TİME SERİES ANALYSİS OF VARİABLES AFFECTİNG GDP: AN EMPİRİCAL STUDY

GSYIH'YI ETKİLEYEN DEĞİŞKENLERİN ZAMAN SERİLERİ ANALİZİ: AMPİRİK ÇALIŞMA

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Abstract
In this study, the relationships between various macroeconomic indicators that determine the performance of the Turkish economy are analyzed by time series analysis. Using World Bank data for the period 1988-2021, GDP growth and the variables of exports of goods and services, imports of goods and services, gross fixed capital formation (investment), value added in the industrial sector (including construction), value added in the services sector, value added in the agriculture-forestry-fisheries sector, foreign direct investment inflows and defense expenditures are considered. First, the stationarity of the series is tested with Ng-Perron unit root tests. Then, Johansen cointegration test is applied to identify long-term equilibria and Vector Error Correction Model (VECM) is estimated for cointegrated variable groups. Granger causality tests were conducted to identify short-term causality relationships and impulse-response analysis was applied to analyze the response of variables to shocks. The findings indicate that the main drivers of growth in the Turkish economy are export performance, foreign capital inflows and developments in the industrial and services sectors. In the short run, growth in the services sector has a leading effect on GDP, while export and investment increases have positive effects on growth. In the long run, a statistically significant equilibrium relationship is found between GDP and imports, exports, investment and industrial production. In particular, it is found that the increase in imports makes the strongest contribution to GDP growth in the long run, while the effects of exports and investment weaken over time. Defense expenditures do not have a significant impact on growth. For policymakers, these findings suggest that sustaining export-led growth strategies, encouraging foreign investment and capital inflows, and productivity-oriented reforms in industry and services sectors are critical for long-term sustainable growth.
Key Words: GDP, time series, empirical study

Özet
Bu çalışmada, Türk ekonomisinin performansını belirleyen çeşitli makroekonomik göstergeler arasındaki ilişkiler zaman serisi analiziyle incelenmiştir. 1988-2021 dönemi için Dünya Bankası verileri kullanılarak; GSYİH büyümesi ile mal ve hizmet ihracatı, mal ve hizmet ithalatı, sabit sermaye oluşumu (yatırım), sanayi sektöründe (inşaat dâhil) yaratılan katma değer, hizmetler sektöründe yaratılan katma değer, tarım-orman-balıkçılık sektöründe yaratılan katma değer, doğrudan yabancı sermaye girişleri ve savunma harcamaları gibi değişkenler ele alınmıştır. İlk olarak, serilerin durağanlığı Ng-Perron birim kök testleriyle sınanmıştır. Daha sonra, uzun vadeli denge ilişkilerini belirlemek amacıyla Johansen eşbütünleşme testi uygulanmış ve eşbütünleşik değişken grupları için Vektör Hata Düzeltme Modeli (VECM) tahmin edilmiştir. Kısa vadeli nedensellik ilişkilerini belirlemek amacıyla Granger nedensellik testleri yapılmış ve değişkenlerin şoklara tepkisini analiz etmek için etki-tepki (impulse-response) analizi uygulanmıştır. Elde edilen bulgular, Türk ekonomisinde büyümenin temel itici güçlerinin ihracat performansı, yabancı sermaye girişleri ve sanayi ile

hizmet sektörlerindeki gelişmeler olduğunu göstermektedir. Kısa vadede, hizmetler sektöründeki büyümenin GSYİH üzerinde öncü bir etkisi bulunurken, ihracat ve yatırım artışlarının da büyüme üzerinde olumlu etkileri görülmektedir. Uzun vadede ise, GSYİH ile ithalat, ihracat, yatırım ve sanayi üretimi arasında istatistiksel olarak anlamlı bir denge ilişkisi tespit edilmiştir. Özellikle, ithalattaki artışın uzun vadede GSYİH büyümesine en güçlü katkıyı yaptığı, buna karşılık ihracat ve yatırımın etkilerinin zamanla zayıfladığı ortaya konmuştur. Savunma harcamalarının büyüme üzerinde anlamlı bir etkisi bulunmamaktadır. Politika yapıcılar açısından bu bulgular; ihracata dayalı büyüme stratejilerinin sürdürülmesinin, yabancı yatırımların ve sermaye girişlerinin teşvik edilmesinin, ayrıca sanayi ve hizmetler sektörlerinde verimlilik odaklı reformların gerçekleştirilmesinin uzun vadeli sürdürülebilir büyüme açısından kritik olduğunu göstermektedir.
Anahtar Kelimeler: GSYIH, zaman serileri, ampirik çalışma

INTRODUCTION

Economic growth is one of the most fundamental indicators for a country to increase its welfare level and achieve sustainable development goals. Therefore, understanding the factors affecting growth and analyzing the dynamic relationships between them are of great importance in economic literature and policy making. In the case of the Turkish economy, factors such as foreign trade performance (exports and imports), capital accumulation (investments) and sectoral transformation (declining share of agriculture and increasing share of industry and services) are considered to have decisive roles in the country's growth process. The aim of this study is to analyze the determinants of economic growth in Turkey using quantitative methods and to reveal the short and long-term relationships between these variables. The empirical findings are expected to guide decision makers in designing more effective economic policies. The rest of the paper is organized as follows: first, in the second section, the effects of the relevant variables on growth within the framework of economic growth theory are discussed theoretically. The third section summarizes selected empirical studies in the form of a literature review. The fourth section describes the data and the econometric methodology used. The fifth section presents the findings of the empirical analysis, while the sixth and seventh sections discuss the findings and provide conclusions and policy recommendations.

ECONOMIC THEORY

Theoretically, economic growth is affected by both supply and demand-side factors. Exports are recognized as one of the main demand-side determinants that contribute to growth. Increased exports stimulate production and investment through the expansion of external demand; they can also generate positive externalities such as economies of scale and technology transfer (Romer, 1990) Imports, on the other hand, can increase access to consumption goods, while imports, especially of intermediate and investment goods, can support growth by increasing productivity (C. M. Lawrence et al., 1999). Fixed capital investments expand production capacity by increasing the capital stock, which is an important determinant of growth in neoclassical and new growth theories (Barro & Sala-i-Martin, 1995; Solow, 1956).Sectoral value added is also an important component of growth. The industrial sector is generally the main area that supports growth through productivity growth and technological progress. The services sector has recently become a driver of growth in developing countries (Doğaner, 2022). The agricultural sector, on the other hand, functions as a growth driver, especially in low-income countries (Tiffin & Irz, 2006). Foreign direct investment (FDI) can contribute to long-term growth by providing knowledge and technology transfer as well as capital inflows (Borensztein et al., 1998). The impact of defense spending

is controversial in the literature; some studies argue that it supports growth, while others argue that it may have a negative impact by crowding out private investment (Benoit, 1978a).

LITERATURE REVIEW

AUTHOR(S)/YEAR	COUNTRY(S)/PERIOD	METHOD	RESULT
Högskola et al., n.d.	69 developing countries (1970-1989)	Cross-country regression analysis	It is concluded that foreign direct investment (FDI) positively affects economic growth and contributes more than domestic investment; however, for this effect to occur, a certain human capital threshold must exist in the country.
(Kılıç Tuğba Funda, 2023)	Türkiye (1990–2020)	ARDL bounds test (time series)	FDI, gross fixed capital formation (GFCF) and inflation variables have a positive effect on GDP in the long run. In the short run, it is found that FDI and GFCF have a positive effect on growth.
(ARSLAN Fırat & ETİZ Alaattin, 2023)	Türkiye (1960–2020)	ARDL cointegration test, Granger causality, FMOLS/CCR regressions	A long-run relationship and positive bidirectional causality between exports and GDP are found. Parameter estimation results show that exports have a statistically significant and positive effect on GDP, confirming export-led growth in Türkiye.
(Baday Yildiz & Berber, 2011)	Türkiye (1989–2007)	Johansen cointegration, VECM and causality analysis	It is reported that there is unidirectional causality from total imports and imports of intermediate goods to economic growth and bidirectional causality between imports of investment goods and growth. The overall findings indicate that import-led growth phenomenon is valid in Türkiye in the analyzed period.
(Barrie et al., 2021)	Sierra Leone (1980–2020)	ARDL bounds test (time series)	Both export-led and import-led growth hypotheses are found to be valid. However, exports are found to affect growth more strongly than imports in the short and long run.
(R. Z. Lawrence et al., 1999)	Japan (1964-1973)	Trade policy analysis, growth calculations	In the case of Japan, in contrast to protectionist policies, lowering tariffs and increasing the volume of imports were found to significantly support the increase in total factor productivity (TFP). No significant effect of export growth on TFP was observed, and it was concluded that increased competition through imports accelerated growth by triggering innovation.

(Yildirim et al., 2005)	Middle East countries + Türkiye (1989-1999)	Dynamic panel (GMM) analysis	Military defense expenditures have a positive effect on economic growth. For Middle Eastern countries and Türkiye as a whole, an increase in defense expenditures significantly increases growth.
(Naımoglu & Özbek, 2022)	Türkiye (1960–2019)	Fourier cointegration test, FMOLS/DOLS estimation	A long-run cointegration relationship was found between defense expenditures and economic growth. Short and long-run coefficient estimates show that an increase in defense expenditures increases GDP growth in Türkiye in a statistically significant way.
(Levine Ross, 1992)	100+ countries (1960s-1989)	Cross-country regression "extreme bounds" analysis	In this comprehensive study, which tested a large number of variables, only variables such as the share of investment in GDP and the foreign trade (openness) ratio were found to have a positive and robust correlation with growth. The effects of many other variables are not consistent with the model specifications.
(Tiffin & Irz Xavier, 2006)	Developing countries (panel)	Panel Granger causality analysis	It has shown that in emerging economies, growth in the agricultural sector is a driver of overall economic growth. Strong evidence has been reported that agricultural value added growth causally leads GDP growth.
			In the long run, industrial sector and exports have a positive and significant effect on growth, while the effect of manufacturing industry is found to be negative; the long-term effects of agriculture and services sectors are statistically insignificant. In the short run, agriculture and manufacturing industry have an increasing effect on growth, while the effect of the service sector is not detected.
(EKİNCİ Aykut, 211 C.E.)	Türkiye, 1980-2010	Time series analysis	It is determined that foreign direct investments contribute positively to economic growth. It is concluded that the increase in imports in Türkiye increases FDI, which in turn increases exports in the long run.
(Mucuk Mehmet & Demirsel Mustafa Tahir, 2009)	Türkiye / 1992-2012	Cointegration Analysis	FDI is found to have a positive impact on economic growth in the long run.

	Türkiye / 1980-2015	Cointegration and causality tests	No long-term relationship was found between FDI and economic growth, while a unidirectional relationship was found in the short run.
(Love & Chandra, 2004)	India, Pakistan, Sri Lanka / 1950-1992	Multivariate modeling	While bidirectional causality is found between economic growth and exports for India and Pakistan, no causality relationship is found for Sri Lanka.
(Konya & Laszlo, 2004)	24 OECD countries / 1960-1999	Panel data analysis	The causality relationship between exports and economic growth varies across countries. For example, a bidirectional causality relationship is found from growth to exports in Canada, Japan and Korea, from exports to growth in Iceland, and from exports to growth in Sweden and the UK.
(Benoit, 1978b)	Developing Countries / 1950-1965	Econometric Analysis	It is concluded that defense expenditures have a positive impact on economic growth.
(Destek Mehmet Akif, 2016)	BRICS and MIST countries / 1990-2013	Panel Granger causality test	There is a bidirectional causality between military expenditures and economic growth.
(Dinç, 2022)	Türkiye / 1968-2020	Bootstrap Toda-Yamamoto causality test	A unidirectional causality relationship was found from the agricultural sector to economic growth. A bidirectional causality relationship was found between the services sector and economic growth.
(Doğaner Ayça, 2022)	Türkiye / 1998-2019	Time series analysis	A bidirectional causality relationship was found between the service sector and economic growth.

ECONOMETRIC METHODOLOGY

Econometric tests based on time series data were applied in this study. We start with the most basic step in time series, which is the stationarity test. Regressions performed with non-stationary series may yield misleading results such as spurious regression. The Ng-Perron Unit Root test has a higher sampling power than traditional tests. Test results may be misleading if the series contain structural breaks. Evaluation is made over four different statistics: MZ_a, MZ_t, MSB, MPT. Johansen Cointegration test based on the Vector Autoregressive (VAR) structure is used to determine the long-run relationship between time series integrated in the same order in multivariate systems. Cointegration is determined by Trace and Max-Eigen statistics. Johansen cointegration test is sensitive to assumptions. The test, which can detect more than one cointegration vector at the same time, provides systematic analysis. The Granger causality test tests whether one variable in a linear relationship can be meaningfully identified as the dependent variable and the other variable as the independent variable, whether the relationship is bidirectional, or whether no functional relationship exists. Stationarity is a prerequisite. Impulse-response analysis measures the

effect of a 1 standard deviation shock to one variable on other variables over time. Cholesky decomposition is used in IRF calculation. It provides information about the direction and duration of shocks. Vector Error Correction Model (VECM) is used to analyze the long-term equilibrium relationship and short-term dynamics between multiple time series variables. In order to be used, the variables must be cointegrated. It extends the Autoregressive Moving Average (ARMA) model to account for both short-term deviations from equilibrium and the long-term equilibrium relationship between variables. It includes an error correction term that adjusts for short-term deviations from the long-term equilibrium relationship. This term captures the speed at which variables return to equilibrium after a shock or disturbance. It is also used to forecast future values of variables. The VECM(p) with the cointegration rank r ≤ k is as follows:

(1) $\Delta y_t = c + \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-1} + \varepsilon_t$

Δ: Operator differencing, where $\Delta y_t = y_t - y_{t-1}$

y_{t-1}: Vector variable endogenous with the 1-st lag.

ε_t: Vector residual.

c: Vector intercept.

Π: Matrix coefficient of cointegration ($\Pi = \alpha\beta$);

α: vector adjustment, matrix with order (k × r) and

β: vector cointegration (long-run parameter) matrix k × r)

Γ_i: Matrix with order k × k of coefficient

Endogenous of the i-th variable.

DATA

Veriables	Abbreviations	Explanation
GDP Growth (Annual %)	GDP	Annual percentage growth rate of GDP where aggregates are based on 2015 prices.
Imports Of Goods And Services (Annual % Growth)	Exports	Value of all goods and services supplied to the rest of the world at constant 2015 prices.
Imports Of Goods And Services (Annual % Growth)	Import	Value of all goods and services purchased from the rest of the world at constant 2015 prices.
Foreign Direct İnvestment, Net İnflows (% Of GDP)	FDI	Net investment inflows are net investment inflows for a permanent management stake in an enterprise operating in the economy.
Gross Fixed Capital Formation (Annual % Growth)	GCF	Land improvements based on constant 2015 prices include purchases of plant, machinery and equipment, and construction of roads, railways and the like, including schools, offices, hospitals, private residences and commercial and industrial buildings.
Services, Value Added (Annual % Growth)	Services	It is based on constant 2015 prices and corresponds to ISIC divisions 45-99.
Industry (İncluding Construction), Value Added (Annual % Growth)	Industry	It is based on constant 2015 prices and corresponds to ISIC section 05-43 and includes manufacturing (ISIC section 10-33).
Military Expenditure (% Of GDP)	ME	It is a trend indicator of the volume of resources used for military activities.
Agriculture, Forestry, And Fishing, Value Added (Annual % Growth)	AFF	It is based on constant 2015 prices and corresponds to agriculture ISIC divisions 01-03 and includes forestry, hunting and fishing, as well as crop cultivation and livestock production.

*Provided from World Bank data for the period 1988-2021.

FINDINGS

Table 1. Data Statistics

Veriables	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis	Jarque-Berra	Prob.
GDP	-0.1511	0.00	1.0668	-1.9713	0.8018	-0.7235	2.7852	3.0321	0.2195
Exports	0.0047	0.00	1.8481	-2.3762	0.8953	-0.3740	3.5787	1.2675	0.5305
Import	0.0262	0.00	1.2919	-1.3988	0.6485	-0.1313	2.6777	0.2449	0.8847
FDI	0.0498	0.00	-2.2394	-0.7266	0.7603	1.1340	3.8572	8.3284	0.0155
GCF	-0.0476	0.00	1.6061	-2.2351	0.8926	-0.5421	2.8833	1.6851	0.4306
Services	-0.1160	0.00	1.6350	-1.8866	0.8094	-0.3815	2.7210	0.9350	0.6265
Industry	-0.1686	0.00	1.6254	-2.2018	0.8565	-0.6151	3.3287	2.2973	0.3170
ME	0.1371	-1.45e-16	0.9467	-0.5769	0.5257	0.1815	1.4728	3.4909	0.1745
AFF	-0.0801	0.00	0.9705	-1.7078	0.7084	-0.5234	2.5160	1.8847	0.3897

When the statistics of the variables in Table 1 are analyzed, it is determined that the FDI variable is normally distributed. The other 8 variables do not meet the normal distribution conditions. Since the normality assumption can be ignored in the tests to be conducted, the analysis is continued.

Figure 1. CUSUM Test

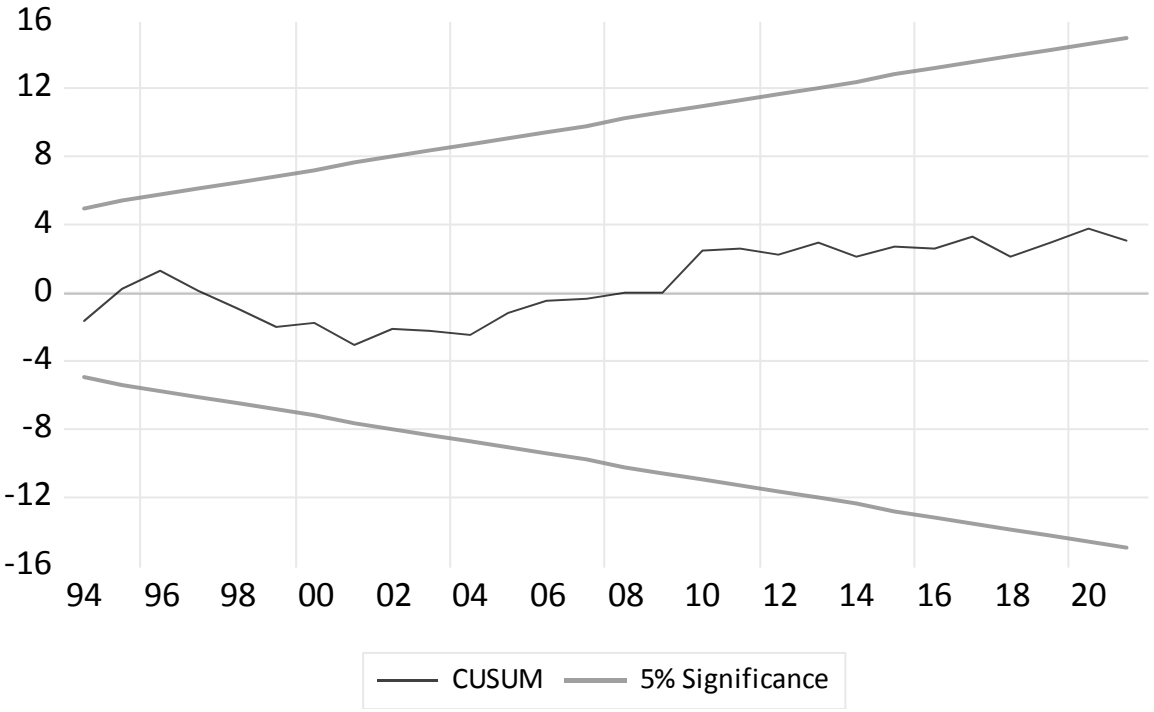
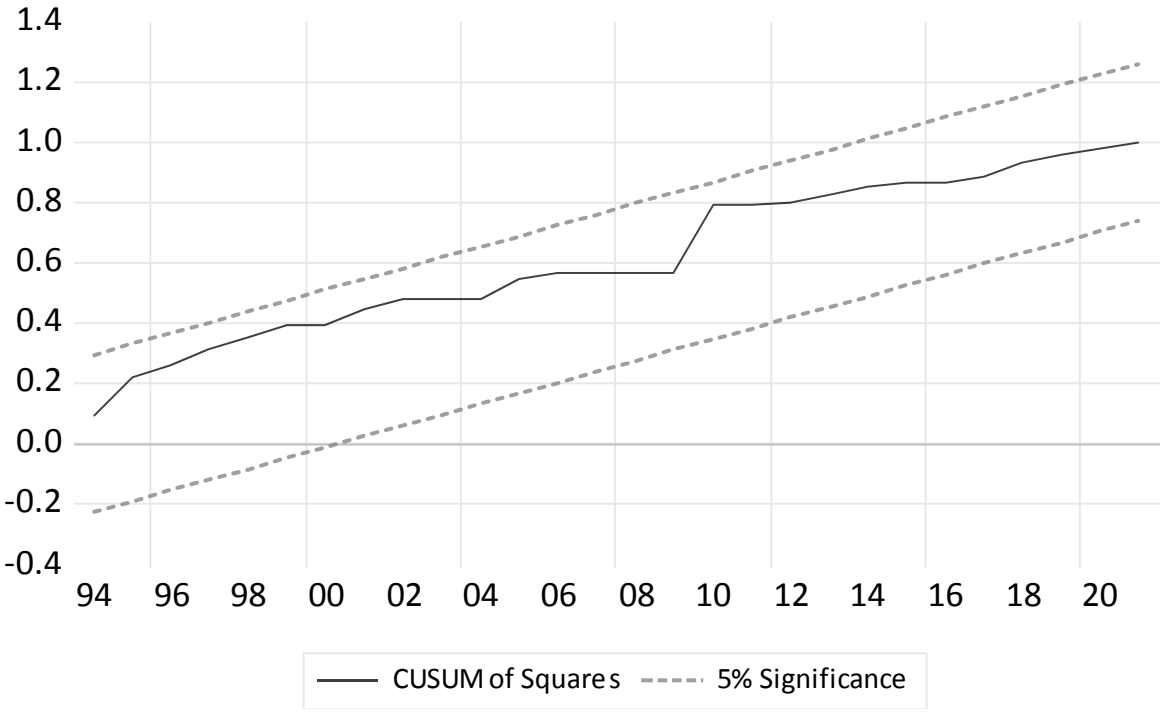


Figure 2. CUSUM Of Squares Test



When the CUSUM and CUSUM of Squares graphs in Figures 1 and 2 are analyzed, it is seen that they are within the 5 percent critical value. This implies that there is no structural break in the series.

Table 2. Ng-Perron Unit Root Test

Deterministic component: constant and trend

Veriables	Test For Unit Root In	Lag	MZ_a	MZ_t	MSB	MP_t
GDP	Level	0	-16.3763	-2.81276	0.17176	5.85179
Exports	Level	0	-15.6849	2.59638	0.16553	6.97016
Import	Level	0	-14.9548	-2.73273	0.18273	6.10361
FDI	1st Difference	0	-15.9531	-2.80051	0.17555	5.85197
GCF	Level	0	-16.3056	-2.85530	0.17511	5.58862
Services	Level	0	-16.0607	-2.72032	0.169380	6.33297
Industry	Level	0	-16.3192	-2.82212	0.17293	5.78706
ME	1st Difference	0	-15.9606	-2.77706	0.17399	5.99008
AFF	2st Difference	5	-0.15538	-0.24576	1.58172	459.086
Asymptotic critical values*:		1%	-23.8000	-3.42000	0.14300	4.03000
		5%	-17.3000	-2.91000	0.16800	5.48000
		10%	-14.2000	-2.62000	0.18500	6.67000

*Critical values are taken from Table1 of (Ng & Perron, 2001). Lags are selected according to modified Akaike in formation.

Hypotheses;
H_0= It's not staunned. Unit has root.
H_a= Stagnant. There is no unit root.
It is as follows.
GDP, Export, Import, GCF, Services and Industry variables were found stationary at level by rejecting the null hypothesis. Since the null hypothesis is accepted at the level for FDI and ME, the null hypothesis is rejected by taking their first differences and it is accepted that there is no unit root. AFF was not stationary even though second order differences were obtained.

Therefore, AFF, ME and FDI variables are excluded from the model as they may lead to spurious regression and forecasting errors.

Table 3. VAR Residual Heteroskedasticity Tests (Levels and Squares)

Chi-sq	Df	Prob.
267.4699	252	0.2403

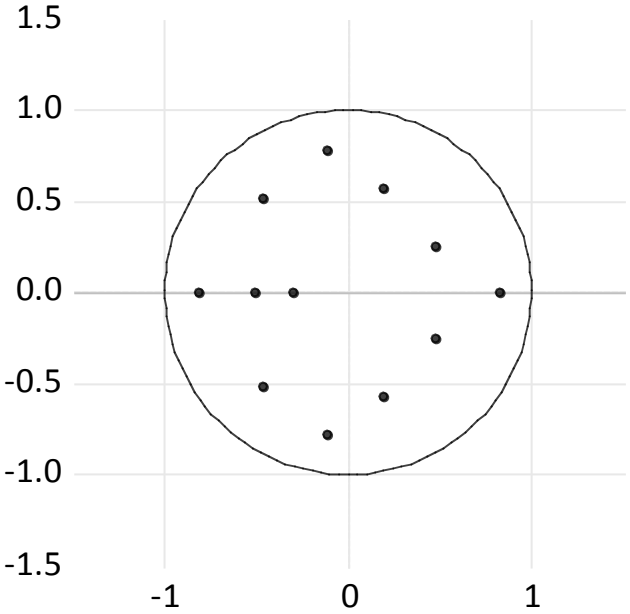
Hypotheses;
H_0= There is no heteroskedasticity.
H_a= There is heteroskedasticity.
When the statistics in Table 3 are analyzed, it is determined that there is no heteroskedasticity.

Table 4. VAR Residual Serial Correlation LM Tests

Lag	LRE* stat	Df	Prob.	Rao F-stat	df	Prob.
1	33.88250	36	0.5696	0.9253	(36, 68.6)	0.5924

Hypotheses;
H_0= No serial corralation at lags 1.
H_a= Serial corralation at lags 1.
When the statistics in Table 4 are analyzed, it is determined that there is no serial correlation with 1 lag.

Figure 3. Inverse Roots of AR Characteristic Polynomial



All the roots of AR polynomial are in the unit circle, the dynamic structure of the model is stable. Achieving this condition means that estimates from the model are meaningful and safe.

Table 5. VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-82.25223	NA	1.20e-05	5.693693	5.971238*	5.784166*
1	-42.31682	61.83548*	9.73e-06*	5.439795	7.382616	6.073106
2	-17.84078	28.42378	2.72e-05	6.183277	9.791374	7.359426
3	44.428092	48.20817	1.20e-05	4.488510*	9.761882	6.207498

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

When the criteria in Table 5 are analyzed, 1 lag value is chosen according to LR and FPE.

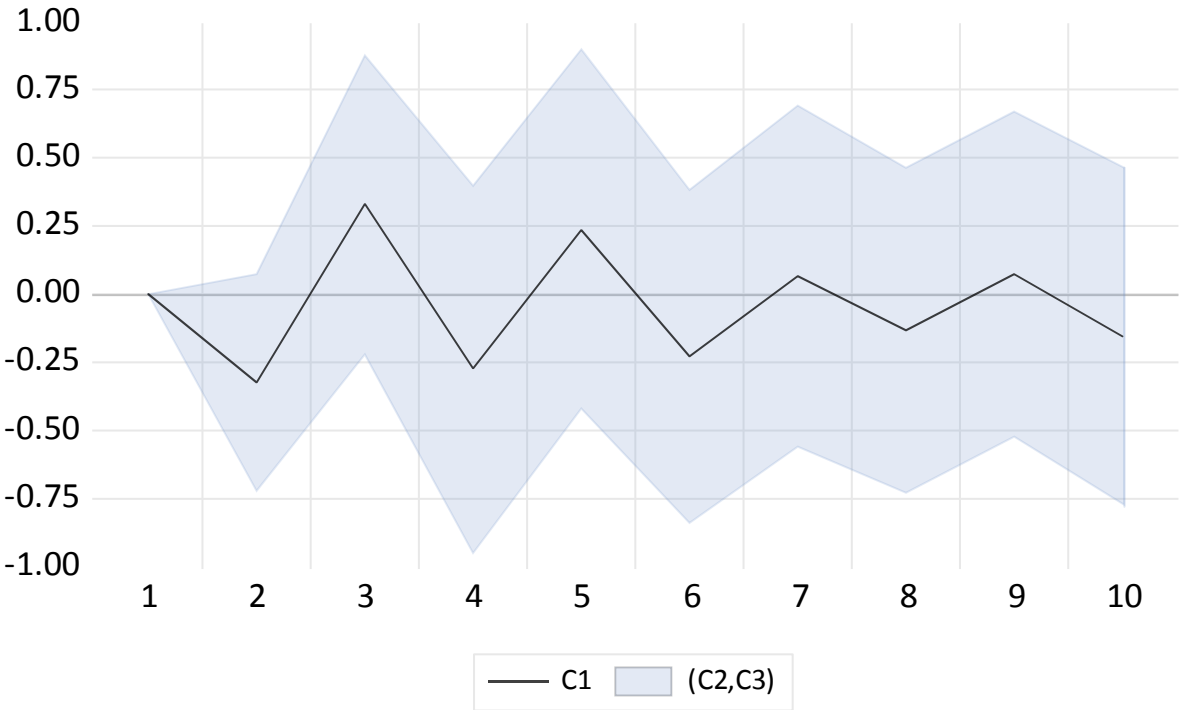
Table 6. Granger Causality Test

Dependent variable: GDP

Excluded	Chi-sq	df	Prob.
Exports	3.68799	2	0.1582
Import	0.190833	2	0.9090
GCF	0.102358	2	0.9501
Services	8.468400	2	0.0145
Industry	3.382615	2	0.1843

Hypotheses;
H_0=Granger is not the cause
H_a=Granger is the cause.
It is as follows.
Services are the Granger cause of GDP. Exports, Import, GCF, Industry are not the Granger cause of GDP.
The lines in the graphs represent the responses of the independent variables to a shock of 1 standard deviation in the error term of the model, while the horizontal axis shows the duration of the response and the vertical axis shows the size of the response.

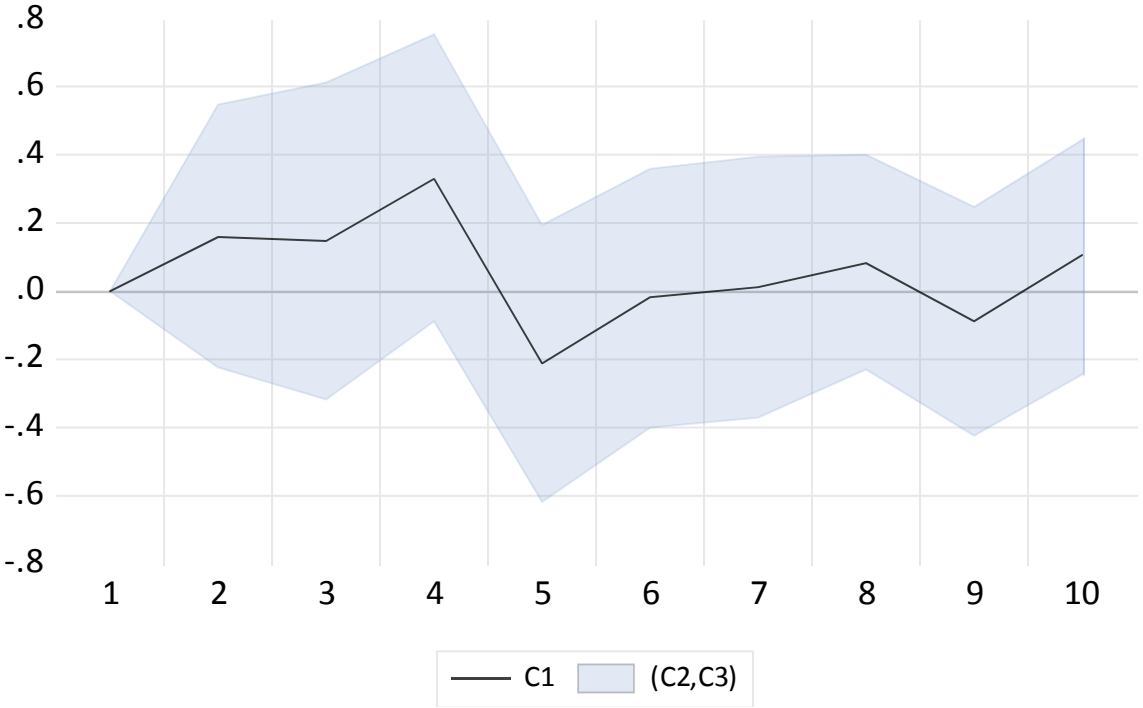
Figure 4. Impulse Response Function- Response of GDP to Exports



According to the graph, when a positive shock of 1 standard deviation is applied to exports, the effect weakens after increasing by approximately 0.27 percentage points in the 2nd and 3rd periods at the 95 percent confidence interval. In the 4th period, it started to increase again and the increase reached approximately 0.25 percentage points in the 5th period. The fact that

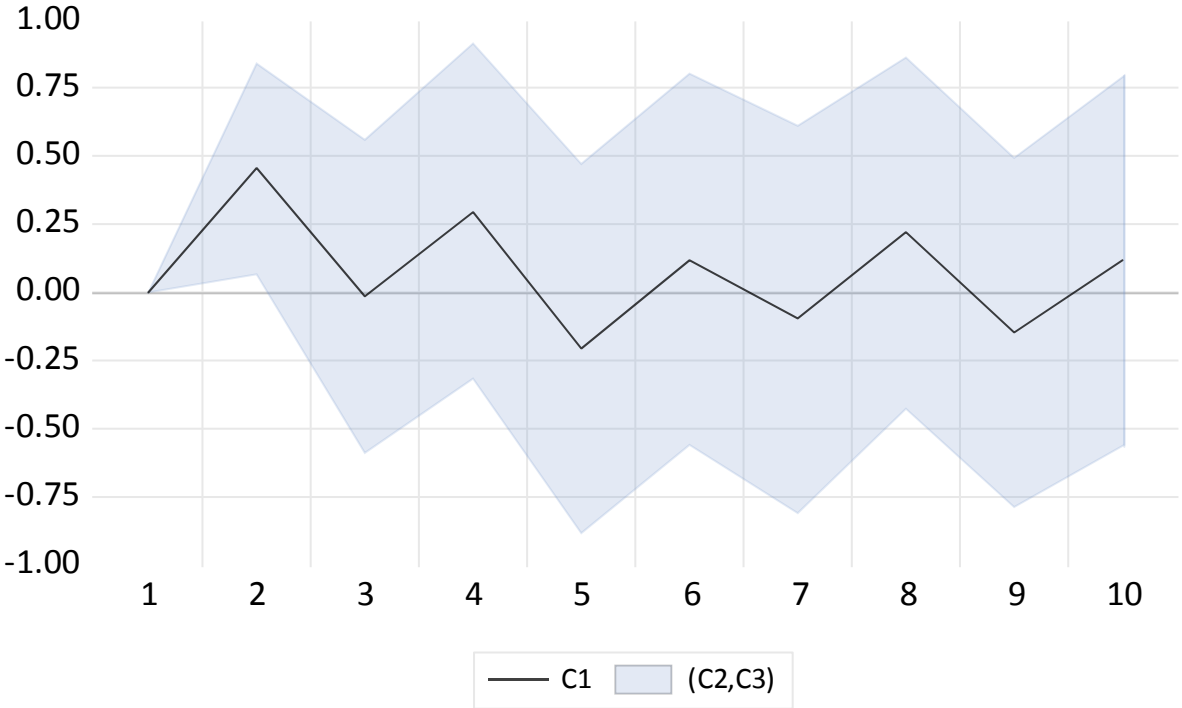
the C2 and C3 intervals increase after this period implies that the effect of the export shock on GDP growth decreases in the long run.

Figure 5. Impulse Response Function- Response of GDP to Imports



According to the graph, when a positive shock of 1 standard deviation is applied to imports, it is observed that the effect weakens after increasing by approximately 0.35 percentage points in the 4th period within the 95 percent confidence interval. After this period, the effect decreases and negative and positive fluctuations are observed around 0. It implies that the effect of import shock on GDP growth decreases in the long run.

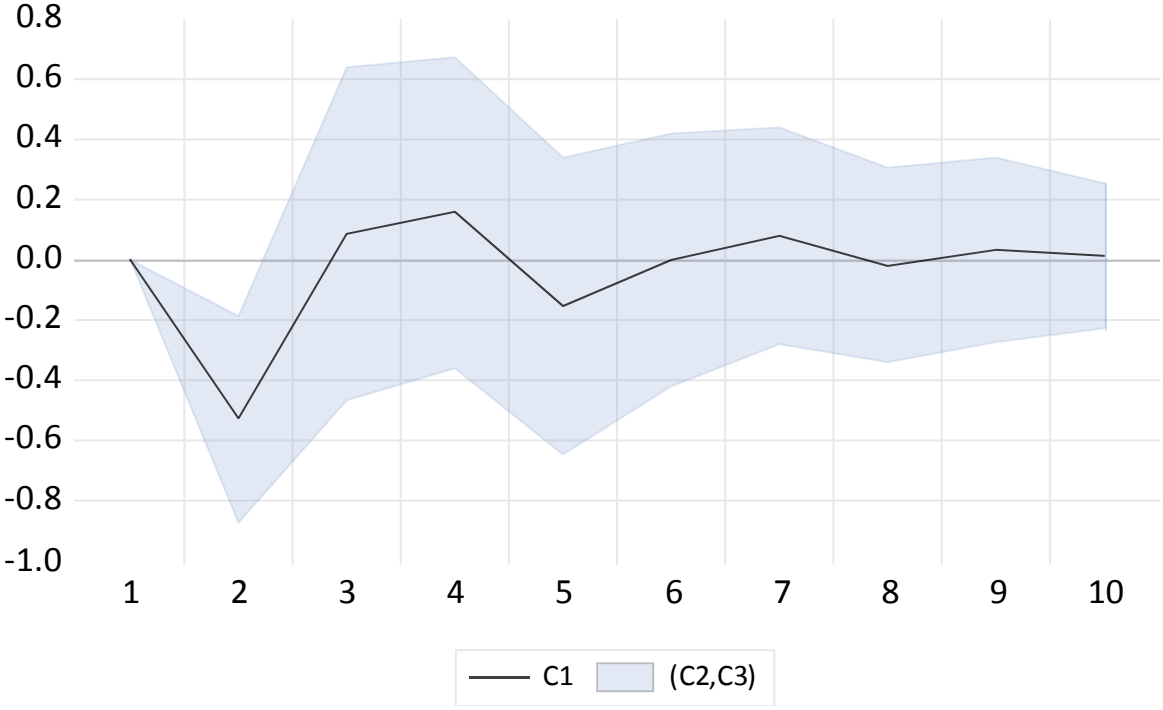
Figure 6. Impulse Response Function- Response of GDP to GCF



According to the graph, when a positive shock of 1 standard deviation is applied to the GCF, it is observed that the increase in the second period weakens after the peak of approximately

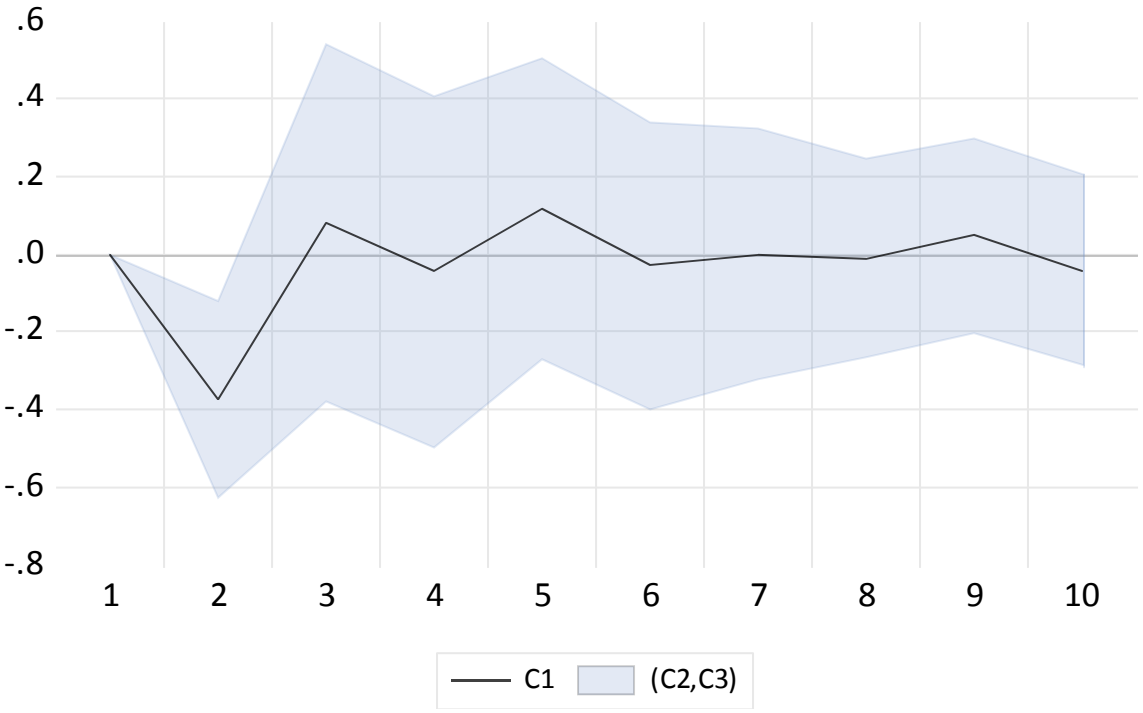
0.40 percentage points in the 95 percent confidence interval. In the short run, the effect is positive and peaks. Since the C2 and C3 intervals increase in the medium and long run, the effect of the GCF shock on GDP growth decreases and becomes uncertain.

Figure 7. Impulse Response Function- Response of GDP to Services



According to the graph, when a positive shock of 1 standard deviation is applied to Services, the decrease in the 95 percent confidence interval until the second period is about 0.50 percentage points, After which the effect weakens and approaches 0. It is found that there is a negative effect in the short run.

Figure 8. Impulse Response Function- Response of GDP to Industry



According to the graph, when a positive shock of 1 standard deviation is applied to Industry, the decline until the second period in the 95 percent confidence interval is approximately 0.37 percentage points, after which the effect weakens and approaches 0. It is found that there is a negative effect in the short run. Since the C2 and C3 intervals increase in the medium and long run, the effect of the Industry shock on GDP growth decreases and becomes uncertain.

Table 7. Johansen Cointegration Test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.** Critical Value
None *	0.743057	128.095673	95.753661	0.0001
At most 1 *	0.653015	84.6107974	69.818887	0.0021
At most 2 *	0.585691	50.7396108	47.856127	0.0261
At most 3	0.360011	22.5429545	29.797073	0.2692
At most 4	0.180734	8.26118661	15.494712	0.4378
At most 5	0.057119	1.88209758	3.8414654	0.1700

Trace test indicates 3 cointegrating equation(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Max-eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.** Critical Value
None *	0.743057	43.484875	40.077573	0.0199
At most 1	0.653015	33.871186	33.876866	0.0501
At most 2 *	0.585691	28.196656	27.584337	0.0417
At most 3	0.360011	14.281767	21.131616	0.3423
At most 4	0.180734	6.3790890	14.264600	0.5651
At most 5	0.057119	1.8820975	3.8414654	0.1701

Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

H_0= No cointegrating equation.

H_a= Cointegrating equation.

No trace test When the "at most 1" and "at most 2" hypotheses are analyzed, the H0 hypothesis is not accepted. This indicates the existence of a cointegration equation with at least 3 components. However, when the "at most 3" hypothesis is analyzed, H0 is accepted and it is determined that there is no 4th equation. Max-eigenvalue test rejects H0 for the "None" hypothesis and confirms that there is at least 1 equation. When "at most 1" is analyzed, H0 is rejected at the limit. However, this situation also indicates that it is undecided. Therefore, the next hypothesis should be examined carefully. When "At most 2" is examined, the H0 hypothesis is rejected and it is confirmed that there are at least 3 equations. Since "At most 1" gives results close to the critical threshold, when analyzed with Trace test results, it is accepted that there are 3 cointegration relationships due to the majority.

Table 8. Cointegration Equation

Cointegrating Eq:	GDP	Exports	Import	GCF	Industry	Services	C
	1.000	-0.358819	0.931266	-0.535176	-0.617513	0.2172488	-8.51559
		(0.086425)	(0.164674)	(0.175634)	(0.152188)	(0.1750788)	
		[-4.15178]	[5.65519]	[-3.04711]	[-4.05757]	[1.24086]	

The VECM estimates for the cointegration equation are presented in Table 8. The long-run relationship is expressed by the following equation (standard errors in brackets):

(2) GDP=-0.358819Exports+0.931266Import-0.535176GCF-0.617513Industry+0.217288Services-8.51559
(0.086425) (0.164674) (0.175634) (0.152188) (0.1750788)

Table 9. Error Correction Coefficients

Variable	ΔGDP	ΔExports	ΔImport	ΔGCF	ΔIndustry	ΔServices
ECT Coefficient	–1,2267	0,5524	–1,5349	–1,2227	–0,5454	–1,3245
Standard Error	0,5978	0,6648	0,4243	0,6679	0,6730	0,6231
t-Stat	–2,05	0,83	–3,62	–1,83	–0,81	–2,13
Meaningful?	Yes (p<0,05)	No	Yes (p<0,01)	Near (p≈0.07)	No	Yes (p<0,05)

Table 9 shows the error correction coefficient for the first difference (Δ) of each variable and the extent to which the deviation from the long-run equilibrium is reversed in the short run.

Table 10. Fit and Performance Measures of the Model

Variable	ΔGDP	ΔExports	ΔImport	ΔGCF	ΔIndustry	ΔServices
R^2	0,5275	0,5030	0,6880	0,5411	0,3941	0,5269
Adj. R^2	0,3897	0,3580	0,5970	0,4073	0,2174	0,3889
F-stat	3,83***	3,47**	7,56***	4,04***	2,23*	3,82***
S.E. Equation	0,9370	1,0419	0,6650	1,0466	1,0548	0,97650,

When the fit and performance criteria of the model established in Table 9 are examined, it is seen that the variables have high explanation rates. When the F-Stat is analyzed, it is determined that the variables are significant (at least p<0.10).
The long-run equilibrium equations constructed using the trace test are given below;

(3) $\beta_1' Y_{t-1} =$
$1.000\,\mathrm{GDP}_{t\text{-}1} - 0.358819\,\mathrm{Exports}_{t\text{-}1} + 0.931266\,\mathrm{Import}_{t\text{-}1} - 0.535176\,\mathrm{GCF}_{t\text{-}1} - 0.617513\,\mathrm{Industry}_{t\text{-}1} + 0.217249\,\mathrm{Services}_{t\text{-}1} - 8.51559 = 0,$

(4) $\beta_2' Y_{t-1} = b_{21}\,\mathrm{GDP}_{t\text{-}1} + b_{22}\,\mathrm{Exports}_{t\text{-}1} + \cdots + b_{26}\,\mathrm{Services}_{t\text{-}1} + b_{20} = 0,$

(5) $\beta_3' Y_{t-1} = b_{31}\,\mathrm{GDP}_{t\text{-}1} + b_{32}\,\mathrm{Exports}_{t\text{-}1} + \cdots + b_{36}\,\mathrm{Services}_{t\text{-}1} + b_{30} = 0.$

DISCUSSION

In the medium and long run, fluctuations in GDP are largely driven by exogenous shocks and sectoral dynamics. Although Granger causality tests show that export growth lagged by one year does not lead GDP growth, impulse-response analysis reveals that export shocks have a positive effect on growth, albeit temporary. These findings suggest that the export-led growth hypothesis is broadly valid for Turkey, but the sustainable contribution of exports depends on the stability of external demand conditions and market diversification. Therefore, policymakers should use long-term, competitive and risk-diversifying instruments (market incentives, Eximbank credits, export subsidies) in export promotion.
Gross fixed capital formation (GFCF) also has a positive impact on GDP in the short run, but the impulse-response and variance decomposition results show that this effect weakens in the medium and long run. The risk-sensitive nature of investments tends to increase when the economy is booming and decrease when the economy is stagnating, which makes it difficult for the GCF to remain a consistent growth driver in the long run. Taking steps to strengthen the predictability of the investment climate in Turkey, lower the cost of capital and facilitate access to financing will increase the contribution of the GCF to sustained growth.
An analysis of the industrial and services sectors reveals that while the services sector stands out as the Granger cause of GDP growth in the short run, industrial production is more strongly involved in long-run equilibrium relations. This suggests that flexible demand channels in services and sustainable capacity growth in industry have different timing patterns. Quality-oriented reforms, digitalization and human resource development programs

to support growth in the services sector will contribute to the stability of short-term growth. On the industrial side, increasing domestic production capacity, localizing intermediate and investment goods, strengthening industrial competitiveness through R&D incentives and trade policies will continue to be the main driver of GDP in the long run.

An analysis of the share of defense expenditures in GDP growth reveals that defense expenditures do not have a significant impact on growth. Although the recent moves towards indigenization in the defense industry have created positive externalities, alternative uses of the defense share of budget resources (infrastructure, education, health) should be considered. In resource allocation, efficiency and long-term growth contribution should be prioritized; while the part of defense expenditures that provide technology transfer to industry should be supported, expenditures that generate high opportunity costs should be reviewed.

The econometric findings of this study reveal that external demand, capital accumulation and sectoral transformation play critical roles in the growth path of the Turkish economy. Policymakers should develop comprehensive strategies to diversify external demand shocks, strengthen the investment climate and maintain the industry-services balance in the face of fluctuations in global markets. Moreover, exchange rate risk insurance, exchange rate adjustments and measures to support domestic demand can help GDP to follow a more stable growth path. For long-term welfare gains, economic policies should jointly optimize exports, foreign capital inflows and inter-sectoral balance.

RESULT

The Johansen Trace test indicates three different long-run equilibrium relationships between GDP, exports, imports, investment (GCF), industry and services (Table 7). Accordingly, a 3rd order VECM is estimated. The first cointegrating equation (normalized by GDP) shows that a one-unit increase in imports increases GDP by 0.9313 units in the long run, while increases in exports, investment and industrial production enter with negative coefficients (-0.3588, -0.5352, -0.6175, respectively) and services with positive but insignificant (0.2173) coefficients (Table 8).

The short-run adjustment rates (Table 9) reveal that GDP corrects deviations from the long-run path quickly (ECT = -1.2267, $p<0.05$), industrial production corrects modestly (ECT = -0.5454, not significant), while exports do not exhibit error correction behavior (ECT = 0.5524, n.s.). Imports and services both significantly restore the balance (ECT = -1.5349, $p<0.01$ and ECT = -1.3245, $p<0.05$).

Model fit statistics are strong: ΔImports explains 68.8% of its variation (Adj-R^2 = 0.597), ΔGDP has an Adj-R^2 of 0.390 and all six equations pass F-tests at least at the 10% level (Table 10). Impulse-response analysis confirms that import shocks have the largest and most persistent positive impact on GDP growth, peaking in the fourth year, while export and investment shocks are positive but decline after three to five years. Services and industry shocks exhibit temporary negative effects on GDP in the short run. Overall, these results imply that for Turkey, imports, error correction dynamics in GDP and service sector responses are important drivers of both short- and long-term growth dynamics. These findings can be an important guide in determining the future economic growth strategies and policies of Türkiye.

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