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An Investigation on the Effects of Oil Price, Industrial Production and Agricultural Production on Inflation in Kazakhstan Using the Toda-Yamamoto Model with Structural Breaks

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ABSTRACT

This article analyzes the impact of oil prices, as well as industrial and agricultural production activities, on inflation in the Kazakh economy using a structural break model. The research was conducted using annual data from 1996 to 2023, employing Toda-Yamamoto causality and Gregory-Hansen cointegration tests. The aim of the study is to provide strategic recommendations to policymakers by examining the dynamic relationships between various economic indicators. The macroeconomic data were analyzed to understand how industrial and agricultural production, alongside oil prices, influence inflation. The findings reveal that oil prices have a direct and statistically significant impact on inflation. Additionally, a bidirectional causality relationship was identified between industrial production and inflation. In contrast, agricultural production was found to affect inflation in the short term but does not have a significant long-term influence. This suggests that agricultural production plays a limited role in the dynamics of inflation. Based on the analysis, the study emphasizes the need to prioritize these factors in economic policy, particularly the impacts of oil prices and industrial production on inflation. It also highlights the importance of increasing industrial production capacity and wisely utilizing oil revenues to support economic diversification. These findings offer valuable guidance for ensuring Kazakhstan's economic stability and fostering long-term growth.

Keywords: Kazakhstan, Oil Price, Industrial Production, Agricultural Production, Inflation, Toda–Yamamoto, Gregory–Hansen Cointegration Test
JEL Classifications: C13, C20, C22

1. INTRODUCTION

Inflation is a key macroeconomic phenomenon characterized by a continuous increase in the general price level of goods and services within an economy. It significantly impacts economic stability. Changes in inflation rates have important consequences across various areas, including economic growth, employment, income distribution, and social welfare, and they can have long-term effects on overall economic performance (Samuelson and Nordhaus, 2009; Niyetalina et al., 2023). While the general price level reflects the absolute prices of goods and services, inflation specifically refers to the ongoing rise in this level. The inflation rate indicates the change in the price level compared to previous periods. A negative inflation rate is termed deflation, which can hinder economic growth, particularly during periods of decreasing demand (Carlin and Soskice, 2006).

High inflation can create economic uncertainties by reducing purchasing power, whereas low and stable inflation rates provide a conducive environment for sustainable economic growth

(Fischer, 1993). Maintaining control over inflation can foster investment by bolstering consumer confidence and helping to reduce income inequalities. However, extremely low inflation rates or deflation may result in stagnant economic activity, reduced consumer spending, and an increased real burden of debt. Thus, understanding the causes and dynamics of inflation is crucial for developing economic policies aimed at ensuring price stability and promoting sustainable growth.

Various indicators, such as the Consumer Price Index (CPI), Producer Price Index (PPI), and Gross Domestic Product (GDP) Deflator, are employed to measure and analyze inflation (Stanford, 2008). These indicators not only assess inflation rates but also provide policymakers with a comprehensive framework for analyzing price movements throughout the economy. Different economic approaches address the sources and effects of inflation. According to monetarist theory, inflation results from an increase in the money supply, explained by the principle that "too much money chasing too few goods" (Friedman, 1968). Keynesian approaches categorize inflation as demand-pull and cost-pull inflations. Demand-pull inflation occurs when aggregate demand exceeds aggregate supply, while cost-pull inflation arises from increases in costs such as energy, labor, and other inputs (Blanchard and Johnson, 2013). Fluctuations in commodity prices affect production costs and consumer prices, adding complexity to the dynamics of inflation.

Kazakhstan is notable for its substantial natural resources. The country holds 3.3% of the world's coal reserves, 3% of its oil reserves, and 1.1% of its natural gas reserves (Mudarissov and Lee, 2014; Xiong et al., 2015; Bekzhanova et al., 2023; Issayeva et al., 2023; Dyussembekova et al., 2023; Ibyzhanova et al., 2024; Sabenova et al., 2024; Sultanova et al., 2024; Yesbolova et al., 2024). While this wealth presents opportunities for economic growth, it also heightens the impact of external shocks, such as fluctuations in oil prices, on inflation. Rising oil prices can lead to cost-pull inflation by increasing production costs, while falling prices may strain budget balances by reducing public revenues (Hamilton, 1983; Kilian, 2009). Furthermore, increased oil revenues can result in economic imbalances, known as "Dutch disease," particularly in situations where economic diversification is limited (Corden and Neary, 1982). This issue influences not only inflation dynamics but also long-term growth prospects.

Industrial production typically exerts downward pressure on prices by increasing supply. However, rises in energy prices, supply chain disruptions, and escalating production input costs can offset this positive effect (Baumeister and Peersman, 2013). The industrial production index measures changes in production activities within the industrial sector over time and is crucial for evaluating this sector's impact on economic growth (Issayeva et al., 2023). The performance of the industrial sector directly affects both domestic demand and export activities, making the impact of production changes on inflation rates especially significant in developing economies.

Agricultural production is another key factor in determining inflation. Although Kazakhstan has a high agricultural production potential due to its vast agricultural lands and meadows, it faces challenges such as adverse climatic conditions, technological limitations, and inadequate infrastructure in this sector (FAO, 2020; Liang et al., 2020; Aidarova et al., 2024). Despite 67.53% of the country's land being classified as meadows, Kazakhstan, which was a major agricultural producer during the Soviet Union era, has seen a significant decline in agriculture's contribution to GDP. This share dropped from 34.9% in 1990 to just 10.9% in 1997 (Timor et al., 2018). As a result, the reduced significance of the agricultural sector in driving economic growth has complicated the effects of agricultural production on inflation.

Fluctuations in food prices contribute to rising general inflation rates and disproportionately affect low-income households (Ivanic and Martin, 2008). Ensuring sustainable agricultural production is essential not only for price stability but also for meeting society's basic food needs. In Kazakhstan, agricultural production is the third-largest export sector, following energy and mining. Key agricultural exports include grain, cotton, and milk (Timor et al., 2018; Sartbayeva et al., 2023). However, the efficiency of agricultural production is limited by factors such as climate change, slow progress in technological innovation, and inadequate infrastructure.

In this context, it is crucial for policymakers to understand how oil prices, industrial production, and agricultural production impact inflation in Kazakhstan. This study will analyze these relationships using the Toda-Yamamoto causality model. The findings will enhance our understanding of the factors influencing inflation in resource-rich countries and contribute to developing strategies aimed at increasing economic stability. Additionally, this research seeks to significantly enrich the academic literature regarding the determinants of inflation in Kazakhstan.

2. LITERATURE REVIEW

Numerous studies have explored the Kazakh economy, oil price fluctuations, industrial production, and agricultural production on inflation, employing various analytical methods across different countries. The Toda-Yamamoto structural break test is one of the widely used approaches for examining the relationship between inflation and other macroeconomic indicators. In this context, this study will also provide insights from relevant studies.

Shahbaz et al. (2013) analyzed the relationships among economic growth, energy consumption, financial development, trade openness, and CO_2 emissions in Indonesia over the period from 1975 to 2011. They employed the Zivot-Andrews unit root test and the Autoregressive Distributed Lag (ARDL) bounds test to identify long-term relationships while accounting for structural breaks. The causality among the variables was examined using the VECM Granger causality method, and the results were further validated through the innovation accounting approach (IAA). The findings indicated that these variables are interrelated and exhibit a long-term relationship. It was noted that both economic growth and energy consumption contribute to increased CO_2 emissions, while financial development and trade openness have a mitigating effect. The study also proposed a feedback hypothesis between energy consumption and CO_2 emissions, along with bidirectional causality between economic growth and CO_2 emissions. This comprehensive analysis provides valuable insights for developing policies aimed at sustainable development and environmental protection.

Similarly, Farhani et al. (2014) investigated the impacts of natural gas consumption, fixed capital investments, and trade on real GDP within the Tunisian economy from 1980 to 2010. The study assessed long-term relationships among the variables using the ARDL bounds test method and analyzed causality relationships with the Toda-Yamamoto approach. The results showed that natural gas consumption, fixed capital formation, and trade support economic growth, and these variables have a causal influence on real GDP. It was recommended that energy policies be comprehensively redesigned to ensure sustained economic growth over the long term. This study made a significant contribution to the literature regarding the effects of energy consumption and trade on economic growth.

Kumar et al. (2015) explored the impacts of energy consumption, trade openness, and financial development on economic growth in South Africa from 1971 to 2011. They utilized ARDL bounds testing, Bayer-Hanck cointegration techniques, and an extended Cobb-Douglas framework to investigate long-term relationships. Their findings revealed that energy and trade both positively contribute to economic growth in the long run, while the effect of financial development is negligible. The Toda-Yamamoto Granger causality test demonstrated unidirectional causality from energy consumption and capital stock to economic output, as well as bidirectional causality between trade openness and economic output. This study underscores the critical importance of energy and trade policies in fostering economic growth in South Africa.

Köse and Baimaganbetov (2015) analyzed the asymmetric effects of fluctuations in Brent oil prices on macroeconomic indicators in Kazakhstan from 2000 to 2013. Using a structural vector autoregression (SVAR) model, the authors found that declines in oil prices had a more pronounced impact on industrial production, the real exchange rate, and inflation compared to increases in oil prices. They also noted that negative oil price shocks significantly affected industrial production, although these shocks did not markedly influence inflation. The study highlights the risks associated with Kazakhstan's high dependence on oil revenues for its economic performance, stressing the importance of investing these revenues in diversified sectors to achieve sustainable growth.

Kurniawan and Managi (2018) examined the impact of economic growth, urbanization, industrial structure, and trade openness on coal consumption in Indonesia from 1970 to 2015. The study evaluated the Environmental Kuznets Curve (EKC) hypothesis regarding coal consumption as a representation of environmental pressure. By employing the Autoregressive Distributed Lag (ARDL) method and conducting cointegration analyses with structural breaks, the authors found that economic growth, urbanization, and trade openness contributed to increased coal consumption, while a decline in the secondary industry reduced consumption. The findings confirmed the validity of the EKC hypothesis and underscored the importance of energy conservation policies to mitigate the environmental effects of coal consumption. The authors emphasized that energy policies should prioritize attracting foreign investments to promote innovative coal technologies and support energy savings in the housing sector.

Syzdykova and Tanrıöven (2018) examined how sensitive the Kazakh economy is to changes in oil prices. Using monthly data from 2000 to 2017, their study employed a VAR model, revealing that oil prices significantly impacted other macroeconomic variables such as the industrial production index, the real effective exchange rate, and interest rates, except for inflation. The lack of a direct effect of oil prices on inflation suggests that inflation is primarily influenced by domestic dynamics. However, the authors indicated that an increase in oil revenues could lead to higher public expenditures, indirectly elevating inflation. The study emphasizes the volatility of oil prices and recommends that Kazakhstan adopt policies to reduce its dependence on oil to ensure economic stability. In this context, diversifying the economy and focusing on sustainable sectors are proposed as primary solutions.

Ranov and Baimaganbetov (2018) investigated the impact of changes in oil prices on food prices in Kazakhstan. Utilizing monthly data from 2002 to 2017, they applied the Zivot-Andrews unit root test and the VAR method, which account for structural breaks. The study reveals that fluctuations in oil prices are a significant external factor influencing food prices in Kazakhstan. The findings indicate a bidirectional causality relationship between oil prices and food prices, showing that increases in oil prices lead to a temporary but notable rise in food prices. This effect was particularly evident in the first two periods, diminishing after 4 months. The study highlights that the relationship between oil and food prices is influenced by factors such as input costs in the energy and agricultural sectors and the demand for biofuels.

Abdibekov et al. (2024) examines the effects of energy consumption, industrial production, and agricultural production on economic growth in Kazakhstan from 2000 to 2022, employing the ARDL method. Their findings reveal that all three variables significantly impact economic growth, with potential economic shocks recoverable within 1.5 years. The study underscores the resilience of the Kazakh economy and offers valuable insights for decision-makers. Additionally, it contributes methodologically to the literature by incorporating industrial and agricultural production as a single index alongside energy consumption in analyzing the determinants of economic growth, serving as a useful resource for future research on the individual effects of these sectors.

Lukhmanova et al. (2025) analyzed the relationship between energy consumption and economic growth in Kazakhstan and Azerbaijan, drawing important implications for energy-rich countries. They used the ARDL and Toda-Yamamoto methods to assess the effects of energy consumption on economic growth in both countries. Their findings indicate that energy consumption is essential for growth in Kazakhstan, while no significant relationship was found in Azerbaijan. The study emphasizes the need to promote renewable energy investments and highlights that the timeframe for reaching equilibrium between the two countries varies based on their economic structures.

3. METHOD

This study employs analysis and testing methods that account for structural breaks in the model, based on the assumption that such breaks occur due to the structure of the data. In the initial stage of the analysis, the Augmented Dickey-Fuller (ADF) test was utilized under the assumption that there are no structural breaks. The test statistic is be represented by the following equation:

$$\Delta Y_t = \beta_0 + \beta_1 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \qquad (1)$$

In the ADF test, if the null hypothesis is rejected for *k*=0,1,3., values, it indicates that the series is stationary at the relevant level (Dickey and Fuller, 1979). Traditional unit root tests do not account for breaks in the economy and therefore may not accurately reflect the natural structure of the series. Consequently, this study employed the Vogelsang-Perron unit root test, which is based on the Additive Outlier (AO) Model trend function, one of the unit root tests that considers structural breaks (Vogelsang and Perron, 1998).

One effective method for analyzing long-term relationships in time series data is the Autoregressive Distributed Lag (ARDL) method. An advantage of the ARDL approach is that it does not require all variables in the model to be stationary at the same level. This method allows for the inclusion of variables that are either stationary at level I(0) or order one, I(1), in its first difference. Additionally, the ARDL method is suitable for small sample sizes (Narayan and Narayan, 2005). In the ARDL method, the first step is to determine whether there is a long-term relationship between the variables. If such a relationship exists, both the short-term and long-term coefficients are estimated and tested (Narayan and Smyth, 2006). The long-term relationship is examined using an F-statistic-based bounds test, following the guidelines below:

- If F Statistic < I(0) Limit: there is no cointegration relationship.
- If F Statistic > I(1) Limit: there is a cointegration relationship.
- If I(0) Limit < F Statistic < I(1) Limit: the cointegration relationship cannot be determined (Pesaran et al., 2001).

In ARDL analysis, the stationarity of the series is first assessed as a preparatory step. Following this, the appropriate lag length is calculated. Common criteria for determining lag length include the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), Log-Maximum Likelihood (LogL), Bayesian Information Criterion (BIC), and the Hannan-Quinn Information Criterion (HQ).

After obtaining the model, it is essential to test its compatibility and overall goodness. The Breusch-Godfrey LM test is used to determine if there is an autocorrelation problem. Additionally, the White Test and the Breusch-Pagan-Godfrey test are applied to identify any issues with heteroscedasticity. The Ramsey RESET test is conducted to assess the appropriateness of the functional structure. Furthermore, the CUSUM and CUSUMSQ tests are employed to check for any structural breaks in the long-term relationship.

In this study, the Gregory-Hansen Cointegration Test, which accounts for structural breaks, is utilized to determine whether a cointegration relationship exists between the variables (Gregory and Hansen, 1996). In the Gregory-Hansen method, the null hypothesis (H0) posits that there is no cointegration between the series given the structural break. If the null hypothesis is rejected, the final step of the research involves investigating whether a causal relationship exists between the series.

For the causality analysis, the Toda-Yamamoto causality test is used. This method has been criticized for potentially producing spurious causality relationships in non-stationary series and for the risk of information loss when analysis is performed after the differences between series are taken. To address these issues, Toda and Yamamoto (1995) proposed a test method based on the VAR model, which is independent of the cointegration status and the stationarity level of the series. In this method, the relationship is examined using the Wald test (Toda and Yamamoto, 1995). The steps of the method can be summarized as follows (Yuan et al., 2014):

1. Establish the VAR model and determine the optimal lag length (k).
2. Estimate the VAR model with a lag length of (k + dmax). In this step, diagnostic tests are performed to evaluate the suitability of the VAR model.
3. Examine the significance of the first k lags of each variable using the Wald test. The test results are compared to the Chi-square critical value. If the results are found to be significant, the null hypothesis stating that there is no causality is rejected.

4. DATA AND FINDINGS

In this study, we examined the relationship between oil prices, the industrial production index, the agricultural production index, and inflation, taking structural breaks into account. It is well known that agricultural production, industrial production, and oil prices are among the most significant macroeconomic variables affecting inflation. Moreover, by considering the ratios of agricultural and industrial production to national income, we indirectly included national income in our model, allowing for a more comprehensive framework for our research. The research variables and their brief definitions are provided in Table 1. The chosen research period spans from 1996 to 2023, during which structural changes have happened both in the global economy and Kazakhstan's economy. Therefore, we accounted for the structural break assumption in our analysis methods.

Table 2 presents the descriptive and distribution statistics for the research variables. The agricultural production index ranges from

Table 1: Descriptive information for variable

Variable	Brief definition of the variable	Source
INFL	Inflation, GDP deflator (annual %)	https://data.worldbank.org
OILR	Oil rents (% of GDP)	https://data.worldbank.org
INVG	The ratio of industrial production index to GDP	https://w3.unece.org
AGFG	Agricultural production index	https://data.worldbank.org

4.28 to 12.15, with a mean of 6.29 and a median of 5.35. These values indicate that the agricultural production index remains relatively low compared to national income. Inflation during the research period fluctuated between 1.82% and 38.90%, with an average inflation rate of 13.10%. The standard deviation of inflation is 7.70%, serving as a measure of its distribution. The industrial production index ranges from 25.59 to 40.60, with an average value of 34.47. In comparison to the agricultural production index, industrial production contributes more significantly to national income. Oil income varies from 2.25 to 24.70, with an average of 14.58. Upon examining the skewness and kurtosis values for oil income, we observe that this variable follows a distribution that is close to normal throughout the research period.

Table 2: Descriptive statistics for variables

Statistics	AGFG	INFL	INVG	OILR
Mean	6.286998	13.09735	34.47090	14.58219
Median	5.353543	12.50933	35.02733	14.61622
Maximum	12.15216	38.89963	40.60242	24.70221
Minimum	4.284763	1.823550	25.58776	2.252188
Standard deviation	2.235608	7.700731	3.766597	5.782483
Skewness	1.196806	1.210102	−0.63011	−0.09816
Kurtosis	3.461054	5.488050	3.272885	2.372534

Table 3: ADF unit root test findings for the variables

Variable code	Level		1st difference	
	t- Statistics	P*	t- Statistics	P*
AGFG	−4.684777	0.0010	−5.0421	0.0004
INFL	−5.795689	0.0001	−7.04351	0.0000
INVG	−2.586124	0.1080	−4.28006	0.0026
OILR	−2.564044	0.1126	−5.86734	0.0001
Test critical values				
1% level	−3.711457		−3.72407	
5% level	−2.981038		−2.98623	
10% level	−2.629906		−2.6326	

ADF: Augmented dickey-fuller

The time-course graph in Graph 1a shows the changes in the agricultural production index (as a ratio of national income) over time. Initially, the agricultural production index was at a level of 12 at the start of the research period. However, by 2010, it decreased to a range of 4-5, where it remained stable in the subsequent years.

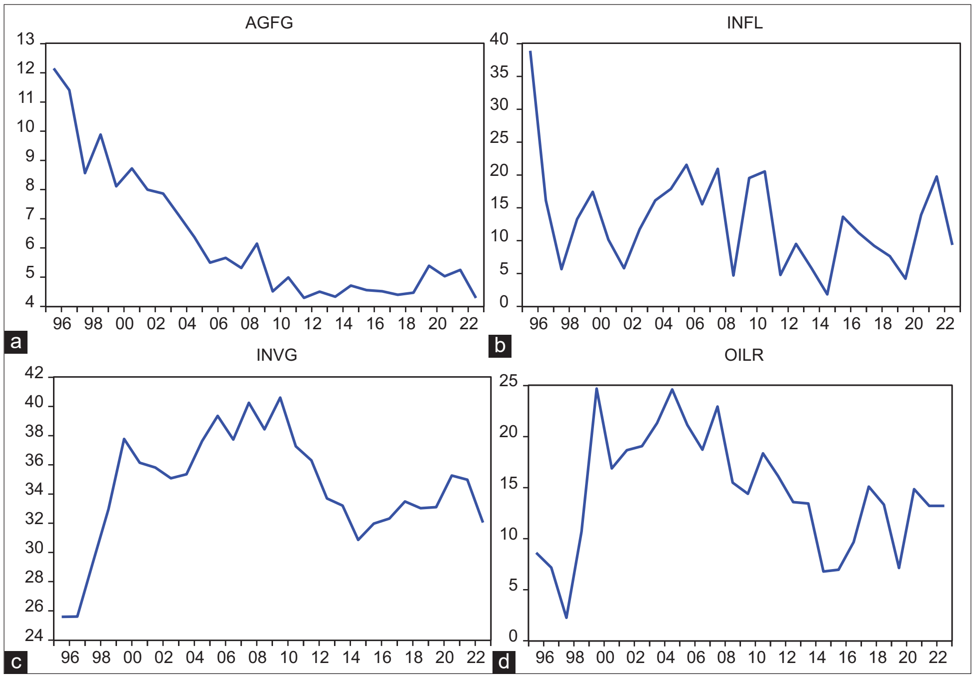
The time-course graph in Graph 1b shows the changes in the inflation rate over time. At the beginning of the research period, the inflation rate was nearly 40%. Since 1998, it has stabilized within the range of 5%-20%. The graph indicates that Kazakhstan experienced minimal fluctuations in inflation, particularly after 1998.

The time-course graph in Graph 1c shows the change in the industrial production index (as a ratio of national income) over time. The industrial production index rose steadily from the beginning of the research period, reaching approximately 38%-40% by 2000, reflecting significant developments in industrial

Table 4: Vogelsang-Perron structural break unit root test

Variable code	Level			1st difference		
	Break Date	t- Statistics	P*	Break Date	t- Statistics	P*
AGFG	2004	−6.13708	<0.01	2006	−10.2123	<0.01
INFL	2011	−6.76637	<0.01	2020	−7.12253	<0.01
INVG	2014	−3.85515	0.2121	2000	−6.73865	<0.01
OILR	2008	−3.07787	0.6410	2000	−8.02869	<0.01

Graph 1: (a-d) Time-course graph for research variables



investments during this period. The graph indicates that industrial production remained relatively high until 2012, although it experienced a slight decrease, settling between 32% and 34% thereafter.

The time-course graph in Graph 1d shows the change in oil income (as a ratio of national income) over time. Beginning at 9% at the start of the research period, oil income fluctuated until 2000, when it peaked. After reaching its highest point in 2000, oil income continued to fluctuate in subsequent years, ultimately settling at around 15% by the end of the analysis period.

The ADF unit root test results for the variables are presented in Table 3. The findings indicate that the series for agricultural production and inflation are stationary at the level ($P < 0.05$), while the series for industrial production and oil revenue are stationary at the first difference ($P < 0.05$).

The results of the Vogelsang-Perron AO structural break unit root test, which also takes into account the possibility of structural break for the research period, are shown in Table 4. The first finding aligns with the ADF unit root test results, confirming that the production regime and inflation level are stationary at the level, yet renewable production and oil revenue growth are stationary at the first difference. The second finding shows that there were structural breaks: in the production regime in 2004, in inflation in 2011, and in industrial production and oil revenues in 2000.

When examining the effects of agricultural production, industrial production, and oil revenue on inflation using the ARDL model, the first step is to determine the appropriate lag intervals. For this purpose, the criteria values for the eight models that provide the best fit in terms of possible models, LogL, AIC, BIC and HQ criteria, are given in Table 5. The results indicate that the ARDL (1, 2, 1, 2) model offers the best fit.

One criterion that shows the compatibility of the ARDL regression model is diagnostic test values. The information in Table 6 shows that, according to the Breusch-Godfrey test, there is no autocorrelation problem. The Breusch-Pagan-Godfrey test indicates no issues with heteroscedasticity, while the Jarque-Bera test confirms that the residuals are normally distributed. Furthermore, the Ramsey RESET test reveals that there is no error in model specification (functional form errors).

In addition to the diagnostic test results of the ARDL model, Graph 2 illustrates the findings from the CUSUM and CUSUMSQ tests (Brown et al., 1975), which were conducted to determine whether the model contains any structural breaks. The results indicate that the model does not exhibit any structural breaks and demonstrates stable performance.

Table 7 presents the findings from the error correction form of the ARDL model. It shows that all variables, except for the oil revenue level, and the estimated values for the error correction term were statistically significant. The error correction term, which ranges from −1 to 0, indicates convergence towards the equilibrium value (Alam and Quazi, 2003). Specifically, the error correction term calculated in

Table 5: Autoregressive distributed lag model selection criteria findings

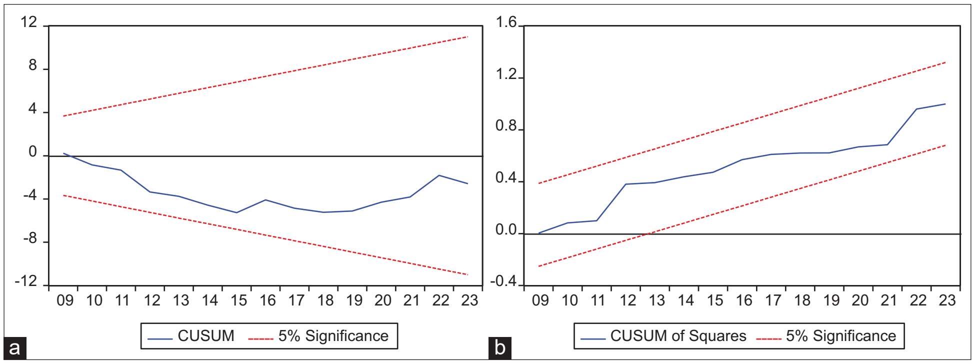
Model specification	LogL	AIC	BIC	HQ	Adjusted R^2
ARDL (1, 2, 1, 2)	−65.9607	6.076856	6.564407	6.212082	0.462252
ARDL (1, 2, 0, 0)	−69.1717	6.093734	6.435020	6.188392	0.420627
ARDL (1, 2, 2, 2)	−65.3461	6.107687	6.643992	6.256435	0.451486
ARDL (1, 2, 1, 0)	−68.4959	6.119670	6.509710	6.227850	0.418832
ARDL (2, 2, 0, 0)	−68.6674	6.133392	6.523432	6.241573	0.410802

AIC: Akaike information criterion, BIC: Bayesian information criterion, HQ: Hannan-Quinn, ARDL: Autoregressive distributed lag

Table 6: Autoregressive distributed lag diagnostic test results

Variables/Tests	Statistics	P
Breusch-Godfrey Serial Correlation LM test	F-statistic: 0.419752	Prob. F (2.13): 0.6658
Heteroskedasticity Test: Breusch-Pagan-Godfrey	F-statistic: 0.782272	Prob. F (9.15): 0.6362
Ramsey Reset Test	F-statistic: 0.446412	Prob. F (1.14): 0.5149
Test of Normality	Jarque-Bera: 1.000726	Prob. 0.6063

Graph 2: 95% Confidence interval for CUSUM (a) and CUSUMSQ (b) tests



the model is −0.895, suggesting that 89.5% of any shocks occurring in the short term can be eliminated within 1 year. This implies that the time required to return to equilibrium after a short-term shock is approximately 1.12 years (about 1 year and 2 months).

Table 7: Findings of the autoregressive distributed lag error correction regression model

Variable	Coefficient	SE	T-statistic	P
D (AGFG)	−7.403082	1.625758	−4.553619	0.0004
D (AGFG (−1))	−4.191188	1.188920	−3.525207	0.0031
D (DINVG)	1.016550	0.427158	2.379799	0.0310
D (DOILR)	−0.144944	0.156565	−0.925775	0.3692
D (DOILR (−1))	0.339330	0.112978	3.003516	0.0089
CointEq (−1)*	−0.895441	0.143256	−6.250627	0.0000
R^2	0.805006	Mean dependent variable		0.147366
Adjusted R^2	0.753692	SD dependent variable		7.824776
SE of regression	3.883388	Akaike info criterion		5.756856
Sum squared resid	286.5334	Schwarz criterion		6.049387
Log likelihood	−65.96070	Hannan-Quinn criterion		5.837992
Durbin-Watson stat	2.239596			

SE: Standard error, SD: Standard deviation

Table 8: Findings of the autoregressive distributed lag bounds test

Test statistic	Value	Significant (%)	I (0)	I (1)
F-statistic	6.169001	10	2.37	3.2
k	3	5	2.79	3.67
-		2.5	3.15	4.08
-		1	3.65	4.66

Table 9: Autoregressive distributed lag model and long-term estimation findings

Prediction findings for the model				
Variable	Coefficient	SE	T-statistic	P
C	13.77040	5.319399	2.588714	0.0206
INFL(−1)*	−0.895441	0.190824	−4.692485	0.0003
AGFG(−1)	−0.910159	0.819353	−1.110826	0.2841
DINVG(−1)	2.171443	0.899561	2.413892	0.0290
DOILR(−1)	−0.876956	0.610866	−1.435596	0.1716
D (AGFG)	−7.403082	2.188963	−3.382003	0.0041
D (AGFG(−1))	−4.191188	1.691536	−2.477740	0.0256
D (DINVG)	1.016550	0.653737	1.554983	0.1408
D (DOILR)	−0.144944	0.287724	−0.503760	0.6217
D (DOILR(−1))	0.339330	0.218339	1.554147	0.1410
Long-term prediction findings				
AGFG	−1.016436	0.907076	−1.120563	0.2801
DINVG	2.424998	1.153203	2.102836	0.0528
DOILR	−0.979357	0.740331	−1.322863	0.2057
C	15.37835	5.068758	3.033947	0.0084

EC=INFL − (−1.0164*AGFG+2.4250*DINVG−0.9794*DOILR+15.3783) SE: Standard error

Table 8 provides the results of the ARDL bounds test, which assesses whether there is a long-term relationship among the agricultural production index, industrial production index, and oil revenues' effect on inflation according to the ARDL model. The analysis concludes that there is indeed a long-term relationship between the variables, as the calculated F value exceeds the critical value from Table I(1) suggested by Pesaran et al. (2001) at a 5% significance level. The ARDL long-term model and error correction regression model will be employed based on these findings.

Table 9 shows the findings of the ARDL model and the long-term estimation values for the effect of agricultural production index, industrial production index and oil revenues on inflation. According to the model estimate, both the one-period lagged values of inflation, the industrial production index, and the agricultural production index and the level value of the agricultural production index are significant at a 5% significance level. Among the long-term effects, only the impact of the industrial production index is positive and statistically significant.

The structural break test results indicated that all series were stationary in the first difference. Based on this finding, the presence of cointegration between inflation and the agricultural production index, and the industrial production index and oil revenues was examined using the Gregory-Hansen cointegration test. The results are presented in Table 10. In the cointegration test, the null hypothesis (H_0) posits that "there is no cointegration under structural breaks." The calculated value of the Augmented Dickey-Fuller (ADF) test is compared with the critical values from the study by Gregory and Hansen (1996). The results show that the null hypothesis was rejected in the Regime Shift model, indicating that cointegration exists among the variables. Consequently, it was determined that causality analysis should be conducted as the next step to explore the relationships between the variables. Furthermore, the cointegration test identified the break date as 1998.

According to the ARDL analysis diagnostic findings, CUSUM and CUSUMSQ analyses concluded that there was no structural break in the long-term relationship among the variables. The causal relationships between the agricultural production index, industrial production index, oil revenues, and inflation were examined using the Toda-Yamamoto Causality Test, with the results presented in Table 11. The findings revealed: (i) a one-way causal relationship from oil prices to inflation, (ii) a one-way causal relationship from inflation to the agricultural production index, and (iii) a two-way causal relationship between industrial production and inflation, all of which were statistically significant.

Table 10: Gregory-Hansen test cointegration findings

Model	Break	ADF Procedure	Critical value (%1)	Critical value (%5)
Level shift	2011	−3.739	−5.440	−5.500
Level shift with trend	2010	−3.243	−5.800	−5.290
Regime shift	1998	−10.926	−5.800	−4.920

Table 11: Toda-Yamamoto causality test findings

Hypothesis	Lag/df	Value	P
OILR - INFL	3/2	12.7184	0.001731
INFL - OILR	3/2	2.418044	0.298489
AGFG - INFL	3/2	0.771737	0.67986
INFL - AGFG	3/2	6.556013	0.037703
INVG - INFL	3/2	7.287352	0.026156
INFL - INVG	3/2	7.535589	0.023103

5. CONCLUSION AND RECOMMENDATIONS

The relationships among agricultural production, industrial production, oil prices, and inflation - key macroeconomic indicators for the country's economy - were analyzed under the assumption of structural breaks. The break dates from the structural break unit root tests were evaluated alongside the economic changes in the country, but the intervals between break dates can be considered worthy of a separate study. Specifically, 1998 was identified as a transformation date concerning the impact of oil prices, agricultural production, and industrial production on inflation. The analysis indicated that oil prices and industrial production exert a causal effect on inflation, while inflation also influences industrial production. An important finding from this research is that agricultural production affects inflation in the short term, but not in the long term. Therefore, industrial production and oil prices should be carefully considered in long-term analyses and economic decisions regarding inflation.

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