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Understanding the COVID-19 Impacts on Industrial Production and Employment: Macro-level Evidence from Türkiye

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Abstract This study aims to quantify the impact of COVID-19 on industrial production and employment in Türkiye. The research applies three models: pooled OLS, random effect model, and two-step system GMM using quarterly data from the Turkish manufacturing industries from 2019_{Q1} to 2021_{Q1}. The findings reveal that although COVID-19 negatively affects employment and output, the impact is not robust. This outcome is likely due to the Turkish government's employment-friendly programme during COVID-19, which restricted the layoffs. On the other hand, exports, real wages, and the lagged value of employment significantly increased employment. In addition, inflation, real wages, and the lagged value of industrial production have a substantial positive contribution to the increasing output. However, currency depreciation has a significant negative effect on both employment and output. The study provides insights into the fact that the reduced-hour policy is more effective.

Keywords COVID-19 · Türkiye · Employment · Industrial production · GMM · Pandemic

JEL Classification E24 · 011 · 014 · 024

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Understanding the COVID-19 Impacts on Industrial Production and Employment: Macro-level Evidence from Türkiye

The world has not experienced anything like COVID-19 in the last couple of decades. It was first detected in Wuhan, China, in 2019 (Yüksel, 2021). The WHO formally announced the COVID-19 outbreak as a pandemic because of the worldwide spread and intensity of the virus on March 11th, 2020 (*WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 - March 11th, 2020*). Since then, it has spread rapidly to many countries. This pandemic not only created a health crisis but also created social and economic crises globally, with the economic loss being especially severe. In many countries, industrial production and consumption have drastically reduced (Mugaloglu et al., 2021). The economic crisis triggered by the COVID-19 pandemic is far more severe and longer-lasting than any other economic disaster that has occurred over the past four decades (Ludvigson et al., 2020). It is predicted that compared to earlier global financial crises, these pandemic-related crises will be far more severe and lasting (Oxford Economics, 2020). Considering the economic challenges, the study intends to investigate how COVID-19 influences industrial production and employment in Türkiye.

The first case was identified in Türkiye in March 2020 (Aldan et al., 2021). The virus affected more than 15 million people and caused the death of approximately 100,000 people (*Türkiye Country Overview | World Health Organisation*, 2022). The Turkish government has taken many measures to prevent the spread of the infectious virus, such as sectoral lockdowns, the shutdown of international flights, school and university closures, and curfews for specific ages (Aldan et al., 2021, p. 19). During the pandemic, the Turkish government took initiatives to safeguard the economy. The most extensive programme was the "reduced hours employment programme" (*İŞKUR*, 2021; *Turkey-KPMG Global*, 2022). Under the programme, the government strictly prohibited layoffs and subsidised private firms to support wages. Employees in the private firm might reduce their working hours by up to two-thirds of their full-time employment. In return, the government would provide an equal subsidy. The implementation of the programme assisted in retaining employees during COVID-19. Later, the Turkish government announced another "cash assistance" programme to compensate workers in April 2020. Although the employees were officially employed, they are temporarily laid off by the employer because of business loss or lockdown. The government subsidised 50% of their original wages (*İŞKUR*, 2021). There were other programmes to support small and medium enterprises.

The economy experienced a shock due to a reduction in consumption, particularly in the service sector. In addition, the global supply-chain disruption further deteriorated the economic situation. The sectoral lockdown caused worries for consumers. On the other hand, social distancing created unfavourable conditions in the labour market. Hence, the question is whether the workers could sustain their jobs during the pandemic and how COVID-19 affected the labour market. Under these circumstances, the labour market became more vulnerable due to internal and global economic shocks in Türkiye, as well as in other developed and developing countries. Furthermore, the restrictive measures implemented during the pandemic slowed down the Turkish economy. These effects were reflected in economic activity, with gross domestic product (GDP) drastically declining in the second quarter of 2020. This prompts a critical question: How did COVID-19 influence industrial production in Türkiye? If COVID-19 impact industrial production, did this effect also extend to the labour market?

To address these questions, the study, by applying the two-step system GMM method with the longitudinal data from the Turkish Statistical Institute, documents a few insights. The pandemic reflects the negative consequences in production as well as in the labour market. However, the intensity of the COVID-19 impact

was not robust. There could be a possible link suggesting that the Turkish government's reduced hour policy lessened the negative consequences of COVID-19 on employment.

The study has made a significant contribution in the literature, though few studies analysed the impact of COVID-19 on the Turkish economy from various aspects. However, no specific research has revealed the effects of COVID-19 on industrial production and employment in Türkiye. The subject matter and scope of study add new knowledge. It also focuses on the impact of real wages, inflation, exports, and exchange rate on production during the pandemic.In addition, it contributes to preliterature by using the advanced two-step system GMM method

The study is divided into the following sections. The article will present the literature review in section 2, while data definition, methodology, results, and discussion occur in sections 3, 4, and 5 successively. In the end, a conclusion is drawn from the closing remarks.

Literature Review

The devastating COVID-19 caused severe disruptions worldwide in countries' economic and employment structures. This deadly virus has not only taken many people's lives but has also jeopardised the economies of many countries worldwide. Many people lost their jobs, and as a result, unemployment around the world has increased.

Fana et al. (2020) examined the impact of COVID-19 on the employment levels of three European countries: Germany, Italy, and Spain. Their findings reveal that COVID-19 negatively impacted the most vulnerable and disadvantaged workers in low-productivity services. The authors also find that workers are more likely to lose their employment in the short term due to the lockdown and that the mid-term is particularly uncertain. Adams-Prassl et al. (2020) conducted real-time surveys in the US, UK, and Germany. Their findings show that the COVID-19 pandemic had a substantial economic impact. In the United States and the United Kingdom, women and employees without a college diploma are substantially more likely to have lost their employment, while younger people are significantly more likely to have reduced their wages. Coates et al. (2020) calculated that as a result of social distancing measures to prevent the spread of COVID-19, between 14% and 26% of Australian workers—1.9 to 3.4 million people—could lose their jobs. Workers with lower income were twice as likely to be unemployed as those with higher income. Younger Australians and women will be at considerable risk, as they are more likely to work in occupations and industries most affected by the COVID-19 response. The researchers predicted that COVID-19 could also put more than half of all hospitality workers out of work in Australia. The effects on income and poverty are more severe for informal labourers than for formal labourers.

The worldwide workforce is estimated to be over 3.3 billion people, with around 2 billion (or 62%) working in the informal economy. Women and migrant workers are especially at risk. Nearly 1.6 billion people are thought to have been significantly impacted by the crisis, either because of lockdown measures or because they work in high-risk industries (Lee et al., 2020). They also show that the income of informal labourers dropped by 60% globally in the first month of the crisis. The drop is significantly higher in Africa and the Americas, at nearly 80%. According to their estimates, the COVID-19 epidemic will raise relative poverty levels among informal labourers from 26% to 59%, with certain regions seeing rates as high as 80% or more.

Türkiye was not spared from this terrible claw of this virus. It has also had an adverse effect on the Turkish economy and labour market. Türkiye has struggled with a high unemployment rate (13.7%) since 2018 (Açikgöz, Ö., & Günay, A. 2020). In addition, since the first COVID-19 case was identified on March 11th, 2020, employment in Türkiye has become more fragile. Seker et al. (2020) developed an Employment Vulnerability Index for the Turkish economy. Their findings showed that textile and clothing manufacturing,

leather manufacturing, accommodation, food production, and agriculture were the most vulnerable to job losses. The Information and Communications Technology (ICT) and banking sectors were considered the least vulnerable. They estimated that over 7 million workers were at risk of losing their jobs due to COVID-19's economic repercussions. Çakmaklı et al. (2021) and Koçak et al. (2022) found that COVID-19 adversely affected the tourism sector, and this effect becomes severe as the number of infected cases increases. Tanrıvermiş (2020) showed the impact of the COVID-19 outbreak on the real estate sector and found that the activities in the real estate sector declined amid the pandemic. Öztürk et al. (2020) and ÖZKAN (2020) investigated the effects of the COVID-19 outbreak on the Turkish stock market. Their findings revealed that more cases recorded in Türkiye than in Europe or the rest of the world impacted sectoral indices.

Data Definition

In the study, the data were collected from two sources from 2019_{Q1} to 2021_{Q1}. COVID-19 was identified as the number of affected people, collected from Refinitiv Eikon. The variables—industrial production, inflation, export volume, employment index, gross wages-salaries index, and interest rate—were taken from the Turkish Statistical Institute (TUIK). The exchange rate data are available in the Central Bank of Türkiye (TCMB). Here, the "ex_rate" indicates the CPI-based real effective exchange rate (2003 = 100)-level, converted to quarterly, and collected from TCMB.

On the other hand, the "inf" represents the domestic producer price index (2003 = 100), which accounts for the variation of prices of goods and services sold as final goods by local producers in a certain reference of time. The "Exp_vol" denotes to the export volume index and it measures the volume changes of exported goods based on base year 2015 = 100, data is classified by CPA2008. The "Int" refers to the commercial interest rate, converted to quarterly, and collected from the TCMB. The "Ind_Production" is a dependent variable, which refers to the Industrial Production Index (2015 = 100). This index measures the changes in the economy and analyses the positive and negative effects made by economic and political decisions in the short run.

The "emp" defined as another dependent variable, refers to the Employment Index (2015 = 100). In the regard of the employment index, only workers are considered into account of employment. Apprentices/ trainees, volunteers, partners, and unpaid family members are not included in the employment indices. And the "gwage" indicates the Gross Wages-Salaries Index (2015 = 100), which includes the regular payments and gross basic wage and salary in the form of the wage. All data are homogenised by converting the index in 2015.

Methodology

The main objective is to determine the effect of COVID-19 on the Turkish economy's employment and industrial production levels. Regarding the nature of the data, the study was conducted with the following dynamic panel model:

$$IP_{it} = \alpha_0 + \gamma GDP_{it-1} + \beta_1 l.CC_{it} + \beta_2 \inf_{it} + \beta_3 ExV_{it} + \beta_4 RW_{it} + \beta_5 ER_{it} + \beta_6 Int_{it} + \mu_i + v_{it} - -1 \quad (1)$$

$$Emp_{it} = \alpha_0 + \gamma Emp_{it-1} + \beta_1 l.CC_{it} + \beta_2 \inf_{it} + \beta_3 ExV_{it} + \beta_4 RW_{it} + \beta_5 ER_{it} + \mu_i + v_{it} - -2 \quad (2)$$

Where IP and Emp are dependent variables, $l.CC$ (one-lagged) is the Covid-19 confirm cases (one-lagged), $\inf$ is the inflation rate, ExV is the export volume, RW denotes the real wage rate, ER is the exchange rate, Int is the interest rate, μ_i is the industry-specific effect, and v_{it} is the standard error. The study included the lagged-dependent variable to allow for the variable's potential dynamic behaviour or persistence. The current values of industry- and employment-specific variables and others can be employed. Those variables' potential endogeneity can be addressed using a system GMM estimator, which is the method used in this study. However, almost all sectors are adversely affected by COVID-19, except for the medical

and IT-related sectors. Likewise, the COVID-19 confirmed cases are considered to be industrial production and employment-specific vital factors. Using simultaneous industrial production and employment-specific variables involves the threat of having too many instruments, which is expected with the sample size. The well-known effects of this so-called instrument proliferation are the overfitting of endogenous variables, estimation bias, and the weakening of instrument validity tests (Roodman, 2009). The study conducted the lagged values of COVID-19 confirmed cases; similarly, it employs the one-legged value of the COVID-19 confirmed cases, which is the industrial production and employment indices specific factor during COVID-19. The one-lagged value of the confirmed COVID-19 cases is used to address due to the concerns about endogeneity.

In both regressions, the study employs explanatory variables to capture the potential connection between the COVID-19 confirmed cases and industrial production, as well as the COVID-19 confirmed cases and the employment level of the Turkish economy. The crucial variable is the confirmed COVID-19 cases, and the control variables are the inflation rate, export volume, real wage rate, and exchange rate. Theoretically, the confirmed COVID-19 cases have a negative impact on the industrial production index and employment level (Açikgöz & Günay, 2020; Dhar, 2020). Similarly, inflation, export volume, real wages, and exchange rates positively affect the industrial production index and employment level (Mollick et al., 2011; Salah Uddin et al., 2022; Tandoğan, 2019; Temiz Dinç et al., 2017; Tenzin, 2019).

Table 1

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
SC_emp	171	112.18	12.71	89.8	166.4
SC_Ind_Pro~n	171	117.84	20.23	66.57	196.83
covid_c	171	5561.89	8195	0	21030
Inf	171	198.08	36.37	113.79	358.58
q_interest~e	171	4.35	1.35	2.53	6.58
exp_vol	171	131.08	29.28	60.64	231.61
real_wage	171	110.32	20.78	67.21	182.95
ex_rate	171	71.3	5.52	63.04	77.88

Table 1 presents the descriptive statistics for 171 observations of the key economic variables of this study.

Table 2

Correlation matrix

	SC_emp	SC_Ind~n	L.covi~c	inf	q_inte~e	exp_vol	real_w~e	ex_rate
SC_emp	1							
SC_Ind_Pro~n	0.40***	1						
L.covid_c	0.36***	0.33***	1					
Inf	0.15**	0.03	0.51***	1				
q_interest~e	−0.1	0.11	0.24***	−0.07	1			
exp_vol	−0.13*	0.19***	0.18**	0.08	0.07	1		
real_wage	0.29***	0.53***	0.13*	−0.54***	−0.01	0.02	1	
ex_rate	−0.34***	−0.23***	−0.53	−0.42***	0.30***	−0.13***	−0.04	1

Table 2 displays the correlation coefficients between the economic variables. Sectoral employment and industrial production show a significant relationship. COVID-19 also has a positive impact on sectoral employment. The table also shows that real wages are strongly positively correlated with industrial production

and negatively correlated with inflation. The exchange rate is negatively correlated with both employment and industrial production.

The endogeneity problem is prevalent during the panel data estimation procedure. However, the system GMM can be used to identify and mitigate this endogeneity issue when the endogenous variables, error terms, and non-constant variance have a non-zero correlation, which creates an endogeneity problem. Furthermore, the non-zero variance in the estimation process allows for unobserved heterogeneity. The two-step system GMM is employed instead of the first-difference two-step first difference GMM in the estimation process because it produces better estimation results for some persistent vital variables. In the system GMM estimation, Arellano and Bover (1995) and Blundell and Bond (1998) found that lagged-level variables are poor instruments when exogenous variables are exceedingly continuous. The lagged level variables were used as instrumental variables during the first difference GMM estimation process; however, the estimated results suffered from a substantial constant sample bias. However, the system GMM produces better estimation results because it has a reduced sample bias and is more efficient when compared to the first difference GMM (Soto, 2009). To counteract the substantial downward bias in the standard errors of the two-step GMM estimates in the empirical implementation, Windmeijer's finite sample correction was used (Windmeijer, 2005). The study also tests the validity of the instrument employed in the two-step system GMM using the Hansen J test (Hansen, 1982) and the Arellano & Bond (1991) tests of order one and order two conducted for the error autocorrelation test.

Result and Discussion

This study uses the two-step system GMM in the empirical estimation process; however, it includes traditional panel estimation to observe the desired model's consistency. This research runs several diagnostic tests for the estimated econometric models. First, the research accepts the null hypothesis and concludes that the random-effects model is recommended here regarding the Hausman test for equations 1 and 2. Second, the null hypothesis is accepted at the 5% significance level when the Sargan and Hansen tests are conducted for both models (equations-1 and 2); the test results are presented in the bottom parts of Tables 1 and 2. The study concludes that the instruments are valid for both estimated GMM models. In addition, the Arellano-Bond test for AR(1) and the Arellano-Bond test for AR(2) were performed for the error correlation, and the null hypotheses were accepted at a 5% significance level. Thus, it can be concluded that the two-step system GMM for both models does not suffer from serial correlation issues.

The research conducted three different empirical estimations, i.e., POLS, random effects, and two-step system GMM. The first two columns of Tables 1 and 2 show the POLS and random effects estimation results. Based on the two-step system GMM (equations-1 and 2), the following results are found in column 4 of Tables 1 and 2. The bottom parts of those tables show the diagnostic test. Regarding the Arellano-Bond tests (AR 1 and AR 2), the study does not reject the null hypothesis at the 5% level. It concludes that there is no error autocorrelation. Likewise, the Sargan and Hansen tests are applied to the validity of the instruments. According to the results of the tests, the study accepts the null hypothesis at the 5% significance level and concludes that the instruments are valid.

The crucial variable, lagged COVID-19 confirmed cases, has a negative and significant impact on the employment level of the Turkish economy. However, lagged COVID-19 confirmed cases have a negative but minimal (-0.0001) impact on the Turkish employment level. During the COVID-19 pandemic, almost all countries were severely impacted and drastically fell employment levels (Açikgöz & Günay, 2020). Besides, the Turkish government took several measures to reduce the working hours instead of lay-off labourers, to boost the economy, which is why the estimated result shows a minimal and negative impact on the employment level. Aldieri et al. (2022) found similar results. The COVID-19 pandemic has had diverse impacts

on unemployment across different regions and demographics. In the United States, larger metropolitan areas experienced higher unemployment rates than smaller cities (Cho et al., 2021). In China, the effects of the pandemic varied based on gender, employment status, and industry, leading to a contraction in full-time employment (Liang et al., 2022). Similarly, in Europe, countries such as the Czech Republic, Lithuania, Latvia, Ireland, and Estonia faced higher youth unemployment rates during the pandemic, whereas Hungary, Italy, and Belgium experienced comparatively lower rates (Lambovska et al., 2021).

The inflation rate positively affects the employment level, which is supported by theory through the coefficient, which is statistically insignificant. Additionally, the export volume significantly and positively influences Turkish employment.

The dynamic term of the two-step system GMM in Table 1, Column 4, the lagged dependent variable, SC_emp, is positive and significant at the 1%. The coefficient for the seasonally adjusted employment level measures the impact of the previous year's employment level on the current year's employment level. In column 3 of Table 1, the estimated coefficient of the lagged dependent variable is 1.029, which leads to convergence before one year if there is any disequilibrium.

Table 3

Employment

	(1)	**(2)**	**(3)**
	SC_emp	**SC_emp**	**SC_emp**
L.covid_c	0.000	0.0001***	−0.0001**
	(0.190)	(2.848)	(-2.492)
Inf	0.070	0.063**	0.031
	(0.178)	(2.142)	(1.136)
exp_vol	−0.087**	−0.001	0.071***
	(0.015)	(-0.041)	(3.096)
real_wage	0.222***	0.157***	0.071*
	(0.000)	(4.504)	(1.647)
ex_rate	−0.383*	−0.365***	−0.158***
	(0.086)	(-5.332)	(-4.308)
L.SC_emp			1.029***
			(11.888)
_cons	111.650***	107.678***	−12.835**
	(0.000)	(8.700)	(-2.028)
Observations	152	152	152
Number of Groups			19
Number of Instruments			16
Arellano-Bond test for AR(1) in first differences: z = −1.68 Pr > z = 0.092			
Arellano-Bond test for AR(2) in first differences: z = 0.88 Pr > z = 0.379			
Sargan test of overid. restrictions: chi2(9) = 48.56 Prob > chi2 = 0.000			
Hansen test of overid. restrictions: chi2(9) = 15.58 Prob > chi2 = 0.076			

*p-values:*** p<.01, ** p<.05, * p<.1*

(1) The pooled OLS Model

(2) The random effect model

(3) and the two-step system GMM Model

Table 4
Industrial Production

	(1)	(2)	(3)
	SC_Ind_Production	**SC_Ind_Production**	**SC_Ind_Productio*n**
L.covid_c	−0.0008	−0.0003***	−0.002***
	(0.0005)	(0.0004)	(0.0004)
Inf	0.304***	0.253***	0.481***
	(0.066)	(0.07)	(0.114)
exp_vol	0.147**	0.211***	0.072
	(0.053)	(0.067)	(0.052)
real_wage	0.0.832***	0.619	1.005***
	(0.137)	(0.130)	(0.131)
ex_rate	0.463	0.026	0.918***
	(0.719)	(0.437)	(0.313)
L3.Int_rate	−4.656	−2.134	−2.134
	(3.547)	(2.490)	(2.490)
L.SC_Ind_Production	-	-	0.312**
			(0.080)
_cons	−63.02	−20.795	−151.416
	(45.345)	(32.516)	(29.788)
Observations	152	152	152
Number of Groups			19
Number of Instruments			10
Arellano-Bond test for AR(1) in first differences: z = −2.39 Pr > z = 0.017			
Arellano-Bond test for AR(2) in first differences: z = 1.17 Pr > z = 0.24			
Sargan test of overid. restrictions: chi2(3) = 40.54 Prob > chi2 = 0.000			
Hansen test of overid. restrictions: chi2(3) = 14.91Prob > chi2 = 0.094			

*p-value: *** p<.01, ** p<.05, * p<.1*
(1) The pooled OLS Model
(2) The random effect model
(3) The two-step system GMM Model

In Table 1, the lag value of COVID-19 shows a significant negative impact on employment; however, it is not robust (Bauer & Weber, 2021), while inflation does not reflect any substantial effect on employment. On the other hand, exports, real wages, and lag value of employment significantly increase employment (Aydiner-Avsar & Onaran, 2010; Tandoğan, 2019). Hence, the increase in exports translates to enhancing the output. To meet the need for higher output, more employees are required to engage in production (Aydiner, 2016). Similarly, a rise in real wage and employment of one-quarter lag also increases employment (Aydiner-Avsar & Onaran, 2010; Seok & You, 2022). However, the depreciation of the Türkiye currency has a significant negative impact on employment because the exported goods are highly dependent on imported raw materials (Salah Uddin et al., 2022).

In the output model (Table 2 and column 4), the dynamic term of the two-step system GMM, the lagged dependent variable, SC_Ind_Production, is positive and significant at 1%. The seasonally adjusted production level coefficient measures the impact of the past year's employment level on the current year's employment level. In column 4 of Table 3, the estimated coefficient of the lagged dependent variable is 0.312, which leads to a convergence of more than three years if there is any disequilibrium. The lagged

value of the COVID-19 cases significantly reduces industrial production. Hence, during COVID-19, the Turkish government imposed a series of restrictions on economic activities and lockdowns in the country, negatively influencing industrial production. However, the exchange rate has a significant positive impact on industrial output. The depreciation of currency translates into an increase in exports as well as production. Hence, the output experiences a positive consequence of currency depreciation. In addition, inflation, real wages, and the lag value of industrial production have a substantial positive contribution to increasing output (Lagos & Rocheteau, 2005; Seok & You, 2022). Moderate-level inflation increases the possibility of profit. The rise in real wages has also increased employment, which has resulted in higher production. Nevertheless, despite the aforementioned positive nexus, the export volume does not show any significant relationship to industrial output.

Conclusion

The adverse impact of COVID-19 on the global economy has been extensively documented. In line with global trends, this study employs a two-step system GMM methodology using quarterly data from 2019Q1 to 2021Q1 to analyse the effects of COVID-19 on Türkiye's output and employment. The findings indicate that while COVID-19 has negatively influenced both output and employment in Türkiye, the intensity of the impact appears to be relatively moderate. This outcome can be attributed to the Turkish government's employment-friendly policies during the pandemic, which restricted layoffs. To mitigate the economic challenges posed by the pandemic, the Turkish government introduced a USD 15 billion economic shield plan in March 2020 (*İŞKUR*, 2021; *Türkiye-KPMG Global*, 2022). This plan included several novel ideas, ranging from tax reductions and payment deferrals for business tax bills to higher minimum pension payouts. In addition, some government organisations have announced specific financial support initiatives to help struggling firms. To ensure that Turkish banks provided sufficient liquidity to the markets, additional economic stimulus measures were taken.

This study also finds that during COVID-19, the level of employment is positively impacted by the inflation rate; however, the correlation is statistically negligible. Additionally, the export volume has a considerable and favourable impact on employment in Türkiye. Exports, real wages, and lag values of employment facilitate significant employment growth. As a result, the rise in exports increases the output. A greater number of workers must participate in production to meet the demand for higher-level output. Similarly, real wages and employment growth in the prior quarter produce a situation in which employment also increases. However, change in the exchange rate has significantly negative impact on employment. Exports generally improve with currency depreciation, which increases output and employment.

The study also reveals that the prevalence of COVID-19 infections significantly lowers industrial output. Therefore, during COVID-19, the Turkish government implemented several economic restrictions and a nationwide lockdown, negatively impacting industrial productivity. Similarly, change in exchange rate has substantial negative impact on industrial output. Türkiye's exports are highly reliant on imported raw materials (Filiztekin, 2004), despite currency devaluation increasing output. As a result, the impact of currency depreciation on production is negative.

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