THE CAUSAL RELATIONSHIP BETWEEN FOREIGN DIRECT INVESTMENT AND ECONOMIC GROWTH IN TURKEY: A TODA–YAMAMOTO ANALYSIS

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Abstract. *This study investigates the causal impact of foreign direct investment (FDI) on economic growth in Turkey using annual time series data spanning the period 1980–2020. Economic growth is proxied by real per capita gross domestic product (GDP). The dataset was sourced from internationally reputable institutions such as the World Bank and TurkStat, and all variables were log-transformed to ensure suitability for statistical analysis. Due to the presence of variables with different orders of integration, the Toda–Yamamoto causality approach—robust to variables with mixed integration orders—was employed. The stationarity of the series was tested using the Augmented Dickey-Fuller and Phillips-Perron tests, while the optimal lag length was determined based on information criteria. Diagnostic tests for autocorrelation, heteroskedasticity, and structural stability were conducted to ensure model adequacy. The empirical findings reveal a statistically significant unidirectional causality running from FDI to economic growth at the 1% significance level, with no evidence of reverse causality. These results indicate that FDI functions not only as a source of external capital, but also as a strategic driver of growth by enhancing productivity, facilitating knowledge and technology transfer, and driving structural transformation. By incorporating a long-term dataset and accounting for the macroeconomic structure, this study offers a methodologically robust and contextually grounded contribution to the literature on the FDI-growth nexus in developing economies.*

Keywords: *foreign direct ınvestment, economic growth, Toda-Yamamoto causality test, time series analysis, Turkish economy.*

TURKIYADA XORIJIY TO'G'RIDAN-TO'G'RI INVESTITSIYALAR VA IQTISODIY O'SISH O'RTASIDAGI SABAB-OQIBAT BOG'LIQLIGI: TODA–YAMAMOTO TAHLILI

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Annotatsiya. *Mazkur tadqiqotda 1980–2020 yillarni qamrab olgan yillik vaqt qatorlari ma'lumotlari asosida Turkiyada xorijiy to'g'ridan-to'g'ri investitsiyalar (XTI)ning iqtisodiy o'sishga sababiy ta'siri tahlil qilinadi. Iqtisodiy o'sish ko'rsatkichi sifatida aholi jon boshiga real yalpi ichki mahsulot (YaIM)dan foydalanilgan. Ma'lumotlar Jahon banki va TurkStat kabi nufuzli xalqaro manbalardan olingan bo'lib, barcha o'zgaruvchilar statistik tahlilga moslashtirish maqsadida logarifmlashtirilgan. Integratsiya tartiblari turlicha bo'lgan o'zgaruvchilar mavjudligi sababli, aralash integratsiya tartiblariga nisbatan barqaror bo'lgan Toda–Yamamoto sababiylik yondashuvi qo'llanildi. Qatorlarning stasionarligi Kengaytirilgan Dikki–Faller va Phillips–Perron testlari yordamida tekshirildi, optimal lag uzunligi esa axborot mezonlari asosida aniqlangan. Modelning mosligini ta'minlash uchun avtokorrelyatsiya, geteroskedastiklik va strukturaviy barqarorlik bo'yicha diagnostik testlar o'tkazildi. Empirik natijalar 1% ahamiyatlilik*

darajasida XTIdan iqtisodiy o'sishga yo'nalgan statistik jihatdan ahamiyatli bir tomonlama sababiylik mavjudligini, aks yo'nalishda esa sababiylik aniqlanmaganligini ko'rsatdi. Ushbu natijalar XTI nafaqat tashqi kapital manbai, balki unumdorlikni oshirish, bilim va texnologiyalar transferini ta'minlash hamda tarkibiy transformatsiyani rag'batlantirish orqali iqtisodiy o'sishning strategik omili sifatida namoyon bo'lishini ko'rsatadi. Uzoq muddatli ma'lumotlar bazasidan foydalanish va makroiqtisodiy tuzilmani hisobga olish orqali tadqiqot rivojlanayotgan iqtisodiyotlarda XTI va iqtisodiy o'sish o'rtasidagi bog'liqlik bo'yicha adabiyotlarga metodologik jihatdan asoslangan va kontekstual ahamiyatga ega hissa qo'shadi.

Kalit so'zlar: xorijiy to'g'ridan-to'g'ri investitsiyalar, iqtisodiy o'sish, Toda–Yamamoto sababiylik testi, vaqt qatorlari tahlili, Turkiya iqtisodiyoti.

ПРИЧИННО-СЛЕДСТВЕННАЯ СВЯЗЬ МЕЖДУ ПРЯМЫМИ ИНОСТРАННЫМИ ИНВЕСТИЦИЯМИ И ЭКОНОМИЧЕСКИМ РОСТОМ В ТУРЦИИ: АНАЛИЗ ТОДА–ЯМАМОТО

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Аннотация. *В данном исследовании анализируется причинное влияние прямых иностранных инвестиций (ПИИ) на экономический рост в Турции с использованием годовых временных рядов за период 1980–2020 гг. В качестве показателя экономического роста используется реальный валовой внутренний продукт (ВВП) на душу населения. Данные получены из авторитетных международных источников, таких как Всемирный банк и TurkStat, и все переменные были логарифмированы для обеспечения пригодности к статистическому анализу. В связи с наличием переменных с различными порядками интеграции был применён метод причинности Тода–Ямамото, устойчивый к смешанным порядкам интеграции. Стационарность рядов проверялась с использованием тестов Дики–Фуллера и Филлипса–Перрона, а оптимальная длина лага определялась на основе информационных критериев. Для подтверждения адекватности модели были проведены диагностические тесты на автокорреляцию, гетероскедастичность и структурную устойчивость. Эмпирические результаты выявили статистически значимую однонаправленную причинность от ПИИ к экономическому росту на уровне значимости 1%, при отсутствии обратной причинности. Полученные результаты свидетельствуют о том, что ПИИ выступают не только источником внешнего капитала, но и стратегическим фактором роста за счёт повышения производительности, содействия трансферу знаний и технологий, а также стимулирования структурной трансформации. Использование долгосрочного набора данных и учёт макроэкономической структуры обеспечивают методологически обоснованный и контекстуально релевантный вклад данного исследования в литературу по взаимосвязи ПИИ и экономического роста в развивающихся экономиках.*

Ключевые слова: *прямые иностранные инвестиции, экономический рост, тест причинности Тода–Ямамото, анализ временных рядов, экономика Турции.*

Introduction.

With the acceleration of globalization and the liberalization of capital movements, foreign direct investment (FDI) has assumed a strategic role, particularly in integrating developing economies into the global system and activating their endogenous growth potential (Borensztein, De Gregorio, & Lee, 1998: 115). In this context, FDI stands out not merely as a financial source but also for its capacity to transform production structures and facilitate technology transfer. The increase in cross-border capital flows has led to a comprehensive

theoretical and empirical examination of the relationship between FDI and economic growth in the fields of development economics and international finance (Alfaro et al., 2004: 91).

This study aims to analyze the direction and structure of this relationship for Turkey during the period 1980–2020 by employing the Toda–Yamamoto causality test, which allows for valid and reliable results in non-stationary time series (Toda & Yamamoto, 1995: 229).

The impact of FDI on economic growth has been theoretically grounded within both classical and endogenous growth frameworks. While Solow's model, stripped of externalities, views capital accumulation merely as a temporary determinant of growth, endogenous growth theorists such as Romer (1986) and Lucas (1988) regard FDI as a factor that enhances long-term productivity (Romer, 1986: 1002; Lucas, 1988: 17). These approaches suggest that FDI can generate lasting effects on the growth process through mechanisms such as technology transfer, human capital enhancement, and innovation capacity. Therefore, FDI is not only a financing instrument but also a structural cornerstone that reshapes production systems, triggers technological transformation, and supports long-term economic performance (Barro & Sala-i-Martin, 1995: 220).

Despite this theoretical framework, empirical findings on the FDI–growth nexus vary across countries and time periods. For instance, Borensztein et al. (1998) and Li & Liu (2005) reveal positive effects of FDI on growth, but emphasize that the magnitude of this effect depends on intermediary factors such as financial development, institutional quality, and human capital levels (Li & Liu, 2005: 392). Conversely, Hermes and Lensink (2003) argue that in countries with weak financial infrastructure and low human capital, FDI may fail to generate the expected growth benefits (Hermes & Lensink, 2003: 111). These conflicting results clearly indicate the need for methodologically flexible analyses that take into account the unique historical, structural, and institutional characteristics of individual countries (Alfaro et al., 2010: 113).

In the case of Turkey, the outward-oriented reforms implemented after 1980 led to a remarkable increase in FDI inflows. Particularly after 2001, privatization policies and the pursuit of macroeconomic stability further accelerated this process (YASED, 2021: 12). However, despite the rising FDI inflows, empirical studies on Turkey have yielded diverse results. For example, Aydın (2007) and Esen & Yıldız (2016) identified a positive and significant relationship, whereas Yalçınkaya & Saraç (2014) found no statistically significant link between FDI and growth (Aydın, 2007: 66; Yalçınkaya & Saraç, 2014: 102). This suggests that when methodological approaches fail to account for the stationarity and integration properties of the data series, the resulting conclusions may be invalid or misleading. Hence, there is a growing need for a data-driven approach based on robust causality analysis in the Turkish context.

Within this framework, the Toda–Yamamoto causality test offers an important methodological advantage, as it does not require variables to be integrated of the same order and does not necessitate a cointegration test (Dritsakis, 2004: 45; Giles, 2011: 9). Furthermore, its compatibility with the VAR framework enables it to produce stable results in analyses using long-term macroeconomic data (Gujarati & Porter, 2009: 675). Therefore, the methodological choice in this study not only ensures analytical robustness but also has the potential to fill methodological gaps in the literature.

Accordingly, this study employs Turkish data from 1980–2020 to analyze the causality relationship between per capita GDP and the FDI ratio using the Toda–Yamamoto test. The findings reveal a statistically significant unidirectional causality running from FDI to economic growth. This result indicates that FDI in the Turkish economy functions not only as a complementary financial resource but also as one of the structural engines of the growth process. Thus, the study contributes to the existing literature and highlights the necessity of prioritizing productivity- and technology-oriented FDI policies within growth strategies.

In conclusion, analyzing the FDI–growth relationship in Turkey through a data-based, causality-focused, and methodologically sensitive approach contributes both to resolving

inconsistencies in the literature and to providing insights that can guide policymakers in designing long-term development strategies. The subsequent sections of the study will present the analytical process in detail, followed by a comprehensive discussion of the conceptual background, literature review, dataset, and econometric methodology. Moreover, the study will examine the multifaceted impacts of FDI not only on macroeconomic growth but also on structural and technological transformation within its theoretical and empirical framework.

1. Conceptual and Empirical Background

Foreign direct investment (FDI) serves as a crucial instrument in growth strategies and the global production structure of developing countries (Giritlioğlu, 2024). The contribution of FDI extends beyond capital accumulation, encompassing technology transfer, human capital development, productivity enhancement, and institutional capacity building (Borensztein, De Gregorio, & Lee, 1998; Alfaro et al., 2004). While Solow's (1956) exogenous growth model considers FDI as a temporary contributor, Romer (1986) and Lucas (1988) conceptualize investments as carriers of knowledge and innovation. Li and Liu (2005), as well as Hermes and Lensink (2003), emphasize that the effectiveness of FDI depends on institutional infrastructure and the level of human capital.

In Turkey, the liberalization reforms implemented after 1980 and the privatization initiatives of the 2000s significantly increased FDI inflows (YASED, 2021), though their impacts vary across methods and time periods. Therefore, this study employs the Toda–Yamamoto (1995) causality approach to ensure robust and valid causal analysis, while the following literature review deepens the conceptual and empirical framework of the research.

Literature Review.

Foreign direct investment (FDI) in developing countries not only provides capital but also contributes through technology transfer, human capital development, employment generation, and productivity enhancement (Borensztein, De Gregorio, & Lee, 1998). The impact of FDI varies depending on institutional infrastructure, the financial system, and production capacity (Hermes & Lensink, 2003; Alfaro et al., 2004). Due to methodological and periodical differences, empirical studies do not present uniform results; however, they generally find that FDI positively influences growth when human capital or financial infrastructure is strong (De Mello, 1999; Carkovic & Levine, 2005; Chowdhury & Mavrotas, 2006).

In the case of Turkey, empirical analyses such as the Johansen cointegration test (Yücel, 2009; Tutar & Tansel, 2016), the ARDL model (Yalçın & Koçak, 2020), VAR analyses (Alagöz & Yılmaz, 2013), and Granger and Toda–Yamamoto causality tests (Ucal, 2014; Yılmaz & Gürsoy, 2022) confirm the existence of a relationship between FDI and economic growth.

Table 1.

Summarizes selected national and international studies

Author(s) & Year	Period	Topic	Country/ Region	Method	Key Findings
Blomström ve Kokko (1996)	1960–1990	FDI and Technology Diffusion	Asia & Latin America	Literature Review	The absorptive capacity of local firms is crucial for FDI to support growth.
Borensztein vd. (1998)	1970–1989	FDI and Human Capital Interaction	69 Developing Countries	Panel Data Analysis	FDI positively affects growth only if sufficient human capital exists.
De Mello (1999)	1970–1990	Dynamics of FDI on Growth	OECD & Latin America	Panel Data Analysis	FDI's impact varies across countries depending on capital accumulation and technology transfer channels.

Campos ve Kinoshita (2002)	1990–2000	Institutional Structures and FDI	Eastern Europe	Panel Data Analysis	Institutional reforms significantly enhance FDI's impact on growth.
Hermes ve Lensink (2003)	1970–1995	Financial Development and FDI Effects	Developing Countries	Panel Data Analysis	FDI has a significant effect on growth when the financial system is developed.
Carkovic ve Levine (2005)	1960–2000	FDI and Long-Term Growth Effects	72 countries	Panel Data Analysis	FDI's effect weakens when fixed effects and time effects are controlled.
Yönet ve Tan (2006)	1987–2003	FDI and Industrial Growth	Turkey	VAR Analysis	FDI increases industrial production, but the effect is limited.
Yücel (2009)	1987–2006	FDI, Trade Openness, and Growth	Turkey	Johansen Cointegration Test	FDI has a positive long-term effect; it is sensitive to short-term fluctuations.
Alagoz ve Yılmaz (2013)	1980–2010	FDI and Productivity	Turkey	VAR Analysis	FDI's effect on productivity and growth fluctuates over time.
Çeviş ve Çam (2015)	1992–2012	FDI and Sectoral Impact	Turkey	Panel Data Analysis	The service sector is most influenced by FDI, while the industrial sector is less affected.
Tutar ve Tansel (2016)	1970–2014	FDI and Long-Term Growth	Turkey	Johansen Cointegration, VECM	Long-term relationship is positive; short-term effects appear unstable.
Ucal (2014)	1992–2011	FDI, Inflation, and Growth	Turkey	Panel Data & Granger Causality	FDI positively affects growth, but its effect weakens when inflation intervenes.
Özkan-Günay (2011)	1980–2009	FDI and Employment Growth	Turkey	VAR & Panel Data	FDI contributes indirectly to growth through productivity and job creation.
Temiz ve Gökçegür (2014)	1994–2012	FDI and Financial Development Interaction	Turkey	Johansen Cointegration	FDI's effect varies depending on the development level of financial markets.
Yılmaz ve Gürsoy (2022)	2000–2020	FDI and Growth Dynamics	Turkey	Toda–Yamamoto Causality Analysis	Findings show that FDI has a one-way effect on economic growth.
Akinlo (2004)	1970–1999	FDI and Growth Context	Nigeria	VECM & Johansen Test	Positive FDI effect varies depending on energy and infrastructure dependence.
Tang vd. (2008)	1970–2005	FDI and Growth Causality	Malaysia	ARDL & Granger Causality	In the short term, there is a two-way interaction between FDI and economic growth.
Pegkas (2015)	1990–2010	FDI and Economic Performance	Eurozone	Panel Data Analysis	FDI positively affects growth in EU countries.
Hussain ve Haque (2016)	1985–2014	FDI and Macroeconomic Performance	Bangladesh	Johansen Cointegration	FDI serves as a positive tool for long-term economic growth.

The studies presented in Table 1 reveal that the impact of foreign direct investment (FDI) on economic growth varies across methodological, geographical, and temporal dimensions. The effect is context-specific and dynamic, shaped by factors such as infrastructure, the level of human capital, and the development of the financial system. Although most studies focusing on Turkey confirm a positive impact, variations are observed in both the short- and long-term effects as well as in the direction of causality. Within this framework, FDI functions as a supportive factor for economic growth under certain structural conditions.

3. Methodology
3.1. Research Model

This study examines the causal relationship between foreign direct investment (FDI) and economic growth in Turkey. The model analyzes real GDP per capita and FDI inflows as a percentage of GDP. Theoretically, both exogenous (Solow) and endogenous (Romer, Lucas) growth theories are taken as the foundation, emphasizing that FDI supports long-term growth not only through capital accumulation but also via the transfer of knowledge and technology.

In the empirical analysis, the Toda–Yamamoto causality test is applied using annual time series data, enabling robust results independent of the stationarity levels of the variables. The model is structured in line with both national and international literature, taking into account the transformation of the Turkish economy and the growing significance of FDI.

3.2. Population and Sample

The population of this research consists of the Turkish economy, while the sample covers annual macroeconomic data for the period 1980–2020. The time series data used in the analysis were obtained from the World Bank's World Development Indicators (WDI) and the Turkish Statistical Institute (TÜİK) databases. The sample includes a balanced and representative dataset covering a 41-year period, consisting of real GDP per capita and FDI as a percentage of GDP. The data were selected to reflect Turkey's process of economic liberalization and the structural transformation in capital movements, aiming to ensure that the model yields reliable and meaningful results in its historical and economic context. The data sources, variable definitions, and measurement methods are presented in detail in the following section.

3.3. Data Collection Tools

The data used in this research are secondary in nature and were obtained from reliable institutional sources such as the World Bank's World Development Indicators (WDI) and the Turkish Statistical Institute (TÜİK). The analysis includes two main variables: real GDP per capita and the ratio of FDI inflows to GDP. The dataset consists of 41 annual observations covering the 1980–2020 period. Before the analysis, the data were checked for compliance with international statistical standards, transformed into natural logarithms, and prepared for time series analysis. The data selection process was based not only on technical validity but also on conceptual consistency and model integrity.

3.4. Data Collection and Analysis

The data used in this study are secondary annual data obtained from official and reliable sources such as the World Bank (WDI) and TÜİK. The analysis focuses on real GDP per capita and FDI as a percentage of GDP. In accordance with time series analysis principles, the stationarity of the series was examined using the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests.

Due to the different levels of integration among the variables, the Toda–Yamamoto (1995) causality approach was preferred over the traditional Granger test. To verify model validity, diagnostic tests such as LM, White, CUSUM, and CUSUMSQ were conducted, while the optimal lag length was determined based on the Akaike (AIC) and Schwarz (SC) criteria. The data and analytical processes were carried out in accordance with the principles of scientific research and academic ethics.

3.5. Research Ethics

Ethical committee approval is not required for this study.

3.6. Data Set and Model

In this study, the causal relationship between foreign direct investment (FDI) and economic growth in Turkey was examined using annual data covering the period from 1980 to 2020. Economic growth was measured by the real per capita Gross Domestic Product (GDP) growth rate, while FDI was represented by the share of net inflows in GDP. All data were obtained from the World Bank (2022) database.

Variable	Description
GDP	Annual growth rate of per capita GDP (%)
FDI	FDI Share of foreign direct investment in GDP (%)

Source: Description of the Variables Used in the Model.

The basic regression model established to analyze the relationship between these two variables is as follows:

     (1) $GDP\_t = \beta_0 + \beta_1 DYY\_t + \varepsilon\_t$

Here:

GDP_t represents the real per capita GDP growth rate.

FDI_t denotes the ratio of foreign direct investment inflows to GDP.

β_0 is the constant term, representing the intercept of the model.

β_1 indicates the coefficient reflecting the marginal effect of FDI on economic growth.

ε_t represents the error term, which captures other factors not explained by the model.

3.7. Data Set and Model

The directional relationship between foreign direct investment (FDI) and economic growth was analyzed in this study using the time series-based Toda–Yamamoto causality test. Time series data are considered a powerful structural tool for analyzing the sequential behavior of economic variables over time (Yılmaz, Duran, & Yavuz, 2011: 18). However, prior to such an analysis, it is necessary to determine the stationarity levels of the series and their integration orders. In the first stage, the stationarity of the series, i.e., whether they contain a unit root, was tested using the Augmented Dickey-Fuller (ADF) (Dickey & Fuller, 1979) and Phillips-Perron (PP) (Phillips & Perron, 1988) tests. The ADF test is based on the following regression equation:

     (2) $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \varepsilon_t$

"ΔY_t is represented by the AR model error (ε_t) explained by the constant term (β_1), time trend ($\beta_2 t$), lagged levels (δY_{t-1}), and lagged differences ($\sum \alpha_i \Delta Y_{t-i}$)."

In this equation:

ΔY_t denotes the first difference of the series,

t represents the time trend,

Y_{t-1} is the lagged level term,

α_i are the coefficients of lagged differences,

ε_t is the error term.

The null hypothesis of the ADF test is that the series contains a unit root. Rejection of the $\delta = 0$ hypothesis indicates that the series is stationary. The PP test serves a similar purpose but offers a more flexible structure by allowing the error terms to be weakly dependent and heteroskedastic. In this test, no additional variables are added to remove autocorrelation; instead, the t-statistic for the δ coefficient is corrected using the Newey-West (1987) estimator (Eyüboğlu & Abdioğlu, 2019: 237).

The stationarity tests revealed that the series were integrated at different levels. Therefore, in the second stage, the Toda–Yamamoto (1995) approach was adopted instead of the traditional Granger causality test. This method allows the causality relationship to be analyzed reliably regardless of whether the variables are cointegrated. In practice, the lag

length was first determined using the Akaike Information Criterion (AIC) and Schwarz Criterion (SC), and then a VAR (k + d_max) model was constructed, considering the maximum integration order of the series, denoted as d_max.

The robustness of the model was tested using the LM test for autocorrelation, White's heteroskedasticity test, and CUSUM/CUSUMQ structural break tests. The results indicated that the model is stable. This methodological framework enables a statistically and directionally reliable analysis of the FDI–growth relationship in Turkey.

3.8. Research Ethics

This study fully complies with research and publication ethics. All data used were obtained in accordance with the principles of scientific integrity, analyses were conducted transparently, and no ethical violations such as plagiarism, falsification, fabrication, or duplicate publication were involved. Furthermore, as this study does not involve human or animal subjects, ethical committee approval is not required.

3.9. Findings

This section presents the results of the stationarity tests that form the basis of the empirical analysis and determines the integration orders of the variables. To assess the stationarity levels of the variables used in the time series analysis, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were applied. Both tests were conducted considering the model with a constant (c) and the model with a constant and trend (c+t). The results obtained are summarized in the table below:

Table 3.

Unit Root Test Results

Test	Variable	Constant Model (c) t-Stat	p-Value	Constant + Trend Model (c+t) t-Stat	p-Value
ADF	GDP	-6.9	<0.01	-6.8	<0.01
ADF	D(GDP)	–	–	–	–
ADF	FDI	-2.2	0.22	-3.3	0.08
ADF	D(FDI)	-5.1	<0.01	-5.0	<0.01
PP	GDP	-7.1	<0.01	-7.0	<0.01
PP	D(GDP)	–	–	–	–
PP	FDI	-2.0	0.27	-2.6	0.26
PP	D(FDI)	-9.7	<0.01	-10.1	<0.01

Source: Unit Root Test Results.

Note: The test results indicate that GDP per capita is stationary at levels (I(0)), while foreign direct investment (FDI) becomes stationary at first differences (I(1)). The findings are consistent across both ADF and PP tests.

3.10. VAR Model: Lag Selection, Diagnostic Tests, and Stability Analysis
Determination of VAR Lag Length

Before applying the Toda–Yamamoto causality test, it is necessary to determine the appropriate lag length to ensure the correct specification of the model. In this study, the number of lags in the constructed VAR model was determined by considering information criteria such as the Akaike Information Criterion (AIC), Schwarz Criterion (SC), Final Prediction Error (FPE), Likelihood Ratio (LR), and Hannan–Quinn Criterion (HQ). As shown in Table 4, the lowest value for all information criteria was obtained at one lag; therefore, the VAR (1) model was preferred.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-148.72	NA	14.844	8.373	8.461	8.404
1	-126.7056	40.35880*	5.460581*	7.372534*	7.636454*	7.464650*
2	-126.1964	0.876946	6.648080	7.566468	8.006334	7.719993
3	-125.2253	1.564572	7.917030	7.734740	8.350552	7.949675
4	-120.5578	7.001309	7.717968	7.697654	8.489413	7.973999

Source: Table 4: VAR Model Lag Length.

All information criteria indicate that the optimal lag length is 1

3.11. Autocorrelation Test (LM Test)

Various diagnostic tests were applied to evaluate the adequacy and predictability of the model. First, the Lagrange Multiplier (LM) test was conducted to determine whether there is an autocorrelation problem in the model. The results are presented in Table 5. The p-values of the LM statistics for lags 1 and 2 are 0.8833 and 0.7289, respectively. At the 5% significance level, these values are not statistically significant; therefore, the null hypothesis (H_0: no autocorrelation) cannot be rejected, indicating that there is no autocorrelation problem in the model.

Otokorelasyon- LM Testi Sonuçları		
Lag	LM Statistic	p-Value
1	1.168	0.883
4	2.038	0.729

Source: Autocorrelation Test Results.

The null hypothesis is formulated as "no autocorrelation," with p-values of 0.88 and 0.72, respectively. These results support the non-rejection of the null hypothesis, confirming that there is no autocorrelation issue in the model.

3.12. Heteroskedasticity Test (White Test)

The White test was applied to examine whether there is a heteroskedasticity problem in the model, and the p-value was found to be 0.4555. At the 5% significance level, this value is not sufficient to reject the null hypothesis (H_0: no heteroskedasticity). Consequently, it can be concluded that there is no heteroskedasticity issue in the model, indicating that the model is reliable.

Chi-Square	Degrees of Freedom(df)	p-Value
11.879	12	0.456

Source: Heteroskedasticity Results Based on the White Test.

The p-value obtained from the White test is 0.45. At the 5% significance level, this value does not allow for the rejection of the null hypothesis (H_0: no heteroskedasticity problem). Therefore, there is no heteroskedasticity or specification problem in the model.

3.13. Inverse Roots of the AR Model Characteristic Polynomial

The structural stability of the model was evaluated through the inverse roots of the AR characteristic polynomial. If the absolute values (modulus) of the inverse roots are less than 1, it indicates that all roots lie within the unit circle, confirming the stability of the model. As shown in Table 7, the obtained modulus values are 0.7528 and 0.0680; since both values are below 1, the stability condition of the model is satisfied.

The absolute values (modulus) of the inverse roots being less than 1 indicate that the characteristic roots lie within the unit circle and that the model is stable. Based on the table data, since all modulus values are below 1, it can be concluded that the VAR model is structurally stable.

Root	Modulus
0.75284	0.75284
-0.06805	0.06805

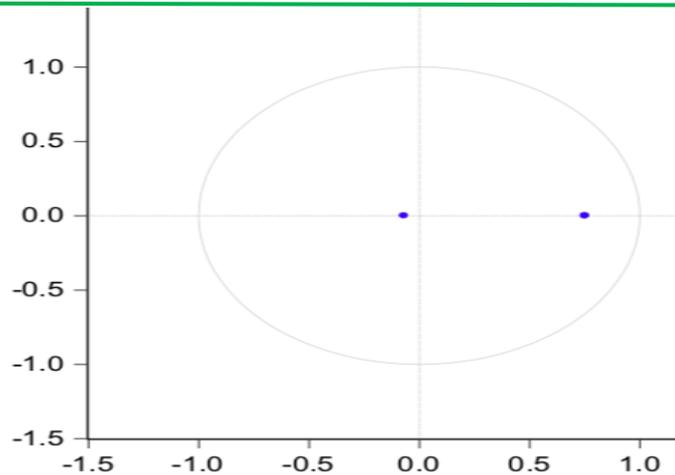*Source: Inverse Root Analysis of the AR Polynomial*

Figure 1: Inverse Roots of the AR Model Characteristic Polynomial

Table 7 presents the inverse roots of the AR polynomial and their absolute values. The roots can be positive or negative; however, since the modulus is calculated based on the absolute value, it is always expressed as a positive number. For example, the root -0.06805 appears as 0.06805 in the modulus column. The fact that all modulus values are below 1 indicates that the roots lie within the unit circle, confirming the stability condition of the model.

3.14. Toda–Yamamoto Causality Test

The Toda–Yamamoto causality test, developed by Toda and Yamamoto (1995), was designed to prevent information loss that may occur in conventional VAR analyses conducted with integrated time series. The method allows the inclusion of variables in levels without differencing, thereby preserving the dynamic relationships (Pata, 2017: 128).

Although the Toda–Yamamoto method is based on the classical VAR approach, it stands out by removing the requirement for series to be integrated of the same order. In this method, the appropriate lag length (k) is first determined using information criteria. Then, the maximum integration order (d_{max}) is identified through unit root tests applied to the series. A VAR model is then estimated with a lag length equal to the sum of these two values (k + d_{max}), and the Wald test is applied to assess causality (Karış & Tandoğan, 2020: 12).

In this study, the lag length determined by the information criteria was k = 1. According to the results of the ADF and PP tests, the FDI series is stationary at first difference (I(1)), whereas the GDP series is stationary at level (I (0)). Therefore, the Toda–Yamamoto test was conducted using a VAR (1 + 1) = VAR (2) model. Additionally, no autocorrelation or heteroskedasticity problems were observed in the model, and the structural stability was confirmed as the modulus values were below 1.

The estimated VAR model is defined considering the optimal lag length (k) and the maximum integration order (d_{max}) as follows:

(3)

$$Y_t = \omega + \sum_{i=1}^{k} a_{1i} X_{t-i} + \sum_{i=1}^{k} \beta_{1i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \partial_{1i} X_{t-i} + \sum_{j=k+1}^{d_{max}} \theta_{1i} Y_{t-i} + \varepsilon_{1t}$$

$$X_t = \varphi + \sum_{i=1}^{k} a_{2i} X_{t-i} + \sum_{i=1}^{k} \beta_{2i} Y_{t-i} + \sum_{j=k+1}^{d_{max}} \partial_{2i} X_{t-i} + \sum_{j=k+1}^{d_{max}} \theta_{2i} Y_{t-i} + \varepsilon_{2t}$$

It is assumed that the error terms have zero mean and a constant covariance matrix (Dereli, 2018: 152). The lag coefficient (k) in the VAR model is determined as 1. The D value is taken as 1 because, according to the unit root tests, FDI is stationary at first difference. The Toda–Yamamoto causality analysis is conducted based on this specified lag coefficient.

Direction of Causality	X^2 (Chi-square) Test Statistic	P-Value	Hypothesis Result
FDI=>GDP	10.08071	0.001498	The causality analysis indicates a statistically strong relationship from foreign direct investments to economic growth at the 1% significance level.
GDP => FDI	1.0498	0.350	The findings show no evidence of causality from economic growth to foreign direct investments at the 5% significance level.

Source: Results of the Toda–Yamamoto Test

In the first stage of the study, the stationarity levels of the series were assessed using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The results indicated that the GDP series is stationary at level (I(0)), whereas the FDI series is stationary at first difference (I(1)). The presence of different integration orders among the variables violates the assumptions of the classical Granger causality test; therefore, the Toda–Yamamoto (1995) approach, which allows working with the levels of the series, was adopted in this context.

The lag length required for model estimation was determined as one based on various information criteria (AIC, SC, HQ, etc.). Furthermore, the statistical adequacy of the model was evaluated through the autocorrelation test (LM), heteroskedasticity test (White), and structural stability test (modulus values of the AR characteristic roots), and no violations were detected. In particular, the fact that all inverse roots have modulus values within the unit circle indicates that the dynamic structure of the model satisfies stability conditions.

The final findings of the causality analysis conducted using the Toda–Yamamoto method reveal a unidirectional causality from FDI to economic growth, which is statistically significant at the 1% level. On the other hand, no significant causality from economic growth to FDI was observed. This result supports the view that foreign direct investments are a key driver of economic growth in the Turkish economy.

The obtained results largely align with similar studies in the literature on the Turkish case. For instance, Tandoğan and Karış (2020) identified a unidirectional causality from FDI to economic growth at the 1% significance level. Similarly, Dereli (2018), using the same method for the period 1995–2017, obtained comparable results, highlighting the guiding effect of FDI on growth. Additionally, Ayaydın (2010), in a study covering 1970–2007, also detected a unidirectional causality between GDP and FDI at the 1% significance level, emphasizing that foreign investments play a statistically significant role in explaining economic growth.

In conclusion, the findings of this study are highly consistent with the existing literature in terms of both methodological integrity and empirical validation, statistically confirming the causal effect of foreign direct investments on economic growth in Turkey.

Conclusion and Recommendations.

This study aims to examine the relational dynamics between foreign direct investments (FDI) and economic growth in Turkey over the period 1980–2020, within an empirical, time-series-based framework. The analysis, conducted using the Toda–Yamamoto causality method, reveals a statistically significant and unidirectional causality from FDI to economic growth. This finding indicates that FDI in the Turkish economy functions not merely as an additional source of finance, but as a structural element that nurtures growth potential.

The results are largely consistent with the existing literature. Studies by Tandoğan and Karış (2020), Dereli (2018), and Ayaydın (2010) also demonstrate that FDI exerts significant and directional effects on economic growth. In this context, the findings support the theoretical

expectation that foreign direct investments contribute to economic growth through production factors, technology transfer, and human capital development. Conversely, the absence of causality from economic growth to FDI suggests that growth alone is not a sufficient determinant for attracting foreign capital; institutional frameworks, political stability, legal security, and the overall investment climate also play critical roles.

In this framework, for Turkey to more effectively and sustainably integrate FDI into its growth strategies, it is essential to ensure macroeconomic stability, enhance the predictability of the investment climate, and implement investment policies targeted at high value-added sectors. Additionally, in order to transform FDI into structural gains such as long-term technology transfer and productivity improvements, it is necessary to strengthen institutional capacity, increase public–private sector collaborations, and prioritize investments in a skilled workforce.

Based on the findings, future research should focus on disentangling the sectoral effects of FDI, the impact of technology intensity, and the effects of the investing countries' groups. Moreover, multi-country comparisons using panel data methods could provide a broader perspective on Turkey's international position. Sub-period analyses over different time intervals would also contribute to a deeper understanding of structural break effects.

4.1. Author Contribution

All sections of this study were prepared by a single author, and the author's contribution is 100%.

4.2. Conflict of Interest

There are no situations that could pose a conflict of interest in this study.

Statement: The author declares that no individual or institution directly contributed to the preparation of this study. The study has not been published in full elsewhere and was created solely through the author's original contributions. Furthermore, this article is not derived from any thesis.

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