


İktisat Politikası Araştırmaları Dergisi Journal of Economic Policy Researches

Submitted 30.05.2025
Revision Requested 17.09.2025
Last Revision Received 08.11.2025
Accepted 09.11.2025

Research Article

 Open Access

Asymmetric Threshold Effects in the Growth–Current Account Deficit Nexus: Evidence from Türkiye Using Quantile-on-Quantile Regression



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Abstract

This study aims to analyse the structure of the relationship between economic growth and the current account deficit in the Turkish economy and how this relationship varies across different levels of growth. It is widely acknowledged in the literature that commonly used linear econometric models often fail to capture potential asymmetries and heterogeneities between variables. Therefore, this study employs the Quantile-on-Quantile Regression method, which allows simultaneous assessment of both dependent and independent variables across various quantile levels. The analysis was conducted using quarterly data for the period 2006:Q1 to 2023:Q3. The findings reveal that the relationship between the current account deficit and economic growth is asymmetric and quantile sensitive. In particular, rising current account deficits have a negative and statistically significant effect on growth at low levels of economic expansion. Conversely, this relationship tends to weaken or reverse at higher growth levels. These results reveal that when the current account deficit exceeds a certain threshold, it becomes unsustainable and acts as a drag on growth. The findings emphasise the need to design growth policies in alignment with external balance objectives.

Keywords

Economic Growth · Current Account Deficit · Quantile-on-Quantile Regression · Türkiye · Asymmetric Effect


JEL Classification


F32 · O40 · C22



Citation: Boğa, S. & Erkişi, K. (2026). Asymmetric threshold effects in the growth–current account deficit nexus: Evidence from Türkiye using quantile-on-quantile regression. *İktisat Politikası Araştırmaları Dergisi–Journal of Economic Policy Researches*, 13(1), 146-164. <https://doi.org/10.26650/JEPR1709609>

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 2026. Boğa, S. & Erkişi, K.

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Asymmetric Threshold Effects in the Growth–Current Account Deficit Nexus: Evidence from Türkiye Using Quantile-on-Quantile Regression

Transformations in the global economic system have rendered the relationship between sustainable growth strategies and external trade balances increasingly critical for developing countries. In particular, for countries with production structures that rely heavily on external inputs, the impact of economic growth on the current account (CA) balance emerges as a key determinant of macroeconomic vulnerability (Cimoli & Porcile, 2014). In economies like Türkiye, where capital accumulation is limited and energy dependence on imports is substantial, understanding the dynamic relationship between growth and CA deficit is essential for macroeconomic stability and sound policy design.

The CA balance is a comprehensive indicator that reflects not only trade in goods and services but also income transfers and capital flows between a country and the rest of the world. During periods of economic expansion, rising import demand and increased foreign exchange needs often lead to a widening of the CA deficit. In this context, the direction, magnitude, and sustainability of the relationship between growth and CA have been extensively debated in both theoretical and empirical literature. Neoclassical economists posit that CA deficits represent a transitional phase necessary for growth (Feldstein & Horioka, 1980), whereas Keynesian perspectives emphasise the demand-side effects and crisis-prone nature of such deficits (Mundell, 1963; Fleming, 1962). Structuralist approaches, on the other hand, argue that CA deficits must be interpreted in light of structural dependencies, technological gaps, and deindustrialisation trends (Prebisch, 1950; Cimoli & Porcile, 2014).

The fundamental aim of this paper is to empirically assess how economic growth interacts with Türkiye's CA deficit, investigating whether this link changes at varying levels of economic expansion. To move beyond the limitations of traditional linear models, this study employs the Quantile-on-Quantile Regression (QQR) method, which captures the effect of the CA deficit across different quantiles of the growth distribution. Rather than offering a singular average effect, this method reveals the nature of the interaction between the dependent variable (growth) and the independent variable (CA deficit) across their respective distributions (Sim & Zhou, 2015). This allows for a nuanced analysis of how the impact of the CA deficit changes at low, medium, and high levels of economic growth.

While numerous time-series and panel data studies have reported positive or bidirectional causality between growth and CA in Türkiye (e.g., Yılmaz & Akıncı, 2011; Karahan & Akçaçakır, 2021), there is growing empirical evidence suggesting that this relationship may be asymmetric. In countries with significant external financing needs and high dependence on energy imports, the CA deficit may exert a constraining effect on growth when it exceeds certain threshold levels (Aromí, 2019; Freund & Warnock, 2005; Razmi, Blecker & Skott, 2012).

Most empirical studies analysing the growth–CA nexus in Türkiye rely on linear approaches, such as VAR, ARDL, or co-integration models, and focus on average effects. However, recent research has highlighted the need to account for heterogeneity and asymmetry in this relationship (Sohag et al., 2022; Meo & Abd Karim, 2022). This points to the necessity for more fine-tuned analyses that enable policymakers to tailor their tools to the prevailing economic context. By adopting the QQR approach, this study observes the effect of the CA deficit at various growth levels, extending beyond the conventional modelling frameworks.

In this context, one of the key contributions of this study is its use of high-frequency (quarterly) data specific to the Turkish economy, along with its alternative perspective to the prevailing linear analyses in the literature by examining the impact of the CA deficit on growth across different intensity levels (quantiles).

This approach enables a clear distinction between the effects of the CA deficit during periods of low and high economic growth, thereby allowing for more tailored policy recommendations. For instance, during periods of sluggish growth, the dampening effect of the CA deficit may be more pronounced, whereas at higher growth levels, this effect may weaken or even reverse. Such findings reveal that “one-size-fits-all” macroeconomic interventions may fall short in effectively addressing this dynamic relationship.

Moreover, the QQR model employed in this study represents an advanced regression approach in that it captures not only the distributional characteristics of the dependent variable (GDP growth) but also those of the independent variable (CA deficit). As a result, it extends beyond standard quantile regression by providing a detailed view of the relationship across different quantile combinations of both variables (Sim & Zhou, 2015). This methodological choice is particularly well suited to the analysis of macroeconomic data, where outliers, structural asymmetries, and vulnerabilities are frequently encountered.

By exploring the economic growth–CA nexus in both theoretical and empirical terms, this study seeks to reveal how the nature of this relationship varies across different growth levels. The findings are expected to contribute not only to the academic literature but also to policy design, emphasising the need to align growth strategies with external balance objectives. The remainder of the paper is organised as follows. Section 1 outlines the theoretical approaches to the relationship between economic growth and the current account. Section 2 reviews the empirical literature. Section 3 details the econometric methodology employed. Section 4 presents the dataset, model, and empirical findings. Finally, the Conclusion summarises the main results and discusses policy implications.

1. Theoretical Approaches to the Growth–CA Relationship

As a developing country with a long-standing dependence on external inputs in its production structure, Türkiye’s economic growth performance has been largely driven by an import-oriented model (Yanar & Kerimoğlu, 2011; TURKSTAT, 2023). In particular, the high share of intermediate goods and energy imports amplifies the impact of growth on foreign trade and CA balance. Consequently, during periods of economic expansion, CA deficits tend to increase systematically. Conversely, in times of economic slowdown or crisis, a decline in import demand can narrow the CA deficit or, in some cases, even result in a temporary surplus. Within this context, the relationship between the CA balance and economic growth can be characterised as bidirectional and time-varying.

The theoretical explanations of this relationship are generally categorised into three main approaches: (i) Neoclassical approaches focus on the savings–investment balance and capital mobility; (ii) Keynesian and post-Keynesian approaches emphasise demand-side effects and the influence of monetary and exchange rate policies on growth; and (iii) structural and critical approaches argue that the dependency of growth on external inputs renders it fundamentally unsustainable.

In the economic literature, the interaction between economic growth and CA has been explored through various theoretical lenses. One of the most prominent is the savings–investment gap hypothesis developed by Feldstein and Horioka (1980). According to this hypothesis, sustainable investment in an economy requires a sufficient accumulation of domestic savings. However, the low savings rates observed in many developing countries mean that investment needs cannot be met through domestic resources alone, necessitating external financing. External financing often manifests as CA deficits. Feldstein and Horioka (1980) empirical findings reveal that in economies where the correlation between savings and investment is weak, capital mobility is high, and CA deficits emerge as an inevitable byproduct of the growth process. In this framework, the CA deficit is seen as both a channel for supporting investment through foreign capital and a structural vulnerability whose sustainability remains questionable. Thus, the positive relationship between

growth and CA deficit is driven by cyclical fluctuations and rooted in a deeper structural dependence on foreign capital due to insufficient domestic savings.

Another important theoretical framework that contributes to open economy macroeconomics is the Mundell–Fleming model. This model analyzes the effectiveness of monetary and fiscal policies under fixed and floating exchange rate regimes, with specific attention to external imbalances, interest rates, and capital flows. A core assumption of the model is that, in the short run, national income, interest rates, exchange rates, and CA are all interrelated. While fiscal policy is considered more effective under a fixed exchange rate system and monetary policy under a floating regime, any expansionary policy aimed at boosting growth—such as interest rate cuts or increased public spending—typically stimulates domestic demand and imports. As a result, trade deficits widen, deteriorating the CA balance.

In environments where capital mobility is high, such as open economies, growth-oriented policies may also place pressure on the exchange rate, thereby increasing the fragility of external balances. In countries like Türkiye—characterised by high trade openness, substantial financial integration, and low domestic savings rates—the growth–CA relationship fits well within this multi-channel interaction structure proposed by the Mundell–Fleming model. Their contributions show that the connection between growth and CA is not solely determined by production and consumption dynamics but also shaped by financial channels such as international capital flows and exchange rate fluctuations (Mundell, 1963; Fleming, 1962).

Beyond these multi-layered interactions, open economy growth models also provide an important framework for understanding the relationship between growth and CA. These approaches examine how economic growth is influenced by foreign trade and global integration, with particular emphasis on the dependence of production on imported inputs in developing countries (Razmi, Blecker & Skott, 2012). Broadly speaking, open economy growth models are categorised into two main types: export-led and import-driven growth. In the former, rising export volumes drive economic growth by boosting foreign currency earnings, and allow expansion without undermining external balance. In contrast, the import-driven growth model heavily relies on foreign-sourced intermediate and capital goods. In such settings, increases in domestic demand or investment tend to directly stimulate imports, thereby widening the CA deficit.

As of 2022, approximately 67% of intermediate goods used in Türkiye’s manufacturing sector were imported (TURKSTAT, 2023). This high figure highlights the structural dependence of the production process on foreign inputs and reinforces the sensitivity of growth to external imbalances. For many years, Türkiye has followed an import-dependent growth model by necessity. Factors such as low utilisation of domestically produced intermediate goods, technological shortcomings, and energy dependence cause import volumes to surge during periods of growth, leading to persistent trade and CA deficits. This structural dependence on imported inputs renders the positive link between growth and CA deficit not only cyclical but also permanent. Thus, the import-driven growth model demonstrates that in developing economies like Türkiye, the CA problem is not merely cyclical but structural—making external imbalances an inevitable byproduct of the country’s growth trajectory.

While open economy growth models highlight the dependence of production on imports, the structuralist approach examines this dependence at a deeper level, aiming to uncover the structural roots of the relationship between economic growth and CA. This approach evaluates the growth process not merely through short-term fluctuations but also by considering structural elements such as the quality of the production structure, level of industrialisation, and technological capacity. It posits that the economic vulnerabilities observed in many developing countries stem from a production structure characterised by low technology, limited value-added, and heavy reliance on foreign inputs. In economies where intermediate and capital goods are predominantly imported, growth targets often trigger a rise in imports, leading to deterioration

in trade and CA balances. Consequently, policies that promote growth—or any surge in production—tend to increase import demand, placing additional strain on external balances. For this reason, the CA deficit is not merely a cyclical phenomenon but rather a persistent structural issue stemming from the functioning of the economy itself (Prebisch, 1950; Cimoli & Porcile, 2014).

Türkiye serves as a tangible example of how the vulnerabilities outlined in the structuralist approach manifest in practice. The country's industrial structure is largely based on assembly manufacturing, domestic production of intermediate goods is limited, and energy imports are substantial. As a result, economic growth periods are closely associated with spikes in imports. This frequently observed “high growth–high CA deficit” pairing should not be seen as a routine macroeconomic fluctuation but as a reflection of a structural dependency. From a structuralist perspective, the relationship between growth and CA in economies like Türkiye is shaped not only by trade volume but also by the production process's reliance on external inputs—a reliance that poses significant sustainability risks.

The literature reveals mixed findings on the direction of the relationship between growth and CA deficit. Some studies suggest that growth stimulates imports, thereby widening the CA deficit (i.e., unidirectional causality from growth to deficit) (Calderón et al., 1999; Telatar & Terzi, 2009; Yurdakul & Uçar, 2015), while others argue that persistently high CA deficits suppress economic growth (Erbaykal, 2007). In particular, surpassing certain deficit thresholds may hinder access to financing and, in turn, lead to slower growth (Aromí, 2019). Moreover, the direction of the relationship may vary depending on the economic cycle: during expansions, causality may run from growth to deficit, whereas in contractions, the effect may be reversed (Roubini & Wachtel, 1998). These dynamics underscore the need to examine the relationship not only around the average but across different levels and periods heterogeneous. This is precisely why this study adopts the Quantile-on-Quantile Regression method—to analyse how the growth–deficit relationship evolves across the distribution.

Going beyond mean effects, this paper assesses how GDP growth and CA deficits interact structurally across their quantiles and diverse economic conditions. Linear and mean-based regression models, which are common in the literature, often overlook how this relationship shifts across different periods and conditions. Yet in fragile economies such as Türkiye, the link between growth and CA may at times be positive, at other times weak, or even negative. Detecting such heterogeneity necessitates the use of non-linear approaches like the Quantile-on-Quantile Regression (QQR).

The QQR method provides a detailed analysis of how specific quantiles of the dependent variable (e.g., the CA) respond to specific quantiles of the independent variable (e.g., economic growth). Although this study employs a model with only two variables, the nature of the method enables an in-depth, distribution-sensitive examination of the relationship. Unlike multivariate models that attempt to explain the growth–deficit relationship through control variables, this study focuses directly on the interaction between the variables across their respective quantiles, allowing for a thorough analysis of non-linear dynamics and conditional dependencies.

In doing so, the study reveals the heterogeneous and asymmetric nature of the growth–CA relationship without disregarding the multivariate frameworks provided by existing theories. By empirically testing this relationship through the QQR approach, it offers a novel methodological contribution to the literature.

Empirical Literature

The relationship between the CA deficit and economic growth in Türkiye has been extensively investigated through time-series analyses, panel data studies, and a range of econometric models. These studies generally reveal a positive and statistically significant relationship between the two variables. However, the

direction and magnitude of this relationship vary depending on the methodology applied and the period under consideration.

Time-series-based studies typically show that economic growth in Türkiye exerts an expansive effect on the CA deficit. For example, Oğul (2021) applied the Toda–Yamamoto causality test to data from 1998–2020 and found that economic growth Granger causes the CA deficit, a result consistent with the conventional view that stronger growth increases import demand, leading to a larger trade gap. Similarly, Erdoğan and Acet (2016), applying Johansen co-integration and Granger causality tests for the period 2003–2015, reported unidirectional causality running from growth to the CA deficit.

Analysing data from 1980–2013, Çiftçi (2014) found evidence of co-integration linking the real exchange rate, GDP growth, and CA deficits. The results demonstrate that both exchange rate fluctuations and economic expansion have significant effects on the CA balance. Ağır, Özbek, and Türkmen (2020), in their analysis covering 2000–2019, applied a VAR model and found that growth shocks have short-term positive effects on the CA deficit—supporting the literature that views import channels as a source of external imbalance.

Dinçer and Yaşar (2014), focusing on the period 1987:Q1–2011:Q4, examined Türkiye’s CA issues through the lens of transmission mechanisms between growth and financial variables using a VAR model. Their findings reveal that Türkiye’s economy—small, open, and prone to growth volatility—requires analysis of the CA via multiple transmission channels. The study finds that credit expansion fuels GDP growth and widens the CA deficit, while increases in growth rates influence the real exchange rate, stimulating imports and further expanding the deficit. Additionally, it concludes that both growth dynamics and capital flows in Türkiye exert direct and indirect impacts on the CA balance.

Özer and Malović (2020), using Granger causality and frequency domain causality tests for the period 2002–2017, found that the CA deficit influences economic growth in the short and medium term. Their study draws attention to the unsustainability of Türkiye’s growth model, which heavily relies on external borrowing. Likewise, Duman (2017) employed a VAR model and Granger causality analysis for the period 2003–2017 and detected a unidirectional causality from growth to the CA.

Researchers have frequently used autoregressive distributed lag (ARDL) and co-integration techniques to examine how economic growth and CA interact over time in Türkiye. For example, Sekmen and Çalışır (2011), using data from 1980 to 2009, demonstrated that economic growth has a positive long-run effect on the CA deficit. Similarly, Uçak (2017) found that growth increases the CA deficit in the short term, although this effect may reverse eventually.

Yılmaz and Akıncı (2011), employing the Johansen co-integration test for the period 1987–2010, identified a long-term relationship and bidirectional causality between economic growth and the CA deficit. This finding implies that, beyond growth influencing the CA, the deficit itself can also affect growth through various financing channels. Similarly, Karahan and Akçaçakır (2021), using data from 2003 to 2019 and applying Johansen co-integration and Granger causality analyses, also found two-way causality between growth and CA. Their study emphasises that this interdependence poses vulnerabilities for sustainable growth and creates exposure to external shocks. As a result, the authors advocate for policy frameworks capable of breaking the cycle from GDP to CA and vice versa.

Altıntaş et al. (2016), using a panel co-integration analysis, demonstrated the existence of a positive long-run relationship between growth and CA deficit across several developing countries, including Türkiye.

Çiğdem (2023) examined the relationship between growth, CA deficit, and inflation in Türkiye over the 1974–2020 period. The results of the Toda–Yamamoto causality analysis revealed bidirectional causality between growth and inflation, as well as unidirectional causality running from growth and inflation to the CA. Catalbaş (2022), using the ARDL bounds testing approach for the period 1998–2020, found that a 1% increase

in economic growth leads to a 0.45% increase in the CA deficit in the long run and a 0.22% increase in the short run. The study highlights that CA is not solely linked to growth but also to factors such as savings, investment, and production structure.

Bolkol and Türkönder (2022), applying the ARDL model with quarterly data for the period 2003–2019, identified a negative relationship between real GDP growth and CA balance in both the short and long term. Their findings reveal that supporting high value-added and technology-intensive sectors is essential to addressing Türkiye's CA imbalance.

Several panel data studies have also compared Türkiye's growth–CA dynamics with those of other developing countries. For instance, Balmumcu and Bozkurt (2020), analysing data from 1990 to 2017, found that economic growth has a positive and statistically significant impact on the CA deficit in developing economies.

Yalçinkaya and Temelli (2014), in their panel data analysis of BRICS and MINT countries, also identified a positive relationship between growth and CA deficit. The study stresses that in countries like Türkiye, financing growth through external resources exerts pressure on external balances. Gençer et al. (2022), using regional data from Türkiye, found that causality runs from growth to the CA in some regions, while in others, the direction is reversed—from the CA to growth. These findings underscore the heterogeneous dynamics of regional economic structures.

In developing countries—including Türkiye—factors such as trade imbalances, energy dependence, and financing structures typically shape the relationship between CA and economic growth. Yessymkhanova et al. (2025), in a panel data analysis covering Argentina, Indonesia, India, Mexico, and Türkiye, found unidirectional causality from growth to the CA deficit. The study also reports that increases in oil prices adversely affect CA balances, reinforcing the idea that energy-dependent countries face greater pressure on their external accounts during growth periods.

Evren and Kaya (2025), in their panel analysis of BRICS-T countries, found that the CA deficit has a negative and statistically significant impact on growth, whereas energy consumption positively influences economic growth. Their findings also indicate bidirectional causality between energy consumption and growth and unidirectional causality running from the CA to growth.

Çiğdem (2019) argued that due to insufficient savings rates in developing countries, economic growth is often financed through CA deficits. Analyses focusing on Türkiye show that growth tends to increase the CA deficit in the short term, thereby amplifying financial vulnerability. Similarly, Okafor et al. (2024) found that in Nigeria, trade deficits negatively affect growth, but this effect can be mitigated through export diversification.

Studies conducted in African countries indicate that the impact of CA deficits on growth varies by regional dynamics. Kutu and Ohonba (2024), in an analysis covering 48 African nations, found that inflation and CA deficits hinder economic growth, whereas export diversification moderates these negative effects. Olakulehin et al. (2024), using the CS-ARDL method, revealed that inflation negatively affects long-term growth and that foreign direct investment (FDI) plays a negative role in Central Africa. These findings underscore the importance of structural reforms and export-oriented policies in addressing CA challenges in developing economies.

Sağlam and Sönmez (2019) examined the causality between CA and economic growth for the Visegrad Four using annual data from 1993 to 2015. Panel data analysis revealed a co-integration relationship between the two variables, and causality tests indicated unidirectional causality from the CA to growth.

In developed economies, the relationship between CA and growth is shaped by factors such as energy policies, fiscal discipline, and production structure. Özkan and Okay (2024) showed that in OECD countries, the use of renewable energy reduces the CA deficit and supports economic growth. Their findings provide evidence that while net energy imports worsen CA, an increase in the share of renewables improves external balance. Additionally, the study confirms the twin deficit hypothesis, indicating that fiscal deficits intensify CA imbalances.

Murai (2024) found that Germany's CA surpluses are sustained through capital account movements. The Toda–Yamamoto causality analysis pointed to causality running from the financial account to the CA, implying that capital exports and low domestic investment are key contributors to Germany's surplus. Staehr (2024) reported that in Baltic countries, growth prior to the global financial crisis was driven by domestic demand and accompanied by CA deficits, whereas post-crisis growth shifted towards an export-led model, which—while reducing growth rates—helped lower financial vulnerability.

Masheed et al. (2024), in their ARDL analysis of Pakistan and Afghanistan, found that high budget deficits and public debt negatively impact economic growth in both the short and long term. Specifically, the study shows that in Pakistan, fiscal deficits constrain growth, whereas in Afghanistan, public debt has a negative effect on GDP. These results challenge the traditional Keynesian view, indicating that budget deficits do not stimulate growth but rather limit its potential.

Empirical studies conducted in Türkiye and other countries demonstrate that the relationship between CA and economic growth is contingent upon the country's economic structure, energy dependence, and financing sources. In Türkiye, growth driven by import-dependent production increases the CA deficit, whereas in developed economies, energy efficiency and the use of renewable energy contribute to external balance improvements. In developing countries, export diversification and structural reforms can alleviate the adverse effects of CA imbalances.

This review of the literature reveals that in Türkiye, the relationship between economic growth and CA is predominantly positive. The rise in import demand associated with growth, along with energy dependence and the need for external financing, has often pushed the CA deficit to unsustainable levels. In the international literature, however, this relationship is shown to vary by a country's level of development and policy orientation. Notably, energy efficiency, export diversification, and structural reforms play critical roles in addressing the challenges posed by CA deficits.

Econometric Methodology

This section introduces the theoretical foundations of the econometric techniques employed in this study. In the initial stage, an investigation into the time series properties of the variables was undertaken, including linearity tests followed by both conventional and nonlinear unit root tests. Subsequently, the structural foundations and applicability of the Quantile-on-Quantile Regression (QQR) approach are explained.

Linearity and Unit Root Testing

In applied time series research, the concepts of unit root and stationarity, along with the tests developed to examine them, hold a central position. A time series is considered stationary if its mean, variance, and covariance converge to a constant value over time. Stationarity is a fundamental assumption in econometric modelling, and its verification is therefore critical (Gujarati, 2021).

Among the most frequently used techniques for testing stationarity are the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979, 1981) and the Phillips-Perron (PP) test (Phillips & Perron, 1988). The ADF test

explores the presence of a unit root through three model variations tailored to capture specific features of the series: (i) without intercept and trend, (ii) with intercept, and (iii) with both intercept and trend. A negative and statistically significant slope coefficient confirms stationarity in the series. To interpret the results, the calculated t-statistics are assessed against MacKinnon's (1996) critical values.

As an alternative to the Dickey-Fuller framework, the Phillips-Perron test generalises the unit root test by incorporating potential issues of serial correlation and heteroskedasticity in the error terms, which are common in time series data. Phillips and Perron (1988) argued that the presence of autocorrelated error terms may lead to misleading results in the standard Dickey-Fuller test. Like the ADF test, the PP test includes three model forms (no constant or trend, constant only, and constant with trend) and relies on the same null hypothesis and critical values. Thus, despite differences in the construction of test statistics, both tests are evaluated using the same benchmark critical values (Çağlayan & Saçaklı, 2006).

Tests such as ADF and PP are referred to as conventional unit root tests and, although widely used, rely on strict assumptions—particularly the assumption of linearity. When this assumption does not hold, the power of these tests declines. In cases of nonlinear behaviour, the Kapetanios, Shin, and Snell (KSS) test (2003) offers a suitable alternative. This test investigates stationarity in nonlinear time series by adopting a test procedure based on the exponential smooth transition autoregressive model.

The KSS test also provides three model specifications: without intercept and trend, with intercept only, and with both intercept and trend. If the calculated t-statistic exceeds the critical value provided by Kapetanios et al., the null hypothesis of a unit root is rejected, leading to the conclusion that the series is stationary.

Quantile-on-Quantile Regression

Standard quantile regression examines the impact of an independent variable on various quantiles of the dependent variable. Originally developed by Koenker and Bassett (1978), the quantile regression (QR) approach serves as an alternative to the classical ordinary least squares model, which focuses solely on the conditional mean of the dependent variable. In contrast to linear regression models, quantile regression offers the flexibility to analyse the effects of the explanatory variable across different points in the distribution of the outcome variable, rather than just its average. In this sense, the QR model provides a more comprehensive and formal framework than the OLS method (Koenker & Bassett, 1978).

Sim and Zhou (2015)'s QQR methodology expands conventional quantile regression analysis, enabling a more sophisticated examination of how variables interact across their distributions. To estimate slope coefficients for each quantile and address potential dependency issues, the QQR method regresses each quantile of the dependent variable on the various quantiles of the explanatory variable. This enables the generation of detailed insights into the entire conditional distributional relationship between the two variables.

The rationale for applying the QQR technique in this study is threefold: i. As illustrated in [Figure 1](#), preliminary analysis in the first stage reveals that the distributions of the CA balance and economic growth series deviate from normality and exhibit asymmetric behaviour. QQR is well-suited to modelling such distributional characteristics. ii. By employing non-parametric features, QQR addresses limitations inherent in OLS and standard QR approaches (Sohag et al., 2022; Meo & Abd Karim, 2022). iii. Given that most of the selected series display asymmetry, as demonstrated through skewness, kurtosis, and Jarque–Bera test statistics, the QQR method appears to be particularly suitable for this analysis (Sohag et al., 2022; Suki et al., 2020).

Moreover, the probability of model misspecification is minimised in the QQR framework, as it is a bivariate technique that estimates the dynamic effects of a single explanatory variable on a dependent series without introducing additional regressors. In this study, the two variables selected are Türkiye's CA balance and real economic growth. The analysis begins by expressing the τ -th quantile of the CA ($\ln CA_t$) as a function of the real economic growth rate ($\ln GDP_t$). This relationship is specified as follows:

$$\ln GDP_t = \beta^\tau \ln CA_t + u_t^\tau \quad (1)$$

In this specification, the relationship between $\ln GDP$ and $\ln CA$ contains two unknown components: the first is β^τ , which is an unknown parameter; the second is u_t^τ , which represents the error term. To convert Equation (1) into a linear structure, a first-order Taylor expansion of the unknown function is used.

There are two unknown components in the relationship between $\ln GDP$ and $\ln CA$: the first is the unknown β^τ , and the second is the error term series u_t^τ . To convert Equation (1) into a linear form, a first-order Taylor expansion of $\beta^\tau(\cdot)$ is performed around $\ln CA_t$, yielding:

$$\beta^\tau \ln CA_t \approx \beta^\tau \ln CA^\theta + \beta^{\tau(\cdot)} (\ln CA^\theta) (\ln CA_t - \ln CA^\theta) \quad (2)$$

As shown in Equation (2), both $\beta^\tau \ln CA^\theta$ and $\beta^{\tau(\cdot)} \ln CA^\theta$ are doubly indexed τ and θ . Therefore, $\beta^\tau \ln CA^\theta$ and $\beta^{\tau(\cdot)} \ln CA^\theta$ can be rewritten as functions of both indices:

$$\beta^\tau \ln CA_t \approx \beta_0(\tau, \theta) + \beta_1(\tau, \theta) (\ln CA_t - \ln CA^\theta) \quad (3)$$

Substituting Equation (3) into the original regression (Equation 1) yields the final form:

$$\ln GDP_t = \beta_0(\tau, \theta) + \beta_1(\tau, \theta) (\ln CA_t - \ln CA^\theta) + u_t^\tau \quad (4)$$

Here, $\beta_0(\tau, \theta) + \beta_1(\tau, \theta) (\ln CA_t - \ln CA^\theta) + u_t^\tau$ represents the τ -th conditional quantile of $\ln GDP_t$. This formulation reflects how Türkiye's economic growth responds to the CA deficit by considering the full distribution of both variables. Unlike standard quantile regression, the coefficients β_0 and β_1 are indexed by both τ and θ , allowing for a more detailed analysis across the distribution. If the same transformation is applied in reverse, i.e., with $\ln CA_t$ as the dependent variable and $\ln GDP_t$ as the independent variable, the relationship is specified as follows:

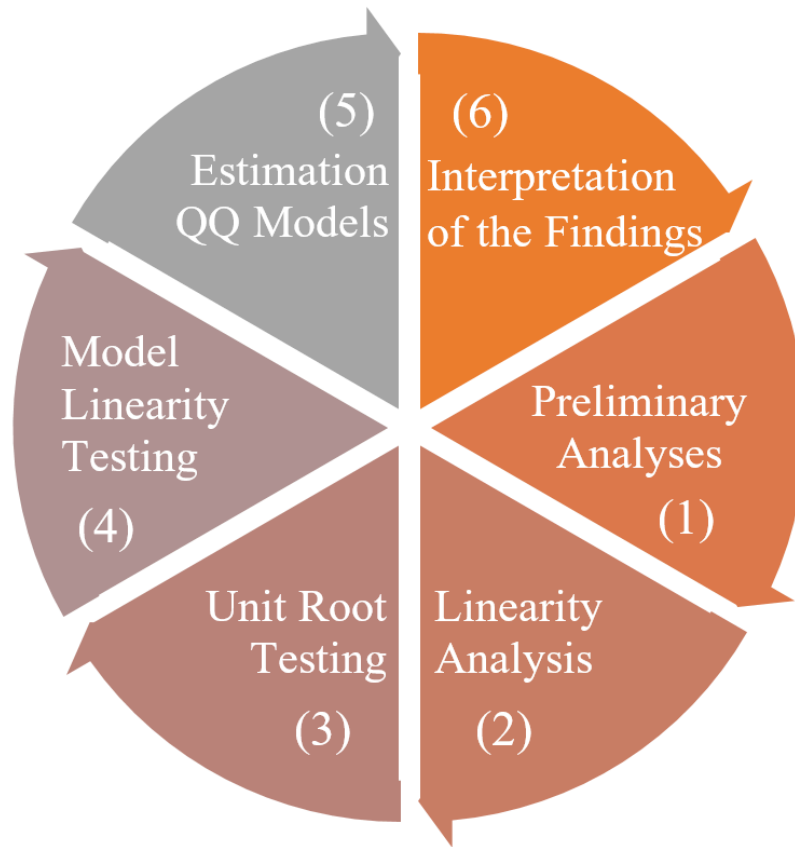
$$\ln CA_t = \beta_0(\tau, \theta) + \beta_1(\tau, \theta) (\ln GDP_t - \ln GDP^\theta) + u_t^\tau \quad (5)$$

Finally, it is important to emphasise the sensitivity of bandwidth selection in nonparametric estimation. While a wider bandwidth reduces the variance of the estimator, it increases bias; hence, careful calibration is essential for balancing precision and accuracy in the QQR method.

Dataset, model, and findings

As illustrated in Figure 1, the first and second steps of the analysis process are shaped by preliminary diagnostic procedures. The initial phase of the time series analysis involves testing the linearity properties of the series using the BDS and HLX tests. This is followed by an examination of stationarity characteristics through the ADF, PP, and KSS unit root tests. In the final stage, the HC test is employed to assess the linearity of the model, and subsequently, the Quantile-on-Quantile Regression (QQR) method is applied to investigate how both the dependent and independent variables behave across different quantile levels.

Figure 1
Methodological framework



Source: Created by the Author

Dataset and Model

The dataset used in this study, which investigates the relationship between the CA deficit and economic growth, was obtained from the Electronic Data Delivery System of the Central Bank of the Republic of Türkiye (CBRT). The CA balance (CA) is expressed in Turkish lira, whereas real economic growth (GDP) is represented by the annual percentage change in expenditure-based GDP and is seasonally adjusted.

To eliminate the differences arising from the units of the variables—and to handle any negative values in the series—the log-modulus transformation was applied. The prefix “ln” in the variable names denotes this logarithmic transformation. The closed-form representation of the models is given in Equations (6) and (7):

$$\ln GDP_t = f(\ln CA_t) \quad (6)$$

$$\ln CA_t = f(\ln GDP_t) \quad (7)$$

Table 1 the summary statistics of the macroeconomic variables analysed in this research. For an accurate assessment of the CA balance and economic growth, raw (non-transformed) values were used only at this stage of descriptive analysis. During the analysed period, Türkiye’s average real economic growth rate was approximately 5.09%. The lowest growth rate occurred in Q1 of 2009, at 14.54%, reflecting a period of contraction. In contrast, the highest growth rate was recorded in Q2 of 2021, reaching 22.35%. Regarding the CA balance, the average and median values were approximately 110 and 18 million USD, respectively—indicating a persistent deficit over the period. The largest CA deficit was observed in Q3 of 2005, at 3.19 billion USD, whereas the largest surplus was recorded in Q3 of 2024, amounting to 696 million USD.

Table 1
Summary Statistics

Variables	Mean	Std. Dev.	Median	Min	Max	JB Statistic
GDP	5.0912	5.2764	5.945	-14.54	22.35	55.2537***
CA	-109.744	435.4626	-17.86	-3192.31	695.90	3502.8120***

Note: *** denotes statistical significance at the 1% level.

To determine the direction and strength of the linear association between the variables, a correlation analysis was conducted. Since the variables $\ln\text{GDP}$ and $\ln\text{CA}$ violated the assumption of normality, Spearman's rank correlation matrix was employed. Table 2 presents the Spearman correlation results and reveals a negative and statistically significant correlation of approximately 0.45 between $\ln\text{GDP}$ and $\ln\text{CA}$.

Table 2
Spearman correlation matrix

Variables	$\ln\text{GDP}$	$\ln\text{CA}$
$\ln\text{GDP}$	1	
$\ln\text{CA}$	-0.4493*** (0.0000)	1

Note: *** denotes statistical significance at the 1% level.

Figure 2 illustrates the quantile–quantile (QQ) plots for the $\ln\text{GDP}$ and $\ln\text{CA}$ series against a theoretical normal distribution. In a normally distributed series, observations are expected to fall along the 45-degree reference line. However, in the case of $\ln\text{GDP}$, observations show clear deviations from the 45° line at both lower and upper quantiles, indicating non-normality in the distribution. Similarly, $\ln\text{CA}$ also exhibits deviations from normality, particularly at the distribution tails. These visual findings are consistent with the results of the Jarque–Bera test, confirming the rejection of normality for both variables.

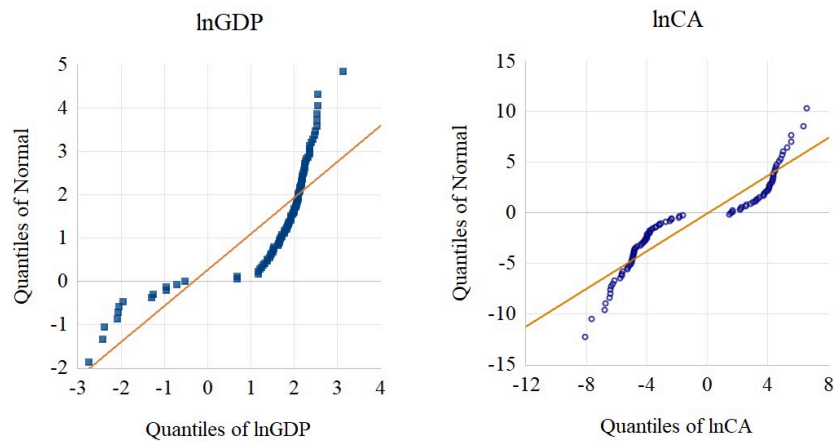
Figure 2
QQ Plots (Theoretical)

Figure 3
QQ plots (Median symmetry)

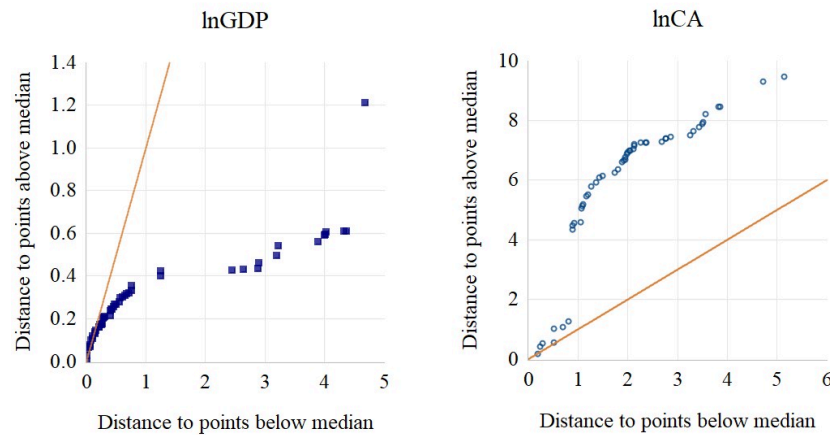


Figure 3 examines deviations from the median, where the reference line represents a symmetric distribution. The observations in the lnGDP series are distributed well above the reference line, indicating a skewed distribution and the presence of outliers. Although the lnCA series appears to be more balanced overall, the distances from the reference line increase notably in the upper tail of the distribution. In conclusion, both lnGDP and lnCA exhibit asymmetric behaviour in their distributions.

Empirical Findings

Linearity Testing

Before proceeding with unit root analysis for the lnGDP and lnCA variables, it was necessary to test whether the linearity assumption, which is a crucial requirement for traditional unit root tests, was satisfied. For this purpose, the BDS and HLX (2008) tests were conducted, and the results are presented in Table 3. Panel A displays the BDS test statistics. For both variables, the Bootstrap p-values are zero, which indicates that the null hypothesis of independence and identical distribution (iid) is strongly rejected. This result points to the presence of nonlinear dynamics in both series. Panel B presents the results of the HLX test. For the lnGDP series, the null hypothesis of linearity is rejected at the 1% significance level. In contrast, the null hypothesis cannot be rejected for the lnCA series. These findings indicate that the GDP series exhibits nonlinear behaviour, whereas the CA series may follow a linear structure.

Table 3

Results of Linearity Tests for Variables

Panel A. BDS Test	lnGDP	lnCA
BDS Stat. M = 2.	0.0993*** (0.000)	0.0608*** (0.000)
BDS Stat. M = 3.	0.1481*** (0.000)	0.0813*** (0.000)
BDS Stat. M = 4	0.1746*** (0.000)	0.0894*** (0.000)
BDS Stat. M = 5	0.1907*** (0.000)	0.0886*** (0.000)
BDS Stat. M = 6.	0.1895*** (0.000)	0.0849*** (0.000)
Panel B. HLX Testi.		
W*	30.48*** [9.21]	2.52 [9.21]

Note: *** indicate statistical significance at the 1% level. ii. Values in parentheses () are Bootstrap p-values.

iii. Values in square brackets [] indicate critical values. iv. M refers to the embedding dimension.

Unit Root Tests

To identify the presence of unit roots in the variables, the widely accepted Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were employed. The results are presented in Table 4. For both lnCA and lnGDP, the null hypothesis of a unit root was rejected at the 1% significance level under both the ADF and PP tests. To obtain more robust evidence of stationarity, the KSS nonlinear unit root test was also applied. The findings of this test are reported in Table 5.

Table 4

Results of the Traditional Unit Root Tests

Variables	ADF Testi		PP Testi	
	τ -Statistic (intercept)	τ -Statistic (intercept & trend)	τ -Statistic (intercept)	τ -Statistic (intercept & trend)
lnCA	-4.6551***	-4.4979***	-4.4651***	-4.4979***
lnGDP	-4.2695***	-4.2571***	-4.2695***	-4.2571***

Note: *** indicates significance at the 1% level.

The null hypothesis of the KSS test also states the presence of a unit root. At various accepted levels of significance, this null hypothesis is rejected for both lnCA and lnGDP. That is, both series do not contain a unit root under nonlinear testing conditions.

Table 5

Results of the Kapetanios–Shin–Snell (KSS) Unit Root Test

Variables	t-Statistic (intercept)	t-Statistic (intercept & trend)
lnCA	-4.165***	-4.147***
lnGDP	-3.320**	-3.293*

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Based on the results presented in Tables 5 and 6, there is strong evidence that both lnCA and lnGDP are stationary in levels. The stationarity of these variables eliminates the risk of spurious regression in the estimation process. Table 7 presents the results of the Harvey-Collier linearity specification test, which was applied to determine whether the models specified in Equations (6) and (7) follow a linear structure. The calculated t-statistics for both Model I and Model II indicate the rejection of the null hypothesis of linearity.

Table 6

Results of the Harvey–Collier Specification Test

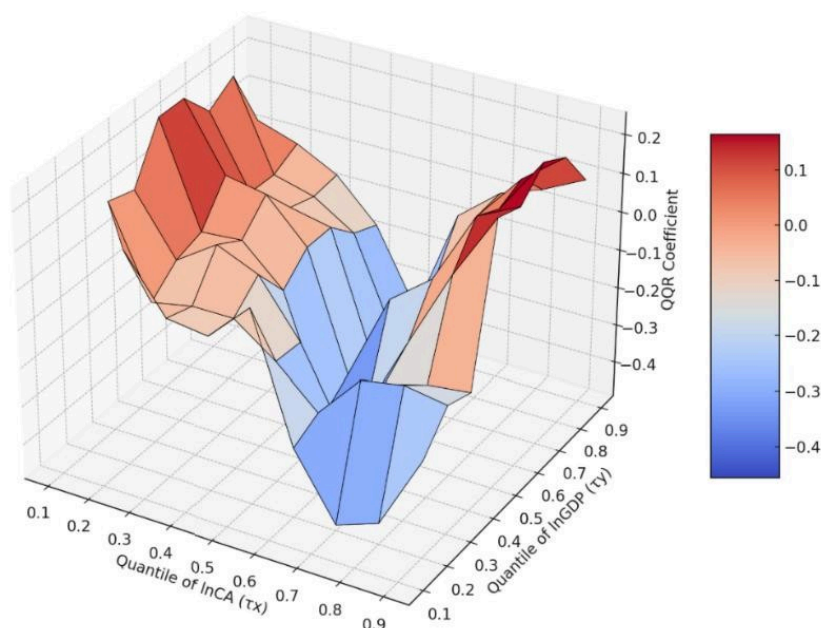
Model	t-Statistic	p-value
Model I	2.203**	0.0300
Model II	2.642***	0.0096

Note: *** and ** indicate significance at the 1% and 5% levels, respectively.

The variable- and model-specific findings, along with the central research question, justify the use of the Quantile-on-Quantile Regression technique in the modelling process. This technique is well suited for capturing nonlinearities and heterogeneities in the relationship between lnGDP and lnCA. The 3D QQR surface plot of Model I, presented in Figure 4, illustrates how different levels of economic growth respond to varying levels of CA balances. The initial findings reveal that the relationship between growth and CA varies across the entire distribution, becoming stronger in some regions and weaker in others. This indicates that the effect of the CA on economic growth is quantile-specific. Particularly, the effects become more pronounced in the extreme regions—that is, under conditions of high deficits or surpluses. The lower quantiles (0.1–0.3)

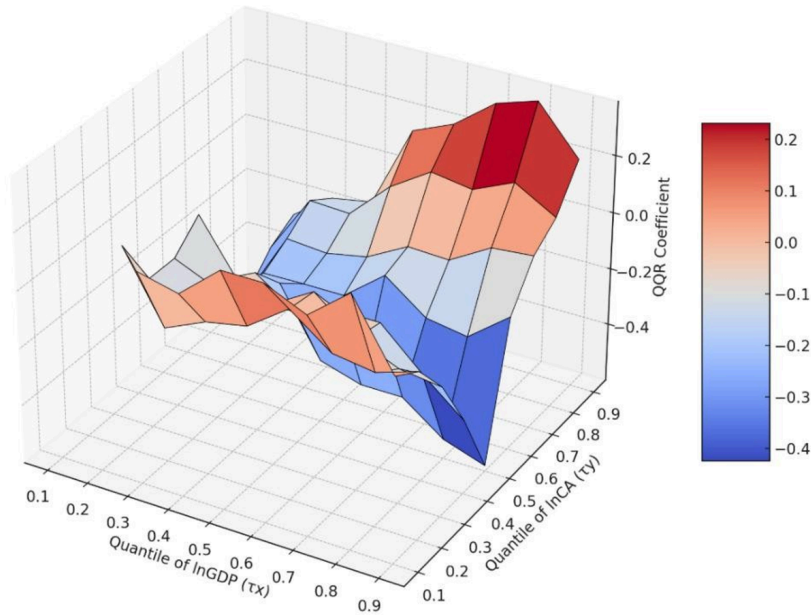
correspond to combinations of very low growth levels and high CA deficits. In these regions, the estimated regression coefficients are predominantly negative, indicating that during periods of low growth, large CA deficits exert a harmful impact on economic performance. Focusing on the middle quantiles (0.4–0.6, including the median), the regression coefficients are observed to be close to zero. This provides evidence that during macroeconomically stable periods, CA balances have no statistically significant effect on growth. However, as the upper quantiles (0.7–0.9) are reached, the pattern changes. These regions experience strong economic growth alongside CA surpluses. In this context, the regression coefficients are estimated to be positive, implying that high growth performance is more likely during surplus conditions. In conclusion, a high CA deficit generally has a negative or neutral effect on economic growth. On the other hand, CA surpluses may create conditions that allow for stronger growth rates.

Figure 4
Model I (lnGDP–lnCA) Quantile-on-Quantile Regression



At this stage, it becomes possible to address one of the central questions of the study: Should high growth be pursued at the expense of large CA deficits? This question motivated the development of Model II, in which economic growth is specified as the explanatory variable. The QQR estimates of this model are presented in Figure 5. The lower quantiles represent regions where high CA deficits coincide with low economic growth rates. In these regions, the regression coefficients are generally negative or close to zero, indicating that low growth does not lead to a significant increase in the CA deficit. In some instances, growth may narrow the deficit. In the middle quantiles, growth and CA appear to be in relative balance. Most of the estimated coefficients in this range are close to zero, implying that when growth is neither significantly low nor high, the CA may behave independently of growth. In the upper quantiles, where high growth rates intersect with large CA deficits, the regression coefficients are positive. This provides evidence that as economic growth accelerates, the CA deficit tends to widen. The relationship between high growth and large CA deficits is strong and systematic in the upper quantile regions. In the lower quantiles, the relationship weakens or even reverses. These findings indicate that once growth surpasses a certain threshold, it begins to exert pressure on external balance.

Figure 5
 Model II ($\ln CA - \ln GDP$) Quantile-on-Quantile Regression



Conclusion

This study investigates the relationship between economic growth and CA deficit in the Turkish economy by applying the Quantile-on-Quantile Regression (QQR) method across different levels of growth. Unlike the linear models widely used in the literature, this study accounts for the asymmetric and density-dependent (nonlinear) nature of the relationship. Thus, it analyzes not only the average effect of the CA deficit on growth but also how this effect varies across a range of growth levels—from low to high.

The empirical findings reveal a statistically significant and negative relationship between CA and economic growth within specific quantile intervals. Particularly during periods of low growth, rising CA deficits appear to exert downward pressure on growth, whereas this effect weakens during high-growth episodes. These results indicate that when the CA deficit exceeds a certain threshold, it may amplify economic vulnerabilities and constrain growth. The evidence also highlights that the effect of the CA on growth is not constant but conditional, thus pointing to the limitations of conventional linear models.

These findings are consistent with several prominent theoretical perspectives. The observed adverse effect of CA deficits during low-growth periods aligns with Keynesian arguments on the crisis-generating potential of external imbalances (Mundell, 1963; Fleming, 1962). Moreover, the results support the structuralist view that emphasises technological dependency and reliance on imported intermediate goods, which increase the sensitivity of growth to external imbalances (Prebisch, 1950; Cimoli & Porcile, 2014). Conversely, the weakening impact of the CA deficit during high-growth periods may be partially compatible with neo-classical interpretations, which associate external savings with higher growth (Feldstein & Horioka, 1980). Overall, the findings demonstrate that the growth–CA relationship is too complex and context-dependent to be fully explained by any single theoretical framework.

The findings point to the need to reconsider Türkiye's growth strategy in line with the sustainability of external balances. Structural characteristics, such as the import-dependent industrial base and energy reliance, contribute to external imbalances via trade deficits during growth phases. Therefore, policymakers should develop a coordinated and multidimensional policy framework that aligns growth targets with CA

sustainability. Key elements of this framework should include energy security, technological upgrading of exports, increasing domestic savings, and improving the quality of capital flows.



Additionally, some CA surplus–growth matchings were identified for Türkiye in specific quantile ranges of the QQR analysis. However, given the structural features of the Turkish economy, these matchings do not reflect a stable or systematic surplus pattern. Türkiye is structurally characterised by chronic CA deficits due to its high dependency on imported energy and intermediate goods, low savings rates, and consumption-driven growth. Therefore, the surplus observations identified in the analysis are most likely temporary or crisis-induced statistical outcomes and should not be interpreted as evidence of a long-term surplus–growth relationship. For instance, cyclical factors such as shrinking imports and production slowdowns largely drove temporary improvements in the external balance during post-pandemic periods like 2020. In this respect, the findings once again emphasise the need for structural transformation of Türkiye’s external balance framework.


One of the most significant contributions of this study is its ability to reveal heterogeneous interaction patterns that are often overlooked using classical approaches. Moreover, the use of high-frequency data specific to the Turkish economy strengthens the practical relevance of the findings—not only for theoretical discussions but also for policy design.

Future studies may expand this line of research by incorporating other macroeconomic variables, such as inflation, exchange rates, and external debt, enabling multivariate QQR analysis. Additionally, the same methodology could be applied to other country groups to facilitate comparative empirical investigations.



Peer Review	Externally peer-reviewed.
Author Contributions	Conception/Design of Study- S.B, K.E.; Data Acquisition- S.B, K.E.; Data Analysis and Interpretation- S.B, K.E.; Drafting Manuscript- S.B, K.E.; Critical Revision of Manuscript- S.B, K.E.; Final Approval and Accountability- S.B, K.E.
Conflict of Interest	The authors have no conflict of interest to declare.
Grant Support	The author declared that this study has received no financial support.

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