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Asymmetric Effects of Macroeconomic and Financial Shocks on Industrial Production: Evidence from Turkiye

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Abstract

This study investigates the macroeconomic and financial determinants of industrial production in Türkiye, focusing on the symmetric and asymmetric effects of key financial variables. Specifically, it examines whether positive and negative shocks exert differential impacts on industrial production in the short and long run. The analysis employs monthly data for Türkiye covering the period 2016M01–2025M12. The model includes the capacity utilization rate, CDS premium, Global Economic Policy Uncertainty index, energy consumption, export unit value index, and the USD/TRY exchange rate. To capture potential nonlinearities and asymmetric adjustments, the Nonlinear Autoregressive Distributed Lag (NARDL) approach is applied. Long-run relationships are examined using the bounds testing procedure, while short-run dynamics and asymmetries are assessed through error correction and Wald tests. The bounds test confirms the existence of a long-run cointegration relationship. The error correction term (−0.1963, p<0.01) indicates that approximately 19.6% of short-run disequilibrium is corrected each month, implying convergence within nearly five months. Short-run results reveal significant asymmetric effects. While positive exchange rate shocks have no immediate impact, their two-period lag increases industrial production (0.1729, p<0.01). In contrast, positive CDS shocks exert an immediate negative effect (−0.0893, p<0.01). Capacity utilization shows the strongest positive short-run impact (1.4374, p<0.01). By employing a nonlinear framework, the study provides evidence that financial shocks influence industrial production asymmetrically, highlighting the dominance of short-run dynamics in an emerging market context.

Key words: Industrial Production, Financial Risk, Asymmetric Effects, NARDL Model

JEL Code: C22, E32, G15

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1. Introduction

Real sector indicators play a crucial role in ensuring the sustainability of economic growth and maintaining macroeconomic stability. In particular, the industrial sector is widely recognized as one of the fundamental determinants of economic activity through its production capacity, employment-generating potential, and contribution to foreign trade performance. In this context, industrial production serves as a leading indicator reflecting changes in economic conditions.

Economic growth refers to an increase in a country's overall income level and is commonly measured by the growth rate of Gross Domestic Product (GDP). The growth process is closely associated with the expansion of an economy's productive capacity, indicating an enhanced ability to generate a greater volume of goods and services. An increase in output contributes to higher income levels for individuals, thereby fostering improvements in overall living standards. Moreover, sustainable economic growth is positively linked to the expansion of employment opportunities within the economy (Ajmair and Hussain, 2017). The industrial sector is also considered one of the key drivers of productivity growth and structural transformation in the process of economic development. According to Kaldor (1968) growth approach, increases in industrial production accelerate the transfer of labor from low-productivity sectors to high-productivity sectors, thereby enhancing the overall productivity level of the economy. This mechanism has led to the characterization of industrialization as the "engine" of economic growth, particularly in developing economies. The economies of scale generated by industrial expansion and the associated labor reallocation process support productivity gains both within the industrial sector and across other sectors. Therefore, examining the determinants of industrial production constitutes an important research area for understanding the dynamics of economic growth.

One of the primary indicators used to monitor changes in production activities within the industrial sector is the Industrial Production Index (IPI). This indicator, which is employed to track overall economic activity and the performance of the industrial sector (Kmietowicz, 1995), is theoretically intended to reflect changes in value added rather than merely variations in production volume. However, due to the practical difficulties associated with directly measuring value added, the index is typically constructed on the basis of production or turnover data. The primary objective of the IPI is to measure monthly volume changes in industrial output, adjusted for price effects, in order to detect economic developments at an early stage. In this respect, the IPI serves as a key leading indicator for evaluating the short-term effects of economic policies, monitoring business cycle conditions, and supporting policymakers in the decision-making process (Öcal, 2013). The trajectory of industrial production is influenced not only by real sector dynamics but also significantly by macroeconomic and financial conditions. Exchange rate movements, financial risk indicators, uncertainty indices, and energy costs are among the main factors affecting industrial production through their impact on production costs, investment decisions, and foreign trade performance. The literature frequently emphasizes that exchange rate fluctuations affect production processes through imported input costs, while increases in financial risk indicators may negatively influence investment and production decisions (Bernanke, 1983). Moreover, energy consumption is considered an important indicator of economic activity, whereas global economic policy uncertainty and risk premium indicators reflect the interaction between financial market conditions and the real sector (Sadorsky, 2011; Baker et al., 2016). Therefore, jointly examining the macroeconomic and financial determinants of the Industrial Production Index contributes to a more comprehensive understanding of the dynamics of economic activity. Although numerous studies have analyzed the relationship between industrial production and macroeconomic indicators, research addressing asymmetric relationships between financial risk indicators and real sector variables remains limited. The assumption that positive and negative shocks may exert different effects on industrial production necessitates the use of nonlinear modeling approaches. In this regard, the Nonlinear Autoregressive Distributed Lag (NARDL) framework developed by Shin et al., (2013) allows for the simultaneous examination of short- and long-run asymmetric relationships.

The aim of this study is to investigate the macroeconomic and financial determinants of the Industrial Production Index in Türkiye and, in particular, to analyze the asymmetric effects of positive and negative changes in the CDS premium and exchange rate on industrial production using the NARDL methodology. The empirical analysis employs monthly data and incorporates the capacity utilization rate, CDS premium, Global Economic Policy Uncertainty index, energy consumption, export unit value index, and the USD/TRY exchange rate into the model. The findings are expected to contribute to a better understanding of the transmission of financial shocks to the real sector.

2. Literature Review

The relationship between industrial production and macroeconomic and financial variables has long been a prominent subject in both theoretical and empirical literature. The effects of exchange rate movements, interest rates, energy prices, uncertainty indicators, and financial risk premiums on real sector performance have been extensively examined across different periods and methodological frameworks. Identifying the determinants of the industrial sector—one of the fundamental pillars of economic production—remains crucial for understanding economic growth dynamics and informing policy design. Accordingly, the existing literature on the macroeconomic and financial determinants of industrial production is systematically reviewed in this section.

An examination of the literature on industrial production indices indicates that this topic has been addressed from various perspectives and constitutes one of the prominent areas of inquiry in empirical economic research. From a historical standpoint, the emergence of the need for such indices, their subsequent construction, and the evaluation of their validity reflect a natural evolutionary process in the development of statistical indicators. The concept of the Industrial Production Index (IPI) dates back to 1919, with the first systematic and modern applications developed in the United States (Federal Reserve, 2025). In Türkiye, although efforts to measure industrial production extend to earlier periods, monthly data published in a modern and systematic framework have been available since 1986 through the Turkish Statistical Institute (TURKSTAT, 2026). The study conducted by Kmietowicz (1995), focusing on developing countries, examines the methods and data sources employed in the calculation of industrial production indices. The findings of this early-period research suggest that many of the indices analyzed were far from reliable. In certain countries, it was not possible to distinguish annual changes in manufacturing output from the average measurement error embedded in the index, which constituted a major source of unreliability. The study concludes by proposing several recommendations aimed at improving the reliability and methodological soundness of industrial production indices.

One of the earliest studies examining the determinants of industrial production was conducted by Marchetti and Parigi (1998). The authors analyze the effectiveness of electricity consumption and business survey data in forecasting the Industrial Production Index for the Italian economy. The study employs monthly data covering the period from January 1986 to April 1995. The dataset consists of the industrial production index, regionally disaggregated electricity consumption, temperature data used to control for household consumption effects, and qualitative indicators derived from business surveys conducted by Isco and CsC. The empirical findings indicate that linear models based solely on electricity consumption exhibit substantial forecasting power; however, hybrid models that integrate electricity data with survey indicators achieve superior forecasting performance, as evidenced by lower RMSE values. Another significant contribution is provided by Harrigan (1999), who investigates differences in industrial output and Total Factor Productivity (TFP) across industrialized countries in order to analyze the determinants of production performance. The study emphasizes the importance of controlling for business cycle fluctuations and changes in capacity utilization rates in empirical analyses of industrial production. Harrigan argues that cross-country differences in industrial output cannot be explained solely by physical inputs; rather, political, legal, and social environments also play a decisive role in shaping production performance. This perspective offers a theoretical foundation for incorporating country-specific risk indicators (such as CDS spreads) and global uncertainty measures (such as GEPU) into industrial production models. Furthermore, the author highlights the impact of sectoral price levels and exchange rates on production, underscoring the importance of trade and cost channels in explaining variations in industrial output. In the same year, Repkine and Walsh (1999) examined why industrial production in Bulgaria, Hungary, Poland, and Romania followed a "U-shaped" trajectory—characterized by a sharp decline followed by partial recovery—during the transition from centrally planned to market economies. The analysis covers the period from 1989 to 1996. The authors argue that this pattern did not arise from inter-sectoral shifts but rather from product-level restructuring within industrial sectors. Their findings suggest that industrial policy should focus not only on production volumes but also on product market orientation and technological innovation capacity.

Barışık and Yayar (2012) investigate the sensitivity of industrial production to internal and external variables in Türkiye following the transition to an export-led growth model after 1980. Using monthly data from January 1998 to December 2010, the study applies regression and Vector Autoregression (VAR) techniques. The results reveal bidirectional causality between the Industrial Production Index and public expenditures, imports, exports, and consumption expenditures. Gutu et al. (2015), on the other hand, analyze the impact of macroeconomic variables on industrial production in Romania during the global financial crisis. Utilizing monthly data from June 2008 to June 2013, the study incorporates lending interest rates, inflation, non-performing loan (NPL) ratios, and the EUR/RON real exchange rate as explanatory variables. The multiple regression results indicate that these macroeconomic variables account for approximately 36.2% of the variation in industrial production during the crisis period.

In their study, Marques, Fuinhas, and Menegaki (2016) aims to examine the relationship between renewable and non-renewable electricity generation and economic growth in Greece. The analysis is based on monthly data covering the period from August 2004 to February 2014. Utilizing the ARDL modeling framework, the findings indicate that, in the short run, fossil fuels play a base-load role in electricity generation and that a clear substitution effect exists among energy sources. In the long run, however, fossil fuels function as a backup energy source, thereby contributing to the development of renewable energy generation. Ejaz and Iqbal (2019) constructed an Industrial Production Index (IPI) for the Pakistani economy and evaluated its forecasting performance using a range of econometric techniques. The analysis was conducted with monthly data covering the period from July 1990 to June 2018. The model incorporated value-added data from key industrial sub-sectors—namely mining, manufacturing, energy, and construction—alongside macroeconomic variables such as KIBOR, money supply, exchange rates, and foreign trade indicators. Applying ARIMA, ARDL, VAR, and BVAR methodologies, the authors found that the newly developed IPI exhibits a strong correlation of 97% with previously published official data. The empirical results further indicate that the ARDL model, which captures financial conditions through interest rates, money supply, and credit volume, delivers the most accurate forecasts. Specifically, it achieves the lowest Root Mean Square Error (RMSE) across all examined forecast horizons of 3, 6, and 12 months, thereby outperforming the alternative model specifications.

Aytekin (2020) empirically examines the relationship among total industrial production, the economic confidence index, and the real exchange rate in Türkiye using monthly data covering the period 2008:M1–2020:M3. Employing the Johansen cointegration test, the study identifies the existence of at least one long-run cointegration relationship among the variables. The findings indicate that exchange rate fluctuations exert a direct effect on industrial production while indirectly influencing economic confidence. Short-run disequilibria are found to be corrected within approximately four months. The study conducted by Çalışcı and Karatay Göğül (2021), aims to investigate the relationship between exchange rates and industrial production. The research focuses on Türkiye and covers quarterly data for the period 2005–2019. The empirical analysis employs the Engle–Granger and Phillips–Ouliaris cointegration tests, as well as the Toda–Yamamoto (1995) causality test. The findings reveal the existence of a long-run cointegration relationship between the variables. However, no evidence of causality is detected between exchange rates and industrial production. The study conducted by Pekçağlayan (2021) examines the determinants of the Industrial Production Index in Türkiye. The analysis utilizes monthly data covering the period from 2007 to 2020. According to the results of the ARDL model, electricity consumption and the manufacturing capacity utilization rate are found to be statistically significant determinants of the Industrial Production Index in the long run. Another study focusing on Türkiye was conducted by Tekin (2022). The research investigates the relationship between the Industrial Production Index and bank credit extended to the private sector. The empirical analysis covers the period 2007–2021 and employs the Johansen cointegration test, the Vector Error Correction Model (VECM), and both Granger and Toda–Yamamoto causality tests. The findings indicate the existence of both short-run and long-run relationships between industrial production and bank credit.

The study conducted by Demir and Özcan (2023) investigates the factors affecting the Industrial Production Index. Capacity utilization rate and the Producer Price Index are included in the model as independent variables. Employing the Employing the Nonlinear Autoregressive Distributed Lag (NARDL) methodology, the analysis is based on monthly data covering the period from 2007 to 2022. The empirical findings indicate that the selected variables exert statistically significant effects on the Industrial Production Index. Ak (2024) investigates the Turkish economy over the period 2016:01–2023:12, focusing on the relationship between industrial production, macroeconomic indicators, and stock market performance. Utilizing a VAR framework and impulse-response analysis, the findings indicate that shocks to the variables dissipate within approximately two to four months, after which the system converges back to equilibrium. Karaman and Kaya (2024) analyze the determinants of the manufacturing Industrial Production Index in Türkiye, particularly under the effects of the 2008 global financial crisis and the COVID-19 pandemic. Using monthly data from 2007:1–2022:9 and applying the ARDL methodology, the study reveals a long-run cointegration relationship between manufacturing output and selected macroeconomic variables. The empirical results suggest that credit volume and capacity utilization exert positive effects on manufacturing production in the long run, whereas interest rates and producer prices have negative impacts.

Overall, the existing literature demonstrates that the Industrial Production Index is closely associated with macroeconomic variables, financial indicators, and real sector dynamics, where exchange rates, interest rates, energy consumption, capacity utilization, and credit volume generate both short- and long-run effects.

Within this expanding body of research, empirical findings occasionally display varying nuances; for instance, while some studies suggest that exchange rate devaluations can stimulate industrial output via the export channel (Akbostancı, 2002; Bahmani-Oskooee & Halicioglu, 2017), others highlight a contractionary pressure driven by imported input costs (Kandil et al., 2007). A critical synthesis of these differing results points toward a twofold research gap. First, a substantial portion of the literature relies on linear methodologies, which predominantly assume a symmetric transmission mechanism and may overlook the reality that real-sector agents react differently to positive versus negative shocks (Shin et al., 2013). Second, prior NARDL literature on Türkiye has largely analyzed exchange rate movements or financial indicators in an isolated manner (Tekin, 2022), leaving the compounding roles of sovereign credit risk and global economic policy uncertainty less explored within a unified framework. In this context, the present study aims to contribute to the literature by developing an integrated, non-linear framework using the NARDL methodology. By simultaneously evaluating domestic cost shocks, sovereign credit constraints, and global uncertainty, this paper seeks to bridge these gaps and offer a more comprehensive perspective on the asymmetric transmission mechanisms affecting industrial production in Türkiye.

3. Methodology

3.1. Data Set

This study examines the relationship between the Industrial Production Index, financial risk, economic uncertainty, real sector capacity utilization, and external trade dynamics. Table 1 presents the dependent and independent variables included in the empirical analysis.

Table 1: Research Data Set

Variables	Variable Description	Code	Source
Dependent Variable	Industrial Production Index	IPI	TURKSTAT
Independent Variables	Capacity Utilization Rate	CUR	CBRT–EVDS
	CDS Premium	CDS	https://tr.investing.com/
	Global Economic Policy Uncertainty	GEPU	https://www.policyuncertainty.com/
	Energy Consumption	EC	CBRT–EVDS
	Export Unit Value Index	EUVI	CBRT–EVDS
	USD/TRY Exchange Rate	USD/TRY	https://tr.investing.com/

Six main indicators are employed as independent variables in this study. In order to represent the production capacity of the real sector, the Capacity Utilization Rate (CUR) is included in the model. As a country-specific financial risk indicator, Türkiye's 5-year Credit Default Swap (CDS) premium is utilized. To capture global uncertainty, the Global Economic Policy Uncertainty (GEPU) index is incorporated. Energy consumption (EC), which is considered one of the key indicators of production activity, is also included in the model. Furthermore, the Export Unit Value Index (EUVI) is incorporated to reflect changes in export prices and to capture the impact of external demand conditions on industrial production. The USD/TRY exchange rate is included in the model, given its potential influence on industrial production through imported input costs and external trade competitiveness channels.

The analysis covers the period 2016M01–2025M12. The primary reason for selecting this time frame is the occurrence of significant financial and economic developments during this period (e.g., the COVID-19 pandemic, exchange rate shocks, and monetary policy shifts), which allow for a clearer observation of their effects on the real sector. Descriptive statistics for the variables included in the study are presented in Table 2.

Table 2: Descriptive Statistics

	IPI	**CUR**	**CDS**	**GEPU**	**EC**	**EUVI**	**USD/TRY**
Mean	4.9813	76.0841	367.0618	240.2303	13.6583	4.6448	2.2793
Median	5.0069	76.3500	316.7450	224.1650	13.6580	4.6225	2.0253
Max.	5.1733	79.9000	844.8000	628.1200	13.9282	4.8426	3.7490
Min.	4.5196	61.6000	160.5800	126.9500	13.4159	4.5056	1.0260
Std. Dev.	0.1393	2.5860	149.7051	83.9336	0.1035	0.0904	0.8913
JB	5.8549	1174.7940	23.4438	112.1960	1.1601	10.3575	10.7670
Prob.	0.0535	0.0000	0.0000	0.0000	0.5598	0.0056	0.0046
Obs.	120	120	120	120	120	120	120

An examination of the descriptive statistics presented in Table 2 indicates that the variable with the highest standard deviation is the CDS premium (149.7051). This finding suggests that significant fluctuations in the country risk premium occurred during the sample period. The CDS variable is followed by the Global Economic Policy Uncertainty (GEPU) index (83.9336). In contrast, the relatively lower standard deviation values of the other variables indicate that no substantial volatility was observed in those series over the period analyzed. With respect to the normality assumption, the results of the Jarque–Bera test reveal that only the energy consumption (LNEC) variable satisfies the normal distribution assumption ($p > 0.05$). The statistically significant Jarque–Bera probability values for the remaining variables indicate that these series do not follow a normal distribution. Overall, it can be concluded that most of the variables do not meet the assumption of normality, with financial indicators—particularly the CDS premium, GEPU, and the exchange rate—exhibiting relatively higher volatility. This finding is consistent with the inherent nature of financial risk and uncertainty indicators, which are typically characterized by more pronounced fluctuations.

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Table 3: Correlation Analysis Results

Variables	IPI	CUR	CDS	GEPU	EC	EUVI	USD/TRY
IPI	1.00	0.15	0.26	0.36	0.72	0.88	0.88
CUR		1.00	-0.28	-0.49	0.07	0.05	-0.19
CDS			1.00	0.39	0.11	0.13	0.28
GEPU				1.00	0.32	0.35	0.54
EC					1.00	0.64	0.67
EUVI						1.00	0.89
USD/TRY							1.00

An examination of the correlation coefficients reported in Table 3 indicates the presence of relatively high correlations among certain variables. This necessitates an assessment of whether a multicollinearity problem exists in the model. To test for the presence of multicollinearity, the Variance Inflation Factor (VIF) analysis is conducted. The VIF results aimed at diagnosing multicollinearity are presented in Table 4. According to the findings, the centered VIF values for all variables are below the critical threshold of 10. This indicates that there is no serious multicollinearity problem in the model.

Table 4: VIF Test

Variable	VIF
CUR	1.71
CDS	1.24
GEPU	1.92
EC	1.95
EUVI	6.92
USD/TRY	8.87

To determine the stationarity properties of the variables, the Augmented Dickey–Fuller (ADF) unit root test is conducted, and the results are presented in Table 5.

3.2. Research Model

The Autoregressive Distributed Lag (ARDL) model developed by Pesaran, Shin, and Smith (2001) is widely used for testing cointegration relationships among time series variables. Compared to conventional cointegration approaches such as Engle–Granger (1987) and Johansen (1988), which require variables to be integrated at the same order, the ARDL framework offers the advantage of identifying relationships among variables integrated at different orders (i.e., I(0) and I(1)). Moreover, the ARDL approach allows for the simultaneous estimation of both long-run and short-run dynamics, which constitutes another important advantage over traditional cointegration techniques. However, when the relationships among variables exhibit nonlinear characteristics, the standard ARDL model may be insufficient. In this context, Shin et al., (2013) extend the ARDL framework by incorporating asymmetric adjustments among variables and develop the Nonlinear Autoregressive Distributed Lag (NARDL) model. The NARDL approach enables the examination of asymmetric long-run and short-run relationships. The long-run asymmetric relationship proposed by the NARDL model is specified as follows (Cavlak, 2022):

$$Y_t = \beta^+ X_t^+ + \beta^- X_t^- + \varepsilon_t \tag{1}$$

In Equation (1), Y_t, represents the k x 1 vector of the dependent variable at time t. The parameters β^+ and β^- enote the long-run asymmetric coefficients. The k x 1 vector of explanatory variables X_t is expressed as follows:

$$X_t = X_0 + X_t^+ + X_t^- \tag{2}$$

Here, X_0 represents the initial value, while and denote the partial sum decompositions of the positive and negative components of the independent variables, respectively. The variable X_t is defined by the following equations:

$$X_t^+ = \sum_{i=1}^{t} \Delta X_i^+ = \sum_{i=1}^{t} \max(\Delta X_i, 0) \tag{3}$$

$$X_t^- = \sum_{i=1}^{t} \Delta X_i^- = \sum_{i=1}^{t} \min(\Delta X_i, 0) \tag{4}$$

In these expressions, ΔX_i represents the changes in the independent variables, while the superscripts "+" and "–" indicate positive and negative shocks in the explanatory variables, respectively.

The NARDL model is based on the assumption that increases and decreases in explanatory variables may not exert effects of the same magnitude or direction on the dependent variable. In this respect, it provides a more flexible analytical framework than the linear ARDL model. Within the NARDL framework, explanatory variables can be decomposed, when necessary, into the partial sums of positive and negative changes, thereby allowing asymmetric effects to be examined. However, the NARDL approach does not require all variables in the model to be decomposed. Rather, depending on the theoretical framework and empirical expectations of the study, only selected variables may be incorporated into the model in an asymmetric form (Shin et al., 2013).

In emerging and structurally externally dependent economies such as Türkiye, the effects of exchange rate movements on industrial production are expected to be asymmetric. Increases in the exchange rate may suppress production

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through the cost channel by raising the costs of imported intermediate goods and energy, while they may simultaneously stimulate production through the competitiveness channel by encouraging exports. However, decreases in the exchange rate do not necessarily reduce production costs at the same speed or magnitude. These opposing cost and competitiveness channels provide a theoretical basis for the nonlinear, or asymmetric, impact of exchange rate shocks on industrial production (Bahmani-Oskooee and Halicioglu, 2017; Tiryaki et al., 2018). Similarly, pessimism and optimism in financial markets and real sector investment decisions tend to operate asymmetrically. The effects of negative news, represented by an increase in CDS premiums and hence higher perceived risk, on macroeconomic indicators and investor decisions are generally more immediate, severe, and disruptive than the effects of positive news, represented by a decline in CDS premiums. When CDS premiums rise, external financing costs increase rapidly, capital outflows may occur, and firms may abruptly postpone or cancel investment decisions. By contrast, when CDS premiums decline, the rebuilding of confidence typically takes time, and the recovery in industrial production is likely to occur more gradually. This provides a strong justification for incorporating CDS premiums into the model asymmetrically (Bernanke et al., 1999).

In this context, specifying the model in a partially asymmetric form makes it possible both to examine the differential effects of increases and decreases in the USD/TRY exchange rate and CDS premium on industrial production and to control the effects of the remaining explanatory variables within a more parsimonious and consistent model structure. This approach is consistent with the positive and negative partial-sum decomposition framework proposed by Shin et al. (2013) within the NARDL methodology.

The short-run and long-run relationships among the variables proposed by the NARDL model are specified in the following equation:

$$\begin{aligned}\Delta IPI_t &= \mu + \phi(IPI_{t-1} - \beta_1 CUR_{t-1} - \beta_2 GEPU_{t-1} - \beta_3 EC_{t-1} - \beta_4 EUVI_{t-1} \\ &- \beta_5^+ USD/TRY_{t-1}^+ - \beta_5^- USD/TRY_{t-1}^- - \beta_6^+ CDS_{t-1}^+ - \beta_6^- CDS_{t-1}^-) \\ &+ \sum_{i=1}^{p-1} \gamma_i \Delta IPI_{t-i} + \sum_{j=0}^{q_1-1} \theta_{1j} \Delta CUR_{t-j} + \sum_{j=0}^{q_2-1} \theta_{2j} \Delta GEPU_{t-j} + \sum_{j=0}^{q_3-1} \theta_{3j} \Delta EC_{t-j} \\ &+ \sum_{j=0}^{q_4-1} \theta_{4j} \Delta IPI_{t-j} + \sum_{j=0}^{q_5-1} (\theta_{5J}^+ \Delta USD/TRY_{t-j}^+ + \theta_{5J}^- \Delta USD/TRY_{t-j}^-) \\ &+ \sum_{j=0}^{q_6-1} (\theta_{6J}^+ \Delta CDS_{t-j}^+ + \theta_{5J}^- \Delta CDS_{t-j}^-) + \varepsilon_t \end{aligned} \tag{5}$$

Here, p denotes the lag length of the dependent variable, while q represents the lag length of the explanatory variables. The parameters ω and γ_n capture the long-run coefficients, whereas δ_n and p_n represent the short-run coefficients.

An inherent econometric advantage of the NARDL framework formulated above is its robust treatment of potential endogeneity, feedback effects, and simultaneity bias among the key macro-financial variables (such as industrial production, exchange rates, and the CDS index) (Shin et al., 2013). Unlike standard cointegration techniques that require strict exogeneity of regressors, the estimation of asymmetric distributed lag structures (p, q) naturally internalizes the dynamic feedback channels within the error-correction mechanism. Provided that the error terms exhibit no serial correlation, the NARDL parameters remain asymptotically unbiased and efficient, eliminating the necessity for external instrumental variables.

4. Findings

This section of the research will present the findings obtained from the analysis. The assumption of stationarity constitutes a fundamental prerequisite for obtaining reliable results in time series analysis. Regression models estimated with non-stationary series may lead to the problem of spurious regression, whereby statistically significant relationships are detected despite the absence of any genuine economic linkage. As demonstrated by Granger and Newbold (1974), even series that are independent of one another but exhibit random walk behavior can produce highly significant regression outcomes. Monte Carlo simulations further confirm that statistical tests may yield misleading inferences when two independent non-stationary series are employed in regression analysis. This issue is particularly relevant in empirical studies based on macroeconomic data, where neglecting the stationarity properties of the variables undermines the validity and reliability of estimated coefficients and associated test statistics. Therefore, to ensure sound and credible empirical findings, it is essential to examine the stationarity characteristics of the series prior to estimation and to apply appropriate transformations when necessary.

Table 5: Unit Root Test Results (ADF Test)

	Level		**First Difference**	
	Constant	**Constant + Trend**	**Constant**	**Constant + Trend**
IPI	-1.9287 [0.3182]	-4.2635* [0.0050]		
CUR	-3.4415 [0.0114]	-4.1296* [0.0076]		
CDS	-2.1937 [0.2097]	-2.0950 [0.5429]	-10.6134* [0.0000]	-10.5991* [0.0000]
GEPU	-3.4672** [0.0106]	-4.2914* [0.0046]		
EC	-0.7880 [0.8182]	-2.4090 [0.3729]	-4.3232* [0.0007]	-4.2948* [0.0047]
EUVI	0.2058 [0.9720]	-1.4748 [0.8329]	-9.4800* [0.0000]	-9.5353* [0.0000]
USD/TRY	0.3214 [0.9785]	-2.3904 [0.3827]	-9.5521* [0.0000]	-9.5496* [0.0000]

*and ** indicate statistical significance at the 1% and 5% levels, respectively. Values reported in square brackets [ ] represent the corresponding probability (p-values).

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According to the ADF unit root test results, the CUR and GEPU variables are stationary at level, i.e., I(0), whereas the remaining variables are stationary at their first differences, i.e., I(1). The absence of any variable integrated at order I(2), and the fact that some variables are stationary at level while others become stationary after first differencing, confirm the applicability of the NARDL approach, which allows for the investigation of asymmetric cointegration relationships.

In order to preserve degrees of freedom and enhance the economic interpretability of the model, only the main external variables theoretically expected to exhibit asymmetric effects (Exchange Rate and CDS Premium) are decomposed into their positive and negative components. The remaining variables (CUR, GEPU, EC, and EUVI) are included in the model in linear form.

The optimal lag structure of the NARDL model is determined according to the Akaike Information Criterion (AIC) as (4, 3, 0, 3, 4, 4, 2, 1, 1). Accordingly, the results of the Bounds test conducted to examine the existence of a cointegration relationship among the variables are presented in Table 6.

Table 6: Cointegration Test Results for the ARDL and NARDL Models

		Asymptotic Critical Values					
	F statistic	%10		%5		%1	
ARDL	1.72	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
		1.99	2.94	2.27	3.28	2.88	3.99
		%10		%5		%1	
NARDL	3.12	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
		1.85	2.85	2.11	3.15	2.62	3.77

To determine the existence of a cointegration relationship among the variables, the linear ARDL Bounds Test was first applied. The results indicate that the calculated F-statistic (1.72) remains below the upper critical bound value at the 10% significance level (2.94). This finding suggests that, within the conventional linear framework, there is no evidence of a long-run cointegration relationship among the variables. However, considering that economic relationships may not always be linear and that shocks may generate asymmetric effects, the NARDL (Nonlinear ARDL) model was subsequently employed. The F-statistic obtained from the NARDL bounds test (3.12) exceeds the upper critical bound value at the 10% significance level (2.85) in a statistically significant manner. These contrasting findings indicate that the relationship between the Industrial Production Index (IPI) and the explanatory variables exhibits an asymmetric structure and that linear models may be insufficient to capture this complex dynamic. This result implies that policymakers should adopt asymmetric approaches that account for the differentiated effects of economic shocks—particularly increases and decreases in exchange rates and risk premiums—rather than relying solely on linear analytical frameworks. The findings confirm the strong explanatory power of the asymmetric components (positive and negative shocks) included in the model. Specifically, the F-statistic obtained from the Asymmetric Bounds Test (NARDL Bounds Test) is greater than the upper critical bound value at the 10% significance level proposed by Pesaran et al. (2001). Therefore, this evidence statistically confirms the existence of a long-run cointegration relationship among the variables within a nonlinear framework.

Following the identification of a cointegration relationship among the variables, the short-run coefficients of the NARDL model are estimated in order to determine the system dynamics and the adjustment process toward equilibrium. The empirical findings are presented in Table 7.

Table 7: Short-Run Coefficients

Dependent Variable: Industrial Production Index (IPI)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
Δ (IPI(-1))	-0.546540*	0.092279	-5.922683	0.0000
Δ (IPI (-2))	-0.110344	0.102065	-1.081110	0.2827
Δ (IPI (-3))	0.141316***	0.082931	1.704010	0.0921
Δ (USD/TRY^{+})	0.091833	0.056967	1.612044	0.1107
Δ (USD/TRY^{+}(-1))	-0.007641	0.054469	-0.140280	0.8888
Δ (USD/TRY^{-}(-2))	0.172918*	0.053850	3.211127	0.0019
Δ (USD/TRY^{-})	0.130623	0.180967	0.721805	0.4724
Δ (CDS^{+})	-0.089394*	0.029270	-3.054111	0.0030
Δ (CDS^{+}(-1))	-0.062380***	0.032918	-1.895035	0.0615
Δ (CDS^{+}(-2))	-0.114429*	0.033848	-3.380617	0.0011
Δ (CDS^{-})	-0.005924	0.037216	-0.159188	0.8739
Δ (CDS^{-}(-1))	0.003775	0.035085	0.107604	0.9146
Δ (CDS^{-}(-2))	0.081831*	0.030067	2.721623	0.0079
Δ (CDS^{-}(-3))	0.059258**	0.027059	2.189992	0.0313
Δ (CUR)	1.437457*	0.117609	12.222302	0.0000
Δ (CUR(-1))	0.335685***	0.184887	1.815626	0.0730
Δ (CUR(-2))	-0.492097*	0.181508	-2.711161	0.0081
Δ (CUR(-3))	-0.403142*	0.149466	-2.697216	0.0084
Δ (GEPU)	-0.026952**	0.011347	-2.375341	0.0198
Δ (GEPU(-1))	-0.022884***	0.011844	-1.932024	0.0567
Δ (EC)	0.090529*	0.031676	2.857948	0.0054
Δ (EUVI)	-0.253382	0.160356	-1.580117	0.1178
CointEq(-1)	-0.196367*	0.034097	-5.759159	0.0000
R2: 0.97 F-statistic: 123.01 Prob: 0.00				
*, **, and *** denote statistical significance at the 1%, 5%, and 10% levels, respectively.				

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The coefficient of determination (R^2), reflecting the overall explanatory power of the model, is calculated as 0.97, indicating that the independent variables explain 97% of the variation in industrial production. The statistical significance of the F-statistic (123.01) confirms the overall validity of the model.

One of the most critical findings of the model, the error correction coefficient (ContEq(-1)), is estimated at −0.1963 and is statistically significant at the 1% level ($p = 0.0000$). The negative and significant coefficient confirms the existence of a long-run cointegration relationship among the variables and indicates that long-run disequilibria in the system converge toward equilibrium over time. According to this result, approximately 19.6% of the disequilibrium caused by a shock to the independent variables is corrected each month. Consequently, the system returns to full equilibrium in approximately five months. The short-run coefficients reveal that exchange rate and CDS premium shocks exert asymmetric effects on industrial production. While positive shocks in the exchange rate ($USDTRY^+$) do not have a statistically significant immediate effect on industrial production, the two-period lagged values ($\Delta(USDTRY^+(-2))$) have a positive and statistically significant impact of 0.1729 ($p = 0.0019$). This finding suggests that increases in the exchange rate stimulate production through the export channel with a certain time lag. In contrast, positive increases in the CDS premium (CDS^+) have an immediate negative and statistically significant effect of −0.0893 at the 1% level ($p = 0.0030$). This result indicates that rising country risk increases investment and financing costs, thereby rapidly suppressing industrial production. Another important finding concerns the capacity utilization rate (CUR), which exhibits the strongest and most positive short-run effect on industrial production (1.4374; $p = 0.0000$). The more efficient use of existing capacity directly and significantly increases the industrial production index. As expected, increases in energy consumption positively affect production (0.0905), while increases in geopolitical risk indices constrain production (−0.0269).

The long-run coefficients of the model are presented in Table 8.

Table 8: Long-Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
USD/TRY^+	-0.1965	0.1576	-1.2471	0.2158
USD/TRY^-	0.0458	0.3271	0.1400	0.8890
CDS^+	0.0745	0.1005	0.7407	0.4609
CDS^-	-0.0965	0.0663	-1.4559	0.1491
CUR	0.9857	0.8158	1.2082	0.2304
GEPU	0.0652	0.0746	0.8735	0.3849
EC	0.1011	0.2330	0.4340	0.6654
EUVI	-0.0872	0.6005	-0.1452	0.8849
C	-0.6996	4.3614	-0.1604	0.8729

The empirical findings reported in Table 8 indicate that although the NARDL bounds test statistically confirms a long-run joint cointegration relationship among the variables, the individual long-run coefficient estimates fail to achieve statistical significance. This econometric divergence—where the joint F-statistic is significant but individual t-statistics are not—requires a rigorous structural evaluation. Econometrically, this condition is primarily driven by the presence of near-multicollinearity among the independent macro-financial series. As evidenced by the diagnostic Variance Inflation Factor (VIF) analysis in Table 4, the USD/TRY exchange rate (8.87) and the Export Unit Value Index (EUVI) (6.92) possess high centered VIF values approaching the critical threshold of 10. In time-series econometrics, high linear dependency among explanatory variables is well-documented to inflate individual standard errors and suppress t-values, thereby masking the statistical significance of individual long-run regressors while leaving the overall equilibrium vector (the bounds test) structurally valid. Furthermore, the complex lag structure estimated over a sample size of 120 observations naturally introduces a degrees-of-freedom constraint in the long-run parameter space, further contributing to the lower precision of individual estimates. Beyond the econometric dimensions, this insignificance carries profound economic implications that reflect the structural realities of the Turkish economy. In an emerging market environment characterized by structural external dependence, recurrent exchange rate shocks, and high geopolitical or domestic risk perceptions, real-sector agents and industrial firms operate under a compressed time horizon. Rather than formulating long-run structural production strategies based on individual macroeconomic variables in isolation, manufacturers and firms heavily prioritize adjusting their capacity utilization, inventory management, and pricing behavior in response to short-run innovations and immediate financial shocks. This structural pattern explains why the short-run dynamics (Table 7) exhibit powerful and highly significant impacts, while the long-run individual impacts dissolve into statistical insignificance despite moving together as a systemic equilibrium constraint over the long term.

Beyond these econometric properties, the divergent dynamics between the decomposed parameters require a deeper macroeconomic contextualization. The empirical divergence between the asymmetric behaviors of the exchange rate and the country risk premium reveals distinct macroeconomic transmission speeds. The USD/TRY exchange rate exhibits asymmetry exclusively in the long run. In the short run, industrial manufacturing firms are largely insulated from immediate currency shocks due to financial hedging instruments, forward-looking import contracts, and pre-existing raw material inventories. Consequently, the asymmetric impact of exchange rate fluctuations requires a longer temporal horizon to penetrate the production function, emerging as a long-run structural reality once old contracts expire and replacement costs adapt to the new equilibrium. In stark contrast, the CDS premium represents systemic risk and sovereign creditworthiness, which operates under high information liquidity and instant market reactions. A positive shock (spike) in the CDS premium instantly activates the financial accelerator mechanism, causing commercial banks to immediately restrict credit lines, raise lending rates, and demand higher collateral from industrial firms. Because liquidity constraints and capital flight occur instantaneously, CDS fluctuations exert a

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powerful asymmetric pressure on industrial production in both the short and long run, whereas the exchange rate transmission operates with a structural lag.

Tablo 9: Robustness Test Results According to Alternative Delay Structures

Critical Indicators/Variable	Main Model	Alternative Model 1 (max. lag: 3)	Alternative Model 2 (max. lag: 2)
F-İstatistiği	123.01	143.26	196.26
CointEq(-1)	-0.1963*	-0.2706*	-0.3425*
Δ (USD/TRY⁺)	0.0918	0.0583	0.0259
Δ (CDS⁺)	-0.0893	-0.0774	-0.0730
R^2	0.97	0.97	0.96
Düzeltilmiş R^2	0.96	0.96	0.96
*, denote statistical significance at the 1% levels.			

Table 9 presents the results of alternative specifications where the maximum lag lengths are restricted to 3 and 2, respectively, to evaluate the sensitivity of the unrestricted baseline model to its lag structure and to verify the robustness of the empirical findings. The obtained results are remarkably striking; as the lag structure of the model is simplified into a more parsimonious form, the joint F-statistic representing the overall validity of the model increases from 123.01 to 143.26 and 196.26, respectively. This trend signals that model parsimony significantly enhances empirical efficiency. More importantly, the error correction term (CointEq(-1)), which indicates the speed of adjustment towards the long-run equilibrium, remains negative and statistically highly significant at the 1% level across all alternative specifications. Notably, as the model becomes more parsimonious, the adjustment velocity accelerates from 19.6% to 34.2%. Furthermore, the signs and magnitudes of the coefficients for the exchange rate (Δ (USD/TRY$^+$)) and the country risk premium (Δ(CDS$^+$)) ‘the core pillars of the short-run asymmetric transmission mechanism’ remain unaffected by the lag restrictions and exhibit a highly stable empirical pattern. Finally, the high coefficient of determination in the baseline model ($R^2 = 0.97$) remains virtually unchanged at 0.96 even in Alternative Model 2 where lags are restricted to 2. This conclusively proves that the initially high explanatory power is not an artifact of artificial overfitting or an excessive loss of degrees of freedom, but rather confirms that the model specification is structurally resilient and highly reliable.

"Furthermore, the diagnostic validation through Alternative Model 1 and Alternative Model 2 in Table 9 directly dispels any concerns regarding artificial overfitting or overparameterization potentially indicated by the high baseline R^2 (0.97). Under severe lag restrictions (max lag = 2), the model's explanatory capacity remains practically unchanged at 0.96 while the joint F-statistic strengthens significantly. This econometric resilience demonstrates that the elevated R^2 is not a mathematical artifact of an overly complex lag structure, but rather an empirical reflection of the intense, direct structural transmission of exchange rate shocks and sovereign risk fluctuations onto the production capacity of an emerging, externally-dependent economy like Türkiye.

The asymmetric interaction among the variables, one of the core assumptions of the NARDL model, is examined for both the short and long run using the Wald (restriction) test. The findings are summarized in Table 10.

Table 10: Asymmetry Test Results

Variable	Type of Asymmetry	F-Statistic	Prob.	Decision
USD/TRY	Short Run (W_{SR})	0.8170	0.3686	Symmetric
USD/TRY	Long Run (W_{LR})	6.5317	0.0124	Asymmetric
CDS	Short Run (W_{SR})	2.7438	0.0976	Asymmetric
CDS	Long Run (W_{LR})	5.9760	0.0166	Asymmetric
W_{SR} and W_{LR} denote the Wald statistics for short-run and long-run asymmetry tests, respectively.				

When the effects of exchange rate shocks on industrial production are analyzed, time-dependent differences are observed. For the USD/TRY variable, the short-run asymmetry test is found to be statistically insignificant. This result indicates that short-term exchange rate fluctuations (increases or decreases) exert a symmetric effect on industrial production. In contrast, the long-run effect of the exchange rate is found to be asymmetric. The result, which is statistically significant at the 5% level, suggests that persistent increases and decreases in the exchange rate generate effects of differing magnitudes on industrial production in the long-run equilibrium. The impact of changes in the CDS premium on industrial production exhibits an asymmetric structure in both the short and long run. The short-run asymmetric effect of CDS shocks indicates that temporary improvements or deteriorations in investor confidence affect industrial production in different ways. The long-run asymmetry of CDS implies that persistent declines in the risk premium contribute positively to industrial production, while increases in the risk premium generate a stronger negative effect.

To fully grasp the economic rationale behind these asymmetric and symmetric coefficients, the empirical findings must be contextualized through specific macro-financial transmission channels, namely the cost, investment, and expectation channels. First, the Cost Channel plays a dominant role in explaining the short-run asymmetric impact of the USD/TRY exchange rate. Türkiye's industrial sector is structurally dependent on imported intermediate goods and raw materials. Consequently, a positive exchange rate shock (depreciation of the Lira) immediately spikes the production costs of manufacturers, leading to an involuntary contraction in industrial output due to working capital constraints. Conversely, negative exchange rate shocks (appreciation of the Lira) do not translate into an equivalent expansion in industrial production with the same velocity. This is primarily attributed to downward price rigidity and the asymmetric pricing behavior of firms, who tend to retain wider profit margins during periods of currency appreciation rather than reflecting the cost reduction onto output prices immediately. Second, the Investment and Financing Channel clarifies the powerful and immediate negative impact of country risk premium fluctuations. According to the financial accelerator mechanism, an increase in the CDS premium acts as a

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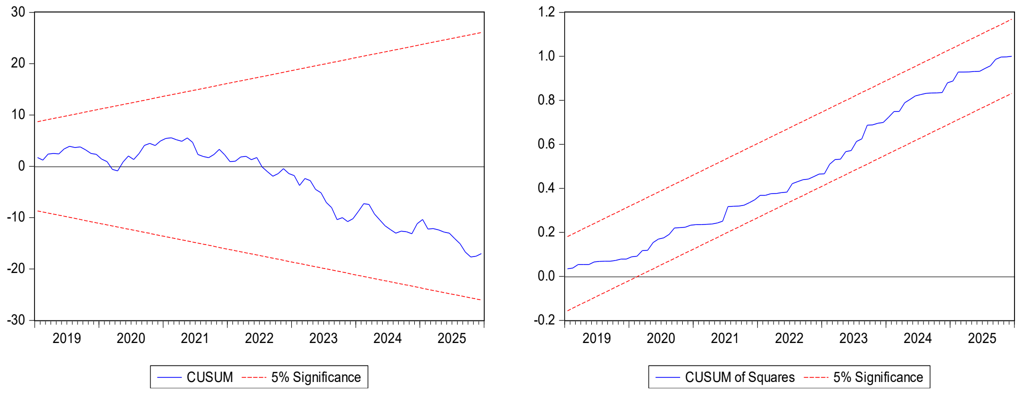
proxy for rising sovereign and systemic risk, which instantly drives up the external borrowing costs for domestic commercial banks and large industrial conglomerates. As external credit lines tighten and cost of capital escalates, industrial firms face severe liquidity squeezes, forcing them to postpone or cancel capital expenditures and long-term capacity expansions. The short-run sensitivity of the Industrial Production Index to CDS shocks confirms that investment decisions in the manufacturing sector are highly elastic to financing costs and risk perceptions. Third, the Expectations Channel bridges the financial shocks and the global economic policy uncertainty with the real economy. High financial volatility alongside global uncertainty damages forward-looking business confidence. In an environment where future cash flows, demand schedules, and inflation expectations cannot be precisely projected, real-sector agents adopt a 'wait-and-see' approach. This behavioral friction dampens manufacturing aggregates, as evidenced by the statistically significant, stabilizing role of the CUR and the dampening effect of risk indicators in our model.

The stability of the model is assessed using the CUSUM and CUSUM of squares tests, and the results indicate that the model is stable over the sample period. The findings are presented in Figure 1.

Figure 1: CUSUM and CUSUM of Squares Tests



The diagnostic test results for the model are reported in Table 10.

Table 11: Diagnostic Tests

Tests	**Sonuç**
Breusch-Godfrey Serial Correlation LM Test:	: 0.7056 [0.3780]
Breusch-Pagan-Godfrey	: 0.7295 [0.8337]
Jarque-Bera Normallik Test	: 0.6792 [0.7120]
Values reported in square brackets [ ] indicate probability (p-values).	

The results presented in Table 11 indicate that at the 1% significance level, there is no evidence of autocorrelation, heteroskedasticity, or non-normality of the error terms in the model.

5. Conclusions

This study analyzes the macroeconomic and financial determinants of the Industrial Production Index in Türkiye using monthly data covering the period 2016M01–2025M12 within the NARDL framework. The model incorporates the capacity utilization rate (CUR), CDS premium, Global Economic Policy Uncertainty (GEPU) index, energy consumption (EC), export unit value index (EUVI), and the USD/TRY exchange rate. In particular, the study examines whether financial risk and exchange rate shocks exert asymmetric effects on industrial production.

The study begins with a systematic review of the literature on the Industrial Production Index. Following the literature assessment, the dataset to be employed in the empirical analysis is introduced, and the main characteristics of the variables are explained. Subsequently, a correlation analysis is conducted to identify potential issues that could affect the reliability of the empirical estimations. The correlation matrix reveals relatively high correlation coefficients among certain variables, raising concerns regarding possible multicollinearity. Accordingly, the Variance Inflation Factor (VIF) test is applied, and the findings indicate that multicollinearity does not pose a significant problem within the model. In order to avoid the problem of spurious regression and to verify the applicability of the planned NARDL framework, unit root tests are performed. The results of the unit root analysis demonstrate that the integration orders of the variables are compatible with the requirements of the NARDL approach. Based on these findings, the model specification is finalized and the empirical estimation process is undertaken.

The results of the NARDL bounds test reveal the existence of a long-run cointegration relationship among the variables. The negative and statistically significant error correction term (ECT) indicates that short-run disequilibria converge toward long-run equilibrium at a measurable speed. This finding confirms that industrial production is embedded within a long-run equilibrium relationship with macroeconomic and financial variables, reflecting the dynamic adjustment mechanism of the model. Although the majority of the long-run coefficients are not statistically significant, the presence of cointegration suggests that the variables move together over time. However, the lack of statistical significance for individual long-run coefficients implies that industrial production is not strongly or permanently driven by individual variables in isolation over the long term. Instead, the effects appear to emerge primarily through short-run dynamics. This result suggests that in economies such as Türkiye—characterized by exposure to financial fluctuations—the real sector may be more sensitive to short-term shocks rather than long-term structural changes.

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The results of the asymmetric analysis indicate that increases and decreases in financial variables generate differential effects on industrial production. The fact that positive and negative shocks in exchange rates and risk premium indicators affect industrial production with differing magnitudes reveals the sensitivity of the real sector to financial vulnerabilities. This finding underscores the critical importance of ensuring financial stability for real sector performance. Furthermore, it suggests that industrial production is shaped not only by real sector dynamics but also by financial risk perceptions and global uncertainty conditions. Therefore, monetary policy, macroprudential measures, and regulatory arrangements aimed at strengthening financial stability should take into account their indirect effects on industrial production. In particular, stabilization-oriented policy frameworks should be developed by considering the potential adverse effects of increases in risk premiums and exchange rate volatility on production decisions.

Based on the empirical evidence and the identified transmission channels, several critical policy implications emerge for policymakers in emerging markets like Türkiye. First, to mitigate the cost channel via structural transformation, macroprudential policies should actively incentivize import-substitution strategies in core manufacturing inputs, given that positive exchange rate shocks aggressively contract industrial output through the imported input cost channel. Transitioning towards localized supply chains and enhancing the production of domestic intermediate goods will structurally decouple industrial performance from exchange rate fluctuations. Second, stabilizing the investment channel through risk mitigation requires maintaining macroeconomic predictability and fiscal discipline, since the manufacturing sector is highly vulnerable to financial accelerator effects triggered by country risk premium spikes. In this context, policymakers should focus on strengthening institutional transparency and optimizing foreign reserves to suppress the sovereign risk premium, thereby ensuring a low-cost, stable financing environment for industrial investments. Finally, for managing the expectations channel via forward guidance, central banking and economic administration authorities should employ clear, consistent, and proactive forward guidance to minimize the adverse effects of expectations-driven contractions during global policy uncertainties. Ultimately, reducing domestic policy ambiguity will shelter business sentiments and prevent industrial firms from over-reacting to short-term global shocks by freezing their production setups.

The empirical findings demonstrate that the effects of financial shocks on the real sector are not symmetric and that production dynamics are shaped through short-run adjustment mechanisms. In this respect, the study contributes to the existing literature. Specifically, the presence of a cointegration relationship between industrial production and macroeconomic and financial variables supports the findings of previous studies such as Tekin (2022) and Demir and Özcan (2023). However, the statistical insignificance of most long-run coefficients indicates that, in the Turkish economy, industrial production is more sensitive to short-term financial and macroeconomic shocks. The asymmetric effects identified in financial variables reveal nonlinear dynamics that cannot be captured by linear modeling approaches, thereby contributing to the literature. Future research may provide a more comprehensive understanding of industrial production dynamics by employing models that incorporate sectoral breakdowns, alternative uncertainty indicators, and regime shifts.

Declaration of AI Use

During the preparation of this text, artificial intelligence tools (Gemini 3, ChatGPT 5.2) were used for grammatical corrections and language enhancement.

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