the upward and downward economic phases. The fact that the bottom of the decline has been reached is indicated by the minimum value of the BAS in the services sector (34.9 in April 2020) due to the deterioration of all its components: delivery times, employment level, and new orders. Having dropped to a minimum, the BAS turns upward, predicting some recovery in business activity.

In construction sector, the peak of growth is characterized by the maximum value of the BAS (57.9) in September 2019, associated with an increase in new orders and an increase in employment. Having reached the maximum growth, the BAS turns downwards, foreshadowing a reversal of the business cycle in the downward direction with some fluctuations in certain months.

Moderate exposure to cyclical changes is established for the sectors: construction and mining. The predominant number of BAS with low, negative values of business activity, less than 50, was evident in the mining sector at 66.3% (53 out of 80) and in the construction sector at 57.5% (46 out of 80). At the same time, the economic phase of decline in the mining sector began earlier than in other sectors: from June 2019 to April 2023.

Let's compare the BAS data with the CLI. At the same time, CLI is characterized by an advance in the dynamics of real GDP by 1-2 quarters. Estimates of CLI and BAS demonstrate the following changes in economic activity in the real sector over the entire research period (Graph 1):

- deterioration of economic activity from September 2016 to March 2017 with the deterioration of BAS in the service sectors, as well as in some months in the construction and mining industry; deterioration of economic activity from January 2020 to September 2021 with the deterioration of BAS in all four sectors: production, services, construction and mining;

- growth of economic activity from April 2017 to December 2019 (from 100.1 to 101.4) with an increase in the BAS in production, as well as in some months in the service, construction and mining sectors;

- revival of the situation with economic activity from January 2020 to September 2021 (from 99.5 to 99.9) with improvement in certain months of the BAS in the production, services and construction sectors.

- maintaining positive dynamics of economic activity from October 2021 to April 2023 at the level of 100.1 with an increase in the BAS in production, as well as in certain months in services and construction sectors.

4. Empirical models

The time series analysis in section 3 of this study demonstrated that the composite leading indicator and the business activity subindexes in the four sectors interact in the same direction: higher values of one indicator correspond to higher values of other indicators, and lower values of one indicator correspond to lower values of others. Therefore, we assume that there may be causal relationships between the series in the following combinations:

1. CLI and BAS in the service sector;
2. CLI and BAS in construction;
3. CLI and BAS in mining industry;
4. BAS in production and BAS in mining industry;
5. BAS in service sector and BAS in construction;
6. BAS in service sector and BAS in mining industry;
7. CLI and BAS in production;
8. BAS in production and BAS in service sector;
9. BAS in construction and BAS in production;
10. BAS in mining industry and BAS in construction.

The selection of a combination of series of leading indicators for inclusion in empirical models was carried out according to the Granger Causality tests. At the same time, the initial data were cleared of seasonality and outliers.

Regarding the presence of Granger causality at a significance level of 5% for ten combinations of paired series, two different results were obtained:

- causal relationships between the first six combinations have not been established (1-6);
- the causal relationships between the series are found in the following form:

7. CLI depends on the BAS in production;
8. BAS in production depends on the BAS in the service sector;
9. BAS in construction depends on the BAS in production;
10. BAS in mining depends on the BAS in construction.

To construct econometric models, the last four combinations of paired series (7-10) were included, which turned out to be cointegrated during the study period (Appendix 1).

In this regard, the analysis of the dynamics of short-term and long-term relationships between the series, based on the vector error correction model (VECM), is continued. When constructing a VECM model, it is necessary for all variables to be stationary at the first difference level. The results of the extended Dickey–Fuller test confirmed that the series under consideration are stationary at the level of the first differences (Appendix 2) and VECM models can be built for them.

Of the four recent types (7-10), the first two combinations (7,8) exhibited an ambiguous nature of the relationship between the variables and did not meet the necessary requirements for modeling, namely:

1) For the series of CLI and BAS in production, a negative sign was obtained in the normalized cointegrating equation of the Johansen model, meaning a negative

influence of BAS in production on CLI. The negative impact is explained by the fact that the growth of business activity in production does not lead to the synchronization of economic cycles, does not contribute to the growth of the composite leading indicator, as a result of which economic growth is not ensured. In addition, the VECM model does not match the quality in terms of the presence of serial correlation and heteroscedasticity of residues. The presence of serial correlation of residuals gives a signal that this model cannot be used to represent the data generation process. The heteroscedasticity of the residuals indicates the heterogeneity of observations, which is expressed in a different (non-constant) variance of the random error of the econometric model.

2) For the BAS series in production and BAS in the service sector, a negative sign was also obtained in the normalized cointegrating equation of the Johansen model, which indicates the opposite effect. Business activity in the production sector does not depend on activity in the service sector. If the business activity trends of these sectors continue, it can be expected that the synchronization of business activity cycles will decrease over time. The less synchronized the business activity cycles, the less similar the response that can be expected to common shocks (innovations). Also, the VECM model does not match the quality in terms of the absence of a normal distribution of residues.

Violation of the requirements regarding the absence of serial correlation and heteroscedasticity of residuals, as well as the non-normal distribution of residuals (for combinations 7 and 8 of series) indicates that the results of these tests are unreliable, and it is not possible to construct high-quality, satisfactory models for forecasting.

VECM models were built using the two remaining combinations (9 and 10):

- BAS in construction depends on BAS in production;
- BAS in mining depends on BAS in construction.

The choice of VECM model parameters was based on the best statistical test options, as well as optimal lag options.

4.1 Model of the dependence of BAS in construction on BAS in production

The first step in building a model is to determine the appropriate lag. To do this, we will use the multidimensional information criterion in EViews.

Table 1 presents the data of the information criteria for determining the lag: Akaike, AIC, Schwarz, SC and Hannan-Quinn, HQ).

The optimal amount of lag is determined using the lowest value of the criterion: the lower the value according to the criterion, the fewer errors and the higher quality. Therefore, we choose 2 lags as recommended by the Akaike and Hannan-Quinn criteria (Table 1).

Table 1. Recommended lags by criteria

VAR Lag Order Selection Criteria
Endogenous variables: CONSTRUCTION_SA_TRM PRODUCTION_SA_TRM
Exogenous variables: C
Sample: 2016M09 2023M04
Included observations: 45

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-164.7604	NA	5.673666	7.411575	7.491871	7.441509
1	-149.4915	28.50211	3.439662	6.910731	7.151620*	7.000532
2	-143.0863	11.38703*	3.095415*	6.803833*	7.205314	6.953501*
3	-142.6630	0.714840	3.640563	6.962800	7.524872	7.172335
4	-137.0408	8.995433	3.407164	6.890704	7.613369	7.160106
5	-134.6918	3.549647	3.700733	6.964081	7.847338	7.293350

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: author's calculations

To check the causal relationship between the series of BAS in construction and BAS in production, we use the Granger test (Engle and Granger, 1987).

The result of the Granger test showed that at a significance level of 5%, a number of BAS in production is the cause of a number of BAS in construction according to Granger, which means that BAS in production predicts a change in BAS in construction (Table 2).

Table 2. Granger causality test

Pairwise Granger Causality Tests
Sample: 2016M09 2023M04
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
PRODUCTION_SA_TRM does not Granger Cause CONSTRUCTION_SA_TRM	60	4.70349	0.0130
CONSTRUCTION_SA_TRM does not Granger Cause PRODUCTION_SA_TRM		0.18265	0.8336

Source: author's calculations

The Trace test statistics indicate 2 cointegrating equations at a significance level of 5%. Consequently, the series of BAS in construction and BAS in production are co-integrated over the study period (Appendix 1, Table C).

The normalized equation has the form (2):

*Normalized Cointegrating Equation= CONSTRUCTION_SA_TRM-0,996*PRODUCTION_SA_TRM* (2),

where *CONSTRUCTION_SA_TRM* and *PRODUCTION_SA_TRM* are the BAS in construction and BAS in production, respectively.

The signs of the coefficients should be reversed in the normalized cointegrating equation of the Johansen model, which characterizes the long-term period.

CONSTRUCTION_SA_TRM – is a target variable (dependent). *PRODUCTION_SA_TRM* – shows a positive and significant impact on *CONSTRUCTION_SA_TRM* in the long term, since the coefficient - 3.4 is statistically significant at the significance level of 5%. Therefore, in the long term, the BAS in production has a positive impact on the BAS in construction, on average, under other equal conditions. Thus, the null hypothesis of the absence of cointegration is rejected in favor of an alternative one, therefore, the series under consideration are cointegrated (Appendix 1, Table C).

The first part of Table G (Appendix 3) is a model of vector error correction in the long term, and the second part characterizes the adjusted coefficients in the short term and shows the effects, under other equal conditions.

The equation of cointegration of BAS in construction and BAS in production in the long term has the form (3):

$$ECT(-1) = CONSTRUCTION\_SA\_TRM(-1) - 1{,}106 * PRODUCTION\_SA\_TRM(-1) + 7{,}108 \quad (3),$$

where ECT (Error correction term) – characterizes the speed of correction. ECT describes any movement of a dependent variable. This is a function of the imbalance in the cointegration relationship and is very close to other independent variables (Engle and Granger, 1987).

BAS in construction as a dependent (target) variable is determined by the following equation (4):

$$D(CONSTRUCTION\_SA\_TRM) = -0{,}918 * ECT(-1) + 0{,}010 * D(CONSTRUCTION\_SA\_TRM(-1)) - \\ -0{,}131 * D(PRODUCTION\_SA\_TRM(-1)) + 0{,}138 \quad (4)$$

In equation (4), the correction (adjusted) coefficients mean the following. The deviation of the previous periods from the long-term equilibrium is corrected with a correction rate of 91.8%. A change in the BAS in production causes a slowdown in the BAS in construction by 0.13 on average, under other equal conditions in the short term.

The error correction coefficient means the rate of correction at which the model will restore its equilibrium after any disturbances. The ECT coefficient in the construction of BAS (-5.1) is negative and statistically significant, which indicates a convergence from short-term dynamics to long-term equilibrium. In the case of BAS in production, the correction coefficient is positive and small (0.2), which characterizes a minor influence on BAS in construction (Appendix 3, Table G).

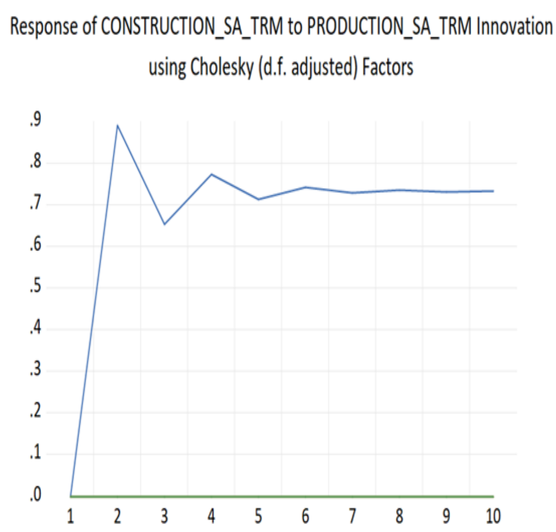
The quality of the VECM model was verified by diagnostic tests for the absence of serial correlation and heteroskedasticity of residues, as well as the presence of a normal distribution of residues (Appendix 3, Tables H, I, J).

We use the pulse response function in order to analyze the parameters of the VECM model.

Graph 2 shows the function of the impulse responses of the BAS in construction to the change in the BAS in production. The pulse response function shows how long and to what extent the dependent variable (BAS in construction) reacts to the shock caused by the independent variable (BAS in production).

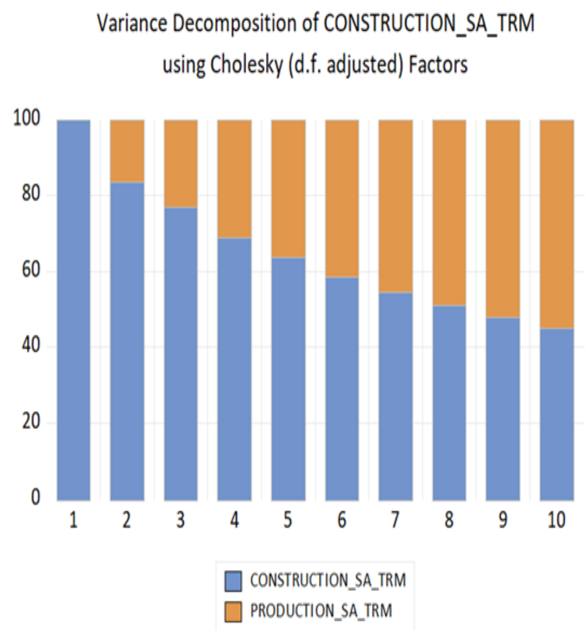
This function has a positive effect. If the change in the BAS in production was unexpected by 1%, then the BAS in construction will change as follows on average, all other things being equal: from 1 to 2 months – an increase of 0.9%, from 2 to 3 months – a slowdown from 0.9% to 0.7%, from 3 to 4 months – an increase from 0.7% to 0.8%, from 4 to 8 months – a slowdown from 0.8% to 0.7% and from 8 months – stabilization of the level.

Graph 2. Function of impulse responses of BAS in construction to changes in BAS in production



Source: author's calculations

Graph 3. Decomposition of the dispersion of BAS in construction by the change in BAS in production



Source: author's calculations

The resulting pulse response function illustrates that the BAS in production predicts a change in the BAS in construction, and its influence has a positive impact. Consequently, an increase in BAS in production will lead to an increase in BAS in construction. Production sector supplies construction sector with the necessary materials, which means that, while waiting for demand to grow, construction firms carry out necessary purchase of material, which is a signal to enterprises producing materials to increase production.

Graph 3 shows the decomposition of variance, characterizing how much a number of BAS in construction is explained by its own innovative shocks and the influence of shocks from BAS in production, respectively. From the 2nd month, the share of the BAS influence in production will be 16.5%, by the 8th month it will increase to 49.1%, and by the 10th month it will increase to 54.9%.

For comparison, the authors of Boldrin et al. (2016) in their study note that it is the enterprises of the construction sector that purchase materials from industries, and they account for about 5% of the final volume of production in the US economy. This result strongly and positively correlates with the conditions of doing business in the USA. This means that construction occupies a central place in the USA production network.

Thus, the construction industry was a major player during the Great Recession in its relationship with other industries. The construction industry buys a lot of material resources from other industries and sells a lot of material resources to other industries. In fact, resources acquired in other industries account for 38% of the gross output of the construction industry. The industry groups from which the construction industry buys the most are other services, metal production, wholesale and retail trade, as well as finance, insurance and real estate; while the industry groups to which the construction industry sells the most are the production of metals, lumber, electrical equipment and mining.

In addition, these authors emphasize that the construction industry is closely connected with other industries, and it is slowly recovering after the recession. In particular, after the US housing crisis began in 2007, it took a long time for the existing housing stock to be sold off and there was a demand for new homes.

4.2 The model of dependence of the BAS in mining on the BAS in construction

The optimal lag for constructing the model is a lag equal to 1, as suggested by the criteria of Akaike, Schwartz and Hannan-Quinn (Table 3).

Table 3. Recommended lags by criteria

VAR Lag Order Selection Criteria
Endogenous variables: MINING_SA_TRM CONSTRUCTION_SA_TRM
Exogenous variables: C
Sample: 2016M09 2023M04
Included observations: 42

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-178.5913	NA	18.61282	8.599587	8.682333	8.629917
1	-166.6223	22.22823*	12.74121*	8.220108*	8.468347*	8.311098*
2	-164.7766	3.251853	14.14288	8.322697	8.736428	8.474345
3	-163.5964	1.967132	16.24025	8.456969	9.036192	8.669277
4	-161.2796	3.640540	17.72303	8.537126	9.281841	8.810094
5	-155.0879	9.140218	16.15117	8.432756	9.342964	8.766384
6	-154.1382	1.311403	18.99616	8.578012	9.653712	8.972298

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: author's calculations

Based on the result of the Granger test, it can be seen that at the significance level of 5%, a series of BAS in construction is the cause of a series of BAS in mining according to Granger. Hence, the BAS in construction predicts a change in the BAS in the mining (Table 4).

Table 4. Granger Causality Test

Pairwise Granger Causality Tests
Sample: 2016M09 2023M04
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
CONSTRUCTION_SA_TRM does not Granger Cause MINING_SA_TRM	67	5.58728	0.0211
MINING_SA_TRM does not Granger Cause CONSTRUCTION_SA_TRM		0.71830	0.3999

Source: author's calculations

Test statistics of both Trace and Max-eigenvalue indicate 2 cointegrating equations at a significance level of 5%. Therefore, the series of BAS in the mining and BAS in construction are co-integrated (Appendix 1, Table D).

The normalized equation has the form (5):

$$\textit{Normalized Cointegrating Equation} = \textit{MINING\_SA\_TRM} - 0{,}921 * \textit{CONSTRUCTION\_SA\_TRM} \quad (5),$$

where *MINING_SA_TRM* and *CONSTRUCTION_SA_TRM* are BAS in mining and BAS in construction, respectively.

In the normalized cointegrating equation of the Johansen model, the signs of the coefficients must be reversed, this model represents a long-term period. *MINING_SA_TRM* is a dependent variable. *CONSTRUCTION_SA_TRM* – characterizes a positive and significant impact on *MINING_SA_TRM* in the long term, since the coefficient - 4.7 is statistically significant at the significance level of 5%. Therefore, in the long term, the BAS in construction has a positive impact on the BAS in the mining, on average, all other things being equal. In this regard, the series under consideration are co-integrated (Appendix 1, Table D).

As shown in the data (Appendix 4, Table K), the cointegration equation for the BAS in the mining industry and the BAS in construction in the long term is as follows (6):

$$ECT(-1) = \textit{MINING\_SA\_TRM}(-1) - 1{,}042 * \textit{CONSTRUCTION\_SA\_TRM}(-1) + 2{,}217 \quad (6),$$

BAS in mining as a dependent variable is determined by the following equation (7):

$$D(\textit{MINING\_SA\_TRM}) = -0{,}284 * ECT(-1) - 0{,}025 \quad (7)$$

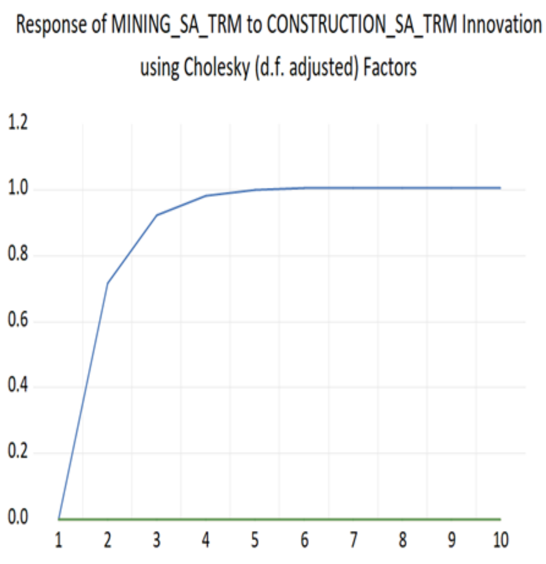
In equation (7), the correction (adjusted) coefficient (-0.284) means that the deviation of previous periods from long-term equilibrium is corrected at a rate of 28.4%.

The error correction coefficient characterizes the rate of correction at which the model will restore its equilibrium after any disturbances. The ECT coefficient for the BAS in mining (-4.2) is negative and statistically significant, which indicates a convergence from short-term dynamics to long-term equilibrium. In the case of BAS in construction, the adjustment coefficient is positive and statistically significant (4.1), which indicates a significant impact on BAS in mining (Appendix 4, Table K).

The quality of the VECM model was confirmed by diagnostic tests for the absence of serial correlation and heteroscedasticity of residues, as well as the presence of a normal distribution of residues (Appendix 4, Tables L, M, N).

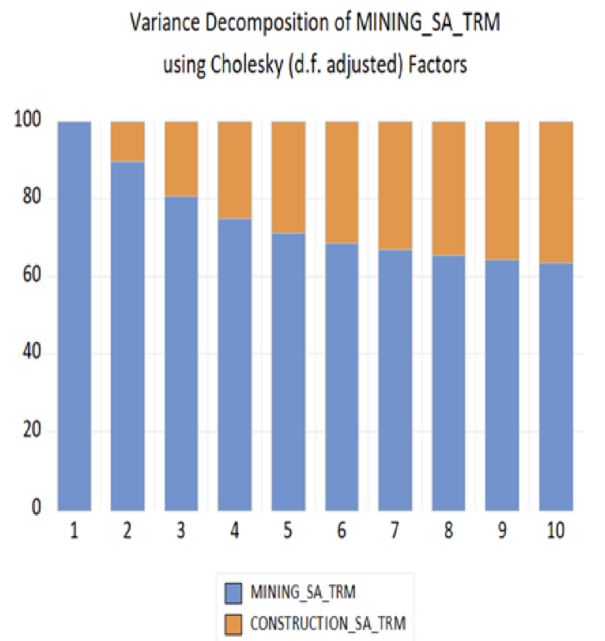
Graph 4 shows the function of impulse responses of the BAS in the mining to changes in the BAS in construction. The pulse response function shows how long and to what extent the dependent variable (BAS in mining) reacts to the shock caused by the independent variable (BAS in construction). This function has a positive effect. If the change in the BAS in construction was unexpected by 1%, then the BAS in the mining industry will change as follows on average, all other things being equal: from 1 to 2 months – an increase of 0.7%, from 2 to 3 months – an increase from 0.7% to 0.9%, from 3 to 5 months – an increase from 0.9% to 1.0% and from the 5th month – stabilization of the level.

Graph 4. Function of impulse responses of BAS in the mining industry to changes in BAS in construction



Source: author's calculations

Graph 5. Decomposition of the variance of BAS in the mining industry on the change in BAS in construction



Source: author's calculations

The impulse response function illustrates that the BAS in construction predicts a change in the BAS in the mining industry, while its influence has a positive impact. Therefore, with an increase in the BAS in construction, the BAS in the mining will increase. Construction companies offer and produce capital goods and services for the mining industry, such as: drilling wells, trenches, pits, quarries, mines, and also carry out design work.

The dispersion decomposition shows how much a number of BAS in the mining industry will be explained by its own innovative shocks and the impact of BAS shocks in construction, respectively. If from the 2nd month the share of BAS influence in construction will be 10.5%, for the 5th month it will increase to 28.8%, then by the 10th month it will increase to 36.7% (Graph 5).

5. Conclusions

Based on the results of the study of leading economic indicators, the following results were revealed.

1. Checking the data of ten combinations of paired series using statistical tests showed three different results: no connection, negative unidirectional and positive unidirectional connections between variables.

2. The absence of causal relationships between six series combinations indicates that the following indicators do not depend on each other:

1) CLI and BAS in the service sector;
2) CLI and BAS in construction;
3) CLI and BAS in mining;
4) BAS in production and BAS in mining;
5) BAS in service sector and BAS in construction;
6) BAS in the service sector and BAS in the mining industry.

3. Negative unidirectional links indicate the opposite effect caused by a decrease in the synchronization of business cycles, and statistical tests indicate the unreliability, unsatisfactoriness of econometric models for forecasting in the following two combinations of series: the business activity subindex in production negatively affects the composite leading indicator of the real sector; business activity subindex in the service sector negatively affects business activity subindex in production.

The less synchronized the business activity cycles are, the less similar the response can be expected to common shocks (innovations), and the less likely the predictive property of these combinations of leading indicators is to be manifested.

4. Positive unidirectional cause-and-effect relationships in business activity: from production to construction, from construction to mining. Production sector supplies the necessary building materials for the growth of the activity of construction sector. In turn, the growth of activity in construction increases the activity of mining industry to extract and process raw materials for construction in the long term. The impulse response functions calculated on the basis of VECM models indicated a positive effect of the impact of these indicators on future changes in the turning points of the phases of economic cycle. Time by months and the levels of turning points have been forecasted: expansion, slowdown, and stabilization.

Decomposition of variances established the share of the impact of their own innovation shocks and shocks of other influencing sectors of the economy.

5. The results of the evaluation of VECM models indicate that there are two models that have long-term cointegration relationships. These models determined the impact of business activity in production on business activity in construction, as well as business activity in construction on business activity in mining industry.

6. The practical significance of the study lies in the possibility of applying by the regulator and government agencies business activity subindexes in production, construction and mining sectors as the best variables for analyzing and forecasting economic activity in Kazakhstan.

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Appendix 1

Table A. Johansen's cointegration test

Sample (adjusted): 2017M03 2023M04
Included observations: 40 after adjustments
Trend assumption: Linear deterministic trend
Series: CLI_SA_TRM PRODUCTION_SA_TRM
Lags interval (in first differences): 1 to 5

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.263859	17.71114	15.49471	0.0228
At most 1 *	0.127546	5.457817	3.841465	0.0195

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.263859	12.25332	14.26460	0.1015
At most 1 *	0.127546	5.457817	3.841465	0.0195

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CLI_SA_TRM	PRODUCTION_SA_TRM
1.063149	0.878875
3.141081	-0.783451

Unrestricted Adjustment Coefficients (alpha):

D(CLI_SA_TRM)	-0.001305	0.020169
D(PRODUCTION_SA_TRM)	-0.410369	0.088595

1 Cointegrating Equation(s): Log likelihood 17.11490

Normalized cointegrating coefficients (standard error in parentheses)

CLI_SA_TRM	PRODUCTION_SA_TRM
1.000000	0.826672
	(0.32175)

Adjustment coefficients (standard error in parentheses)

D(CLI_SA_TRM)	-0.001387
	(0.01135)
D(PRODUCTION_SA_TRM)	-0.436283
	(0.14646)

Source: author's calculations

Table B. Johansen's cointegration test

Sample (adjusted): 2016M12 2023M04
Included observations: 59 after adjustments
Trend assumption: Linear deterministic trend
Series: PRODUCTION_SA_TRM SERVICES_SA_TRM
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.313403	30.14873	15.49471	0.0002
At most 1 *	0.126273	7.964254	3.841465	0.0048

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.313403	22.18448	14.26460	0.0023
At most 1 *	0.126273	7.964254	3.841465	0.0048

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

PRODUCTION_SA_TRM	SERVICES_SA_TRM
0.177253	0.580228
1.190736	-0.575829

Unrestricted Adjustment Coefficients (alpha):

D(PRODUCTION_SA_TRM)	0.087569	-0.313080
D(SERVICES_SA_TRM)	-0.533013	-0.051567

1 Cointegrating Equation(s):		Log likelihood	-147.5504

Normalized cointegrating coefficients (standard error in parentheses)

PRODUCTION_SA_TRM	SERVICES_SA_TRM
1.000000	3.273451
	(0.75552)

Adjustment coefficients (standard error in parentheses)

D(PRODUCTION_SA_TRM)	0.015522
	(0.02168)
D(SERVICES_SA_TRM)	-0.094478
	(0.01953)

Source: author's calculations

Table C. Johansen's cointegration test

Sample (adjusted): 2016M12 2023M04
Included observations: 55 after adjustments
Trend assumption: Linear deterministic trend
Series: CONSTRUCTION_SA_TRM PRODUCTION_SA_TRM
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	Prob.**
None *	0.204455	20.27299	15.49471	0.0088
At most 1 *	0.130531	7.692977	3.841465	0.0055

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.204455	12.58001	14.26460	0.0907
At most 1 *	0.130531	7.692977	3.841465	0.0055

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CONSTRUCTION_SA_TRM	PRODUCTION_SA_TRM
-0.899794	0.896462
0.222603	-1.183424

Unrestricted Adjustment Coefficients (alpha):

D(CONSTRUCTION_SA_TRM)	0.992931	-0.025268
D(PRODUCTION_SA_TRM)	0.080492	0.341015

1 Cointegrating Equation(s): Log likelihood -190.2096

Normalized cointegrating coefficients (standard error in parentheses)

CONSTRUCTION_SA_TRM	PRODUCTION_SA_TRM
1.000000	-0.996297
	(0.29235)

Adjustment coefficients (standard error in parentheses)

D(CONSTRUCTION_SA_TRM)	-0.893433
	(0.25193)
D(PRODUCTION_SA_TRM)	-0.072427
	(0.12303)

Source: author's calculations

Table D. Johansen's cointegration test

Sample (adjusted): 2016M11 2023M04
Included observations: 62 after adjustments
Trend assumption: Linear deterministic trend
Series: MINING_SA_TRM CONSTRUCTION_SA_TRM
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.331762	35.45607	15.49471	0.0000
At most 1 *	0.155289	10.46317	3.841465	0.0012

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.331762	24.99290	14.26460	0.0007
At most 1 *	0.155289	10.46317	3.841465	0.0012

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

MINING_SA_TRM	CONSTRUCTION_SA_TRM
-0.450236	0.414588
0.376453	0.276768

Unrestricted Adjustment Coefficients (alpha):

D(MINING_SA_TRM)	0.801064	-0.398923
D(CONSTRUCTION_SA_TRM)	-0.817514	-0.821053

1 Cointegrating Equation(s):	Log likelihood	-254.3819

Normalized cointegrating coefficients (standard error in parentheses)

MINING_SA_TRM	CONSTRUCTION_SA_TRM
1.000000	-0.920823
	(0.19795)

Adjustment coefficients (standard error in parentheses)

D(MINING_SA_TRM)	-0.360668
	(0.09000)
D(CONSTRUCTION_SA_TRM)	0.368074
	(0.14099)

Source: author's calculations

Appendix 2

The Extended Dickey-Fuller test (Augmented Dickey-Fuller, ADF) showed that the absolute value of t-Statistical for a number of CLI (1.85) is less than all absolute values of critical values at the significance levels of 1%, 5% and 10%, respectively: 3.52, 2.90 and 2.59. The absolute value of t-Statistical for a number of BAS in the service sector (3.50) is less than the absolute value of the critical value (3.52) at the significance level of 1%. This means that these series are non-stationary (Table E).

The absolute values of t-Statistical in the series of BAS in production, BAS in construction and BAS in mining (4.14, 4.32 and 4.49, respectively) are greater than all the absolute values of critical values. Consequently, these series are stationary (Table E).

Table E. The results of the extended Dickey–Fuller test for the stationarity of CLI and BAS series

		t-Statistic	Prob.*
Null Hypothesis: CLI_SA has a unit root Exogenous: Constant Lag Length: 6 (Automatic - based on SIC, maxlag=11)	Augmented Dickey-Fuller test statistic	-1.853343	0.3523
	Test critical values:		
	1% level	-3.522887	
	5% level	-2.901779	
	10% level	-2.588280	
Null Hypothesis: PRODUCTION_SA has a unit root Exogenous: Constant Lag Length: 0 (Automatic - based on SIC, maxlag=11)	Augmented Dickey-Fuller test statistic	-4.140624	0.0015
	Test critical values:		
	1% level	-3.515536	
	5% level	-2.898623	
	10% level	-2.586605	
Null Hypothesis: SERVICES_SA has a unit root Exogenous: Constant Lag Length: 0 (Automatic - based on SIC, maxlag=11)	Augmented Dickey-Fuller test statistic	-3.497099	0.0105
	Test critical values:		
	1% level	-3.515536	
	5% level	-2.898623	
	10% level	-2.586605	
Null Hypothesis: CONSTRUCTION_SA has a unit root Exogenous: Constant Lag Length: 0 (Automatic - based on SIC, maxlag=11)	Augmented Dickey-Fuller test statistic	-4.316452	0.0008
	Test critical values:		
	1% level	-3.515536	
	5% level	-2.898623	
	10% level	-2.586605	
Null Hypothesis: MINING_SA has a unit root Exogenous: Constant Lag Length: 0 (Automatic - based on SIC, maxlag=11)	Augmented Dickey-Fuller test statistic	-4.493890	0.0005
	Test critical values:		
	1% level	-3.515536	
	5% level	-2.898623	
	10% level	-2.586605	
*MacKinnon (1996) one-sided p-values			

Source: author's calculations

Given that the series of CLI and BAS in the service sector are non-stationary, we will check them for stationarity at the level of the first differences. The results of the extended Dickey–Fuller test showed that the CLI and BAS series in the service sector are stationary at the level of the first differences (Table F).

Table F. Results of the extended Dickey–Fuller test for stationarity of CLI and BAS series in the service sector at the first difference level

		t-Statistic	Prob.*
Null Hypothesis: D(CLI_SA) has a unit root Exogenous: Constant Lag Length: 5 (Automatic - based on SIC, maxlag=11)	Augmented Dickey-Fuller test statistic	-3.560581	0.0090
	Test critical values:		
	1% level	-3.522887	
	5% level	-2.901779	
	10% level	-2.588280	
Null Hypothesis: D(SERVICES_SA) has a unit root Exogenous: Constant Lag Length: 1 (Automatic - based on SIC, maxlag=11)	Augmented Dickey-Fuller test statistic	-8.296548	0.0000
	Test critical values:		
	1% level	-3.517847	
	5% level	-2.899619	
	10% level	-2.587134	
*MacKinnon (1996) one-sided p-values			

Source: author's calculations

Table G. VECM

Vector Error Correction Estimates Sample (adjusted): 2016M11 2023M04 Included observations: 60 after adjustments Standard errors in ( ) & t-statistics in [ ]		
Cointegrating Eq:	CointEq1	
CONSTRUCTION_SA_TRM(-1)	1.000000	
PRODUCTION_SA_TRM(-1)	-1.106215 (0.24408) [-4.53212]	
C	7.107971	
Error Correction:	D(CONSTRUCTION_SA_TRM)	D(PRODUCTION_SA_TRM)
CointEq1	-0.918297 (0.18002) [-5.10107]	0.018317 (0.09213) [0.19882]
D(CONSTRUCTION_SA_TRM(-1))	0.009705 (0.13347) [0.07272]	-0.008145 (0.06831) [-0.11925]
D(PRODUCTION_SA_TRM(-1))	-0.130541 (0.29081) [-0.44889]	-0.484548 (0.14883) [-3.25569]
C	0.137764 (0.25755) [0.53489]	-0.033751 (0.13181) [-0.25605]
R-squared	0.466770	0.189108
Adj. R-squared	0.438204	0.145667
Sum sq. resids	219.4396	57.47605
S.E. equation	1.979536	1.013093
F-statistic	16.34011	4.353247
Log likelihood	-124.0383	-83.84702
Akaike AIC	4.267943	2.928234
Schwarz SC	4.407566	3.067857
Mean dependent	0.128405	-0.076860
S.D. dependent	2.641035	1.096064
Determinant resid covariance (dof adj.)		3.957327
Determinant resid covariance		3.447272
Log likelihood		-207.4001
Akaike information criterion		7.246671
Schwarz criterion		7.595728
Number of coefficients		10

Source: author's calculations

The probability values for lags 1 (0.96) and 2 (0.70) are higher than the significance level of 5%, so there is no serial correlation of residuals in the VECM model (Table H).

Table H. Test for serial correlation of residuals

VEC Residual Serial Correlation LM Tests
Sample: 2016M09 2023M04
Included observations: 60

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	0.616830	4	0.9612	0.153208	(4, 106.0)	0.9612
2	2.222101	4	0.6950	0.556088	(4, 106.0)	0.6950

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	0.616830	4	0.9612	0.153208	(4, 106.0)	0.9612
2	3.645227	8	0.8876	0.450408	(8, 102.0)	0.8877

*Edgeworth expansion corrected likelihood ratio statistic.

Source: author's calculations

There is no heteroscedasticity of residuals in the VECM model, since the probability value according to Joint test (0.37) is higher than the significance level of 0.05 (Table I).

Table I. Test for the presence of heteroskedasticity of residuals

VEC Residual Heteroskedasticity Tests (Levels and Squares)
Sample: 2016M09 2023M04
Included observations: 60

Joint test:

Chi-sq	df	Prob.
19.36991	18	0.3694

Individual components:

Dependent	R-squared	F(6,53)	Prob.	Chi-sq(6)	Prob.
res1*res1	0.119100	1.194289	0.3237	7.145997	0.3076
res2*res2	0.049073	0.455848	0.8376	2.944379	0.8158
res2*res1	0.150999	1.571049	0.1739	9.059929	0.1702

Source: author's calculations

The series of BAS in construction and BAS in production, both individually and as a whole in the model, have a normal distribution of residues, since the value of the probabilities according to Jarque-Bera is higher than the significance level of 0.05 (Table J).

Table J. Test for normal distribution of residuals

VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: Residuals are multivariate normal
Sample: 2016M09 2023M04
Included observations: 60

Component	Skewness	Chi-sq	df	Prob.*
1	-0.115481	0.133358	1	0.7150
2	-0.592571	3.511408	1	0.0609
Joint		3.644766	2	0.1616

Component	Kurtosis	Chi-sq	df	Prob.
1	4.034173	2.673786	1	0.1020
2	3.241018	0.145224	1	0.7031
Joint		2.819010	2	0.2443

Component	Jarque-Bera	df	Prob.
1	2.807144	2	0.2457
2	3.656632	2	0.1607
Joint	6.463776	4	0.1671

*Approximate p-values do not account for coefficient estimation

Source: author's calculations

Table K. VECM

Vector Error Correction Estimates
Sample (adjusted): 2016M10 2023M04
Included observations: 67 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
MINING_SA_TRM(-1)	1.000000	
CONSTRUCTION_SA_TRM(-1)	-1.042121 (0.19157) [-5.44003]	
C	2.216510	
Error Correction:	**D(MINING_SA_TRM)**	**D(CONSTRUCTION_SA_TRM)**
CointEq1	-0.284376 (0.06799) [-4.18259]	0.409872 (0.10009) [4.09497]
C	-0.024568 (0.20219) [-0.12151]	-0.027864 (0.29766) [-0.09361]
R-squared	0.212064	0.205076
Adj. R-squared	0.199942	0.192846
Sum sq. resids	178.0397	385.8477
S.E. equation	1.655014	2.436415
F-statistic	17.49406	16.76879
Log likelihood	-127.8089	-153.7190
Akaike AIC	3.874892	4.648329
Schwarz SC	3.940704	4.714140
Mean dependent	-0.024568	-0.027864
S.D. dependent	1.850296	2.711896

Determinant resid covariance (dof adj.)	16.01351
Determinant resid covariance	15.07175
Log likelihood	-281.0173
Akaike information criterion	8.567681
Schwarz criterion	8.765116
Number of coefficients	6

Source: author's calculations

The probability values for lag 1 (0.19) are higher than the significance level of 0.05, and therefore there is no serial correlation of residuals in the VECM model (Table L).

Table L. Test for serial correlation of residuals

VEC Residual Serial Correlation LM Tests
Sample: 2016M09 2023M04
Included observations: 67

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	6.158026	4	0.1877	1.565434	(4, 124.0)	0.1877

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	6.158026	4	0.1877	1.565434	(4, 124.0)	0.1877

*Edgeworth expansion corrected likelihood ratio statistic.

Source: author's calculations

There is no heteroscedasticity of residuals in the VECM model, since the probability value according to Joint test (0.98) is higher than the significance level of 0.05 (Table M).

Table M. Test for heteroskedasticity of residuals

VEC Residual Heteroskedasticity Tests (Levels and Squares)
Sample: 2016M09 2023M04
Included observations: 67

Joint test:

Chi-sq	df	Prob.
1.023680	6	0.9847

Individual components:

Dependent	R-squared	F(2,64)	Prob.	Chi-sq(2)	Prob.
res1*res1	0.004794	0.154141	0.8575	0.321185	0.8516
res2*res2	0.003421	0.109862	0.8961	0.229236	0.8917
res2*res1	0.011053	0.357655	0.7007	0.740564	0.6905

Source: author's calculations

The BAS series in the mining and BAS in construction, both individually and as a whole, in the model have a normal distribution of residues, since the Jarque-Bera probability value is higher than the significance level of 0.05 (Table N).

Table N. Test for the presence of normal distribution of residuals

VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: Residuals are multivariate normal
Sample: 2016M09 2023M04
Included observations: 67

Component	Skewness	Chi-sq	df	Prob.*
1	0.260791	0.759465	1	0.3835
2	-0.100077	0.111839	1	0.7381
Joint		0.871304	2	0.6468

Component	Kurtosis	Chi-sq	df	Prob.
1	2.643877	0.354050	1	0.5518
2	3.680941	1.294442	1	0.2552
Joint		1.648492	2	0.4386

Component	Jarque-Bera	df	Prob.
1	1.113514	2	0.5731
2	1.406282	2	0.4950
Joint	2.519796	4	0.6411

*Approximate p-values do not account for coefficient estimation

Source: author's calculations