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Abstract: Previous studies on the relationship between government debt and economic growth have produced very diverse findings. This study examines the relationship between public debt and economic growth in developing countries using a quantile regression approach with fixed effects and bootstrapping on the 10% to 90% quantile distribution. The quantile grouping is based on specific percentiles of economic growth in developing countries. This study uses panel data from 127 developing countries for the period 2012 to 2019. Data were obtained from the World Development Indicators, the World Bank, and Transparency International. The results of this study indicate that public debt is not friendly to economic growth. Public debt actually hinders economic growth in developing countries, especially in the 30% to 90% quantile. Other factors that influence economic growth in developing countries are trade, inflation rates, government spending, corruption, and net foreign direct investment. Trade and net direct investment significantly increase economic growth in developing countries. Meanwhile, public debt, the inflation rate, government spending, and corruption actually inhibit economic growth in developing countries. On the other hand, education spending, private debt, tax revenues, and labor force participation do not contribute significantly to economic growth in developing countries. These findings confirm that public debt governance and governance are very important in driving economic growth in developing countries. This paper provides empirical and policy contributions to the assessment of institutional effectiveness in relation to the impact of public debt management on economic growth in developing countries.

Keywords: public debt; economic growth; quantile regression; fixed effects; bootstrapping

1. Introduction

The findings of several studies on the relationship between public debt and economic growth are expanded upon in this study (Augustine & Rafi, 2023; Gu et al., 2022; Moreira, 2005; Mqolombeni et al., 2023; Musa et al., 2023; Quazi, 2005; Reinhart & Rogoff, 2010; Shaari et al., 2023). Research is especially needed to determine how public debt affects economic growth in developing nations. Public debt is debt that a nation's government issues or guarantees (Bank Indonesia, 2021).

Public debt raises various debates among academics and practitioners. Debt can encourage economic development through infrastructure development and education (Moreira, 2005; Liu et al., 2021). Debt can also be an economic policy instrument to prevent the negative effects of business cycle fluctuations. The issuance of debt securities can stimulate emerging bond and corporate markets (Moreira, 2005; Liu et al., 2021).

However, several studies show that public debt can give rise to a crowding-out effect (Gu et al., 2022; Sandow et al., 2022). Public debt will impact currency devaluation. Debt is highly vulnerable to capital flight (Gu et al., 2022; Sandow et al., 2022; Augustine & Rafi, 2023). Debt has emerged as a significant barrier to economic recovery in wealthy nations after the 2008 financial crisis (Eggertsson & Krugman, 2012; Gu et al., 2022).

The inverse U-shaped relationship between public and private debt and economic development is explained by a number of empirical studies (Cecchetti et al., 2011; Checherita-Westphal & Rother, 2012; Reinhart et al., 2012; Arcand et al., 2015). However, other research indicates that when comparing multiple nations, the correlation between public debt and economic growth is weaker. There are significant national differences in the link between debt and long-term economic growth, and it can be either linear or nonlinear (Chen et al., 2024; Chudik et al., 2017; Eberhardt & Presbitero, 2015; Mqolombeni et al., 2023; Musa et al., 2023; Shaari et al., 2023).

Several empirical studies have been conducted by Cordella et al. (2010), Checherita-Westphal and Rother (2012), Kourtellos et al. (2013), Panizza and Presbitero (2014), and Eberhardt and Presbitero (2015) using standard neoclassical growth models to examine the relationship between debt and economic growth. Eberhardt and Presbitero's (2015) study on 118 developing and developed countries shows that the long-term debt coefficient differs across countries. Debt has a negative effect on GDP in the long term in countries that have a high debt ratio.

Studies by Al-Majali (2018), Eberhardt and Presbitero (2015); Emran and Farazi (2009), Heylen et al. (2013), Greiner (2012a, 2012b), Minea and Villieu (2010), Musa et al. (2023), and Shetta and Kamaly (2014) assert that the economy is negatively impacted by the public debt and budget deficit. However, studies conducted by Casares (2015), Checherita-Westphal and Rother (2012), Grobety (2018), Lin (2000), Teles and Mussolini (2014), and Yakita (2008) express that a nation's economy may be positively or negatively impacted by budget deficits and public debt.

Studies examining the impact of public debt using panel data are often hampered by two main challenges, namely, country heterogeneity and cross-sectional dependence. In an effort to overcome these obstacles, previous researchers have adopted a variety of relevant econometric techniques. For example, Chudik et al. (2013) developed the cross-sectionally augmented distributed lag (CS-DL) method, which takes into account the interconnectedness between countries in the distributed lag analysis. Beqiraj et al. (2018) chose the mean group regression and cointegration regression approaches to capture the dynamics of the debt–growth relationship. Asteriou et al. (2021) used a comprehensive set of econometric methods, including the pooled mean group, mean group, dynamic fixed effect, and techniques for common correlated effects and the asymmetric panel ARDL model.

Meanwhile, Gómez-Puig et al. (2022) chose the grouped fixed effect (GFE) estimator and the multinomial logit model to identify factors that drive differences in characteristics between observation units. Kostarakos (2022) relied on the common correlated effects mean group (CCE) estimator developed by Pesaran (2006), combined with cross-sectional averages to address the problem of inter-unit dependence. The study also compared the results of the standard two-way fixed effects estimator, the pooled estimator, the "naive" mean group estimator from Pesaran and Smith (1995), and the augmented mean group (AMG) estimator introduced by Bond and Eberhardt (2013). Furthermore, Carvelli (2024) used the dynamic common correlated effects model to analyze the dynamics of the relationship between variables by considering the general correlation effect.

Several studies using panel data examining the relationship between public debt, inflation, and economic growth have yielded mixed findings. Chudik et al. (2013), who an-

alyzed data from 40 countries over the period 1965–2010, concluded that public debt and inflation significantly hinder economic growth in the long run. However, they also found that temporary spikes in the debt-to-GDP ratio are not necessarily negative, provided the ratio returns to normal levels. Beqiraj et al. (2018), who focused on 21 OECD countries over the period 1991–2015, identified a long-term relationship between debt and structural primary balance. Meanwhile, Asteriou et al. (2021) found that increases in government debt were consistently negatively correlated with economic growth, both in the short and long run, in selected Asian countries over the period 1980–2012.

Gómez-Puig et al. (2022) found that the negative impact of debt on economic growth can be exacerbated by high debt levels and short debt maturities, but can be mitigated by good institutional quality and productive allocation of spending. This study was conducted in 115 countries during the period 1995–2016. Kostarakos (2022) highlighted the more significant negative impact of public debt on public investment, and identified a nonlinear relationship between debt and investment. Meanwhile, Carvelli (2024) showed that positive shocks to public debt tend to harm private sector growth. However, this negative impact can be neutralized if the countries have implemented fiscal consolidation policies for the previous five years.

On the other hand, there are several panel data studies that use the quantile regression approach; for example, Awan et al. (2022), Bassett and Koenker (2017), Buchinsky (1994), Cade and Noon (2003), Canay (2011), Chamberlain (1994), Chernozhukov et al. (2010), He (1997), Koenker (2004), Koenker and Hallock (2001), Machado and Silva (2019), and Musa et al. (2023). In this article, we examine the relationship between public debt and economic growth in 127 developing countries using the quantile regression approach with fixed effects and bootstrapping based on panel data for the period 2012–2019. Developing countries were chosen as the unit of analysis because the level of economic growth in developing countries varies greatly. Given that there are still many areas that can be developed, developing countries have a lot of room for higher economic growth.

We selected 2012 as the start of the research period because the measurement of corruption as one of the variables analyzed in this research has used a new methodology since 2012. The difference in the methodology for measuring the Corruption Perception Index in 2012 compared to the previous period mainly lies in the change in scale and data sources used. In 2012, Transparency International changed the Corruption Perception Index assessment scale to 0–100, whereas before 2012, the Corruption Perception Index used a scale of 0–10. Apart from changes in the scale, there were also changes in the data sources and survey questions used. The survey questions asked of respondents in 2012 and thereafter generally placed a greater emphasis on issues of accountability and public service. This was performed to provide a more comprehensive picture of the perception of corruption in a country.

We selected 2019 as the end of the research period because that year was the end of the normal economic period before the COVID-19 pandemic occurred. The research data were selected during normal economic times with the consideration of analyzing more carefully the effect of public debt on economic growth. After the COVID-19 pandemic occurred, there was a large-scale increase in public debt in various countries. However, the increase in public debt during the COVID-19 pandemic was mostly aimed at financing the health and education sectors and stabilizing the economy, not at encouraging economic growth.

The original contribution of this study lies in the use of a quantile regression analysis with fixed effects and bootstrapping to more specifically examine the effects of public debt on economic growth in developing countries. Previous studies have used the cross-sectionally augmented distributed lag method Chudik et al. (2013), the mean group regression approach and cointegration regression (Beqiraj et al., 2018), common correlated

effects and asymmetric panel ARDL models (Asteriou et al., 2021), the GMM approach (Caner et al., 2021), the grouped fixed effect (GFE) estimator (Gómez-Puig et al., 2022), common correlated effects mean group (Kostarakos, 2022), autoregressive distributed lag panel analysis (Shaari et al., 2023), threshold regression model (Augustine & Rafi, 2023), and the dynamic common correlated effects model (Carvelli, 2024). The new perspective in this study lies in the analysis of the effect of public debt on economic growth in developing countries carried out at each regression quantile with fixed effects and bootstrapping, starting from the 10% quantile to the 90% quantile (Q1 to Q9). Bootstrapping is a resampling technique using a computer to estimate the sampling distribution of statistics in order to obtain normally distributed residual data. A detailed analysis of each quantile has not been performed by previous researchers.

The advantage of quantile regression allowed us to analyze the effect of public debt on different quantiles of the economic growth distribution. This is especially important because the effects of public debt may not be linear and can vary significantly across the distribution of economic growth. Quantile regression is more resistant to outliers because it focuses on the quantiles of the distribution, not the average, so that the analysis results are more robust and reliable. Quantile regression allows us to analyze the effect of changing public debt on different parts of the economic growth distribution in more depth than just looking at the average effect.

The novelty of this research is the use of quantile regression analysis which is divided into quantiles from 10% to 90% (Q1 to Q9). Quantile regression was used in this study because of outliers and high data diversity among 127 developing countries in the 2012–2019 period. The study of the pattern of influence of public debt on economic growth is supported by graphical visualization of each variable from 10% to 90% quantiles (Q1 to Q9). Therefore, it is hoped that this research will provide benefits to policy makers in developing countries regarding best practices for managing public debt to encourage economic growth.

Another novelty of this research is the inclusion of governance variables using the Corruption Perception Index proxy. Various previous studies did not include corruption variables to examine the role of good governance in encouraging economic growth. Apart from that, this research also analyzes the effects of trade, education spending, inflation rates, government spending, private debt, taxes, labor force participation, and net foreign direct investment on economic growth in developing countries.

The remainder of this paper is laid out as follows. A literature review and theoretical underpinnings are covered in Section 2. The research technique is presented in Section 3. The empirical findings and discussion are presented in Section 4. Conclusions and policy proposals are finally presented in Section 5.

2. Theoretical Background and Literature Review

The impact of public debt on economic growth is still a hotly debated topic among economists. Views regarding the role of public debt in driving economic growth vary depending on the economic perspective used. According to Keynesians, government debt can be a driver of economic growth through increased investment and job creation. Keynesians believe that public debt can trigger a multiplier effect in future spending, which will then drive economic growth through new investment, job creation, and demand stimulus (Aspromourgos, 2018; Castelnuovo et al., 2018; Musa et al., 2023; Tempelman, 2007).

In contrast, classical and neo-classical economists argue that government debt can hinder economic growth in the long run because it causes increased interest rates and a crowding out effect. Classical and neo-classical economic theorists criticized the arguments of Keynesian theory, stating that public debt would only help during periods of crisis, but would trigger an increase in interest rates and a crowding out effect that would cause

the private sector to experience capital shortages, and would ultimately affect economic growth in the long term (Tsoulfidis, 2007; Barreyre & Delalande, 2020; Musa et al., 2023).

In the New Keynesian economic view, government debt is considered an instrument that can trigger economic growth. Proponents of the New Keynesian school argue that through debt, the government can finance large-scale capital projects and investments. This step will increase aggregate demand in the economy. According to New Keynesian theorists, this mechanism works through a multiplier effect, where each increase in government spending will result in a greater increase in overall economic output (Musa et al., 2023). Thus, public debt is seen as an effective catalyst to stimulate economic activity and drive growth.

This study examines the relationship between debt and economic growth, based on existing theory and developing recent empirical studies. According to Caner et al. (2021), an increase in the government budget deficit that occurs simultaneously with a decrease in GDP can lead to a higher public debt to GDP ratio. Public debt's negative impact on economic growth has been described by Reinhart and Rogoff (2010), Checherita-Westphal and Rother (2012), Caner et al. (2010), and Caner et al. (2021). This negative impact will be more pronounced if the large debt results in financial repression in the future (Cochrane, 2011). Moreover, during the COVID-19 pandemic, all countries faced a significant increase in public debt and a drastic decline in GDP (Pjanić & Mitrašević, 2023). Musa et al. (2023) took a quantile approach through moments using heterogeneous panel data on 44 developing countries for the period 1990 to 2000. The results of their study show that public debt inhibits economic growth in all quantiles.

Several previous studies have found that state debt has the potential to provide an impact that supports economic development, especially if it is managed carefully and its use is directed at productive activities. A study conducted in Nigeria by Yusuf and Mohd (2021) showed that loans obtained domestically proved to be more effective in stimulating economic growth compared to loans from abroad, with the note that good debt management is a crucial factor. Similar findings were also obtained by Saungweme and Odhiambo (2019), who studied conditions in Zambia, where government debt was shown to have a positive contribution to the economy by supporting domestic production, capital formation, and increasing economic growth.

Various studies examining the effect of public debt on economic growth using cross-country panel data face econometric challenges in the form of country heterogeneity and cross-sectional dependence. In panel data research, Pesaran (2006) introduced an innovative method for estimation and inference to deal with models with multifactor error structures. The study discusses two important aspects: the estimation of individual explanatory variable coefficients and the estimation of the average of individual coefficients assumed to be random. The proposed estimator is the common correlated effects (CCE) estimator. The CCE estimator has an asymptotic distribution that is derived under various regularity conditions, either when the time dimension (T) is fixed or when N and T go to infinity. One significant advantage of the CCE mean group (CCEMG) estimator is its robustness to the number of unobserved common factors, even when N and T increase simultaneously. The Monte Carlo experimental results confirm the theoretical derivation and show that the combined estimator has satisfactory performance even for relatively small values of N and T.

Kapetanios et al. (2011) extended the work of Pesaran (2006) on a method that utilizes cross-section means to provide valid inference in the case of stationary panel regression with a multifactor error structure. They examined the important case where unobserved common factors follow a unit root process using the CCE estimator and Monte Carlo experiments for the means. They showed that the main result of Pesaran (2006) continues

to hold in the more general case. This is interesting, given the fact that there is usually a large difference between the results obtained for unit roots and stationary processes. The Monte Carlo experiments also showed that the CCE-type estimator is robust to a number of deviations. Most importantly, tests based on the CCE estimator are of the correct size, while the factor-based estimator proposed by Bai (2009) shows considerable distortion even in the case of relatively large samples.

Chudik et al. (2013) investigated the long-term impact of public debt and inflation on economic growth. The study makes both theoretical and empirical contributions. On the theoretical side, the study develops a cross-sectionally augmented distributed lag (CS-DL) approach for estimating long-term impacts in dynamic heterogeneous panel data models with cross-sectionally dependent errors. The relative advantages of the CS-DL approach are illustrated with small-sample evidence via Monte Carlo simulations. On the empirical side, using data on a sample of 40 countries over the period 1965–2010, the study finds significant long-term negative impacts of public debt and inflation on economic growth. Interestingly, if the debt-to-GDP ratio is increased and the increase is permanent, then it will have a negative impact on economic growth in the long run. However, if the increase is temporary, there is no long-term growth effect, as long as the debt-to-GDP ratio is restored to normal levels. No universal threshold effect was found in the relationship between public debt and growth.

Chudik and Pesaran (2015) extended the common correlated effects (CCE) approach developed by Pesaran (2006) to heterogeneous panel data models with lagged dependent variables and/or weakly exogenous regressors. The study showed that the group-average CCE estimator remains valid but the following two conditions must be met to handle dynamics: a sufficient number of lags of the cross-sectional averages must be included in the individual panel equations, and the number of cross-sectional averages must be at least as large as the number of unobserved common factors. The study establishes a consistency level, derives asymptotic distributions, suggests the use of covariates to handle the effects of multiple unobserved common factors, and considers recursive de-meaning and jackknife bias correction procedures to reduce small-sample time series bias. The theoretical findings were accompanied by extensive Monte Carlo experiments, which show that the proposed estimator performs well as long as the dimension of the panel time series is large enough.

Eberhardt and Presbitero (2015) examined the relationship between public debt and economic growth with a focus on heterogeneity and nonlinearity. This paper does not explicitly use the CCE technique in its original form, but adopts a very flexible approach to account for unobserved heterogeneity, which is the main purpose of CCE. The study used the error correction model (ECM) and fractional polynomial regression to capture the complexity of the debt–growth relationship. This approach addresses the problem of heterogeneity in an adaptive way, similar to the spirit of CCE in dealing with common unobserved factors. The study concluded that the relationship between public debt and economic growth is complex and nonlinear. The effect of public debt on economic growth varies significantly across countries and at different debt levels. There are nonlinear effects, where the impact of public debt on economic growth can change depending on the debt level.

In another study, Chudik et al. (2017) analyzed the effect of debt thresholds on output growth using panel data of 19 developed countries and 21 developing countries for the period 1965–2010. The study built a model by taking into account the endogeneity of debt and growth, fixed effects, dynamics (homogeneous and heterogeneous), and cross-sectional error dependence. The study discussed simultaneity bias, and took into account the slope heterogeneity in the underlying output and debt growth equations. The study analyzed the long-term effects of public debt accumulation on economic growth using the

ARDL and DL specifications discussed in Chudik and Pesaran (2015), as well as their cross-sectionally augmented versions. The study used the ARDL and DL specifications plus cross-sectional averages, denoted by CS-ARDL and CS-DL. After taking into account the impact of global factors and spillover effects, the study found no evidence of a universal threshold effect in the relationship between public debt and economic growth. However, there was a significant negative long-term effect of public debt accumulation on output growth.

Beqiraj et al. (2018) analyzed the government's reaction to debt accumulation and examined whether the government voluntarily takes corrective actions when the debt-to-GDP ratio starts to increase or whether it allows debt to increase. Using panel data from 21 heterogeneous OECD countries from 1991 to 2015, the study distinguished between discretionary and automatic responses of the primary balance of government actions. This study used mean group regression and cointegration regression. The results showed a systematic long-term relationship between debt and the structural primary balance. The government's long-term discretionary response to an increase in the debt-to-GDP ratio was negative. This means that the government did not take long-term actions to counteract the increase in debt and did not satisfy the intertemporal budget constraint. In the short run, the asymmetric fiscal policy response exploits the output gap. The government intervenes with deficits and new debt when the output gap is positive, but does not make symmetric corrections when the situation reverses.

Asteriou et al. (2021) examined the relationship between public debt and short-term and long-term economic growth in selected Asian countries for the period 1980–2012. The study used several econometric methods: pooled average group, average group, and dynamic fixed effects, and also took into account common correlated effects. The impact of changes in public debt was also analyzed using the asymmetric panel ARDL method. The results of the study showed that increasing government debt is negatively related to economic growth in both the short and long term.

Gómez-Puig et al. (2022) modeled the heterogeneity of the debt–growth relationship and the underlying factors that may explain it using panel data from 115 countries over the period 1995–2016. The grouped fixed effect (GFE) estimator was used to endogenously classify countries into groups. The study also used a multinomial logit model to explore the drivers of the detected heterogeneity. The GFE estimator classified countries into five groups whose debt has different impacts on economic growth. The results showed that the strong impact of debt on economic growth is likely moderated by the quality of institutions and the proportion of productive spending but intensified by the level of debt and debt maturity.

Kostarakos (2022) studied the public debt–aggregate investment relationship across a number of European Union (EU) countries. The study used the CCE mean group estimate from Pesaran (2006) coupled with cross-sectional averages of observable factors to filter out the impact of unobserved factors. The study also used the standard two-way fixed effects estimator, a pooled estimator that assumes that time-varying heterogeneity has a common impact across countries. In addition, the "naive" mean group estimator from Pesaran and Smith (1995) was used. The augmented mean group (AMG) estimator introduced in Bond and Eberhardt (2013) was used to account for the heterogeneous impact of common unobserved factors. The empirical results showed that public debt, on average, has a significant adverse impact on public investment. Furthermore, there was evidence to suggest a nonlinear relationship between debt and investment.

Carvelli (2024) used projections from the IMF World Economic Outlook (WEO) database to explore the relationship between public and private debt by estimating the response of private output to debt shocks in G7 countries over the period 2010–2021. The problems of coefficient slope heterogeneity and cross-sectional dependence were ad-

dressed using the dynamic CCE model to analyze panel data when there is cross-sectional dependence and unobserved variables that affect all cross-sectional units. The results showed that positive shocks in public debt are detrimental to private output dynamics. However, the effect is neutral if countries have followed a fiscal consolidation pattern in the previous five years. The estimates at the individual level were consistent with the general findings, except for a small group of countries. Although high debt levels are associated with a rapid decline in the debt coefficient, nonlinear effects in the form of a Laffer-type curve seem unlikely.

Carvelli and Trecroci (2024) used data from 167 countries during 1970–2019 to examine the relationship between government debt and growth. In this study, several panel features were used, especially asymmetry, cointegration, endogeneity, country heterogeneity, and cross-sectional dependence. This study used augmented Dickey–Fuller (ADF) regression which adapted the cross-sectionally implemented panel unit root test (CIPS) testing procedure. The CIPS test, which is based on the cross-sectionally augmented Dickey–Fuller (CADF) test, was used to test the stationarity in panel data by considering cross-sectional dependence. The pooled mean group (PMG) estimator is between the dynamic fixed effect (DFE) estimator and the mean group (MG) estimator (Blackburne & Frank, 2007; Ditzen, 2018). The results of this study showed that increasing the debt per worker is detrimental to long-term output dynamics, but nonlinear estimates show that changes in government debt spread their impact through different channels. The treatment of using gross and net public debt interchangeably as debt measures also yields different results. Since the results of the analysis are very sensitive to the model specification, we must be careful in interpreting the results.

There are several other studies that have used the CCE estimator; for example, Pesaran and Tosetti (2011) extended the CCE framework to include spatial correlation, while Ditzen (2018) provides a practical guide to implementing dynamic CCE using Stata software (version 13). Baltagi (2021) provides a comprehensive explanation of panel data analysis methods, including CCE. In addition, there are several other studies that have used panel data; for example, Herwartz and Siedenburg (2008) conducted an analysis of poolability in a panel with cross-sectional dependence, while Coakley et al. (2006) discussed the problem of unobserved heterogeneity in panel time-series models.

Chen et al. (2024) conducted a study using panel data from 40 countries during the period 1980 to 2010. The study used the kink panel regression method with a latent group structure approach to explore the heterogeneous threshold effects of government debt on economic growth based on previously unknown group patterns. The results of the study revealed that the nonlinear relationship between government debt and economic growth is characterized by heterogeneous threshold levels, which vary across groups of countries.

Augustine and Rafi (2023) explored the nonlinear dynamics between public debt and economic growth by estimating debt threshold levels for 39 developing countries in the period 1980 to 2019. The study was conducted using a threshold regression model developed by Hansen (2000) so that the threshold value could be determined in the model. This study found variations in debt thresholds ranging from 24 percent to 132 percent. The relationship between public debt and economic growth in the form of an inverted U only occurred in six countries. The policy of expanding debt even beyond the threshold actually encouraged economic growth in some countries, while debt hindered growth even at low debt levels in some countries.

Abbas et al. (2021) conducted a study on the mediating effect of state governance on the relationship between debt and national output. With WGI data from 106 countries for the period 1996–2015, the study used fixed effects least-square dummy variables and GMM estimation techniques to overcome endogeneity. The results of the study showed that a

nonlinear pattern between public debt and economic growth occurs through quality state governance. Although public debt has a negative impact on economic growth, the results were statistically significantly positive when public debt interacted with governance.

The quality of government governance is often seen as a crucial factor that determines the effectiveness of public debt on economic growth. A number of studies show that debt can have a negative impact on the economy when governance is weak. Abbas et al. (2021) argued that public debt will only be optimal in driving economic growth if it is balanced with strong governance. On the other hand, debt has the potential to harm the economy if the quality of government governance is low and there is structural rigidity that results in fund leaks (Abbas et al., 2021; Yasar, 2021). Mitu and Stanciu (2023) showed that public sector performance is higher and more efficient in the middle-scale government group than in the lower or upper groups.

Good governance is often considered the main pillar in determining the success of public debt management. Without transparent and accountable governance, public debt has a high potential to fail to achieve its goal of encouraging economic growth. Several studies have highlighted that weaknesses in governance are often the main cause of public debt failure (Appiah-Kubi et al., 2022; Law et al., 2021). Good governance creates a conducive environment for the productive use of debt, minimizes the risk of corruption and inefficiency, and ensures that debt is used for investments that are sustainable and beneficial to society. Thus, the quality of government governance has a direct impact on the effectiveness of public debt in driving inclusive and sustainable economic growth.

However, the consistency of research results regarding the effectiveness of governance in debt management is not completely uniform. Dorobantu and Müllner (2019), for example, presented different findings that the effectiveness of governance may vary depending on the country-specific context. Similarly, Shittu et al. (2018) revealed that under certain conditions, poor governance can actually trigger GDP growth originating from foreign debt, especially in Sub-Saharan African countries. This confirms that the relationship between governance, public debt, and economic growth is not a linear relationship, but is very complex and influenced by various contextual factors.

This lack of uniformity in findings motivates further research using a more robust methodology. In this way, it is hoped that it can provide a more comprehensive contribution to the understanding of the dynamics of the relationship between governance, public debt, and economic growth, as well as provide a more solid basis for effective policy making.

Most previous research examined the relationship between public debt and economic growth in OECD, North American, EU, and Sub-Saharan African countries, as well as certain other countries. At the same time, the literature on developing countries is limited. Various previous studies on the relationship between public debt and economic growth were analyzed using the GMM approach (Caner et al., 2021), autoregressive distributed lag panel analysis (Shaari et al., 2023), and threshold regression models (Augustine & Rafi, 2023).

On the other hand, there are several panel data studies that used the quantile regression approach, for example, Awan et al. (2022), Bassett and Koenker (2017), Buchinsky (1994), Cade and Noon (2003), Canay (2011), Chamberlain (1994), Chernozhukov et al. (2010), He (1997), Koenker (2004), Koenker and Hallock (2001), Machado and Silva (2019), and Musa et al. (2023). Musa et al. (2023) studied the relationship between public debt, governance, and economic growth with heterogeneous panel data in 44 developing countries for the period 1990–2000 using the quantile via moments approach. Awan et al. (2022) studied the impact of renewable energy, internet usage, and foreign direct investment on carbon dioxide emissions in 10 developing countries for the period 1996–2015 using quantile moment regression. However, there is not much literature that examines the effects of public debt on economic growth.

Various previous studies using panel data indicated that there were problems of country heterogeneity and cross-sectional dependence which were attempted to be overcome using various econometric approaches, as described in the section above (Abbas et al., 2021; Asteriou et al., 2021; Augustine & Rafi, 2023; Baltagi, 2021; Beqiraj et al., 2018; Carvelli, 2024; Carvelli & Trecroci, 2024; Coakley et al., 2006; Chen et al., 2024; Chudik & Pesaran, 2015; Chudik et al., 2013; Chudik et al., 2017; Ditzen, 2018; Eberhardt & Presbitero, 2015; Hansen, 2000; Herwartz & Siedenburg, 2008; Gómez-Puig et al., 2022; Kapetanios et al., 2011; Kostarakos, 2022; Pesaran, 2006; Pesaran & Tosetti, 2011).

In this study, to overcome the econometric problems of country heterogeneity and cross-sectional dependence, we used the quantile regression approach. The quantile regression approach offers a powerful solution to address econometric challenges such as country heterogeneity and cross-sectional dependence. Quantile regression focuses not only on the conditional mean as in OLS regression but also on other quantiles of the conditional distribution. The use of quantile regression allowed us to analyze how the effects of public debt vary across different levels of economic growth. For example, the effects of public debt may differ significantly in countries with low economic growth compared to countries with high economic growth. The quantile regression approach is very flexible in dealing with non-normally distributed data and outliers. This is especially important in the context of developing countries, where the variation in economic conditions and data is often very large. Thus, quantile regression is very good at dealing with country heterogeneity.

In this study, the application of quantile regression was strengthened by testing fixed effects and bootstrapping. Quantile regression allows the analysis of the effects of public debt at various levels of economic growth (quantiles), not just the average. The quantile regression approach is very useful for understanding how the effects of public debt differ across countries with low, medium, and high economic growth. Fixed effects are added to a quantile regression to control for unobserved and time-varying country heterogeneity, such as differences in institutions or cultures, which may affect the relationship between public debt and economic growth. Quantile regression is more robust to outliers than mean regression, which is often a problem in macroeconomic data.

Bootstrapping is a resampling method with a small computerized change so that the residuals produced approach a normal distribution, so that the coefficients become consistent even if there is a violation of the normality assumption. Bootstrapping stops the probability of the resulting coefficients from being disturbed by heteroscedasticity, autocorrelation, and normality. Bootstrapping provides a robust standard error estimate for violations of the normal distribution assumption, which often occurs in macroeconomic data. Bootstrapping can overcome the problem of cross-sectional dependence by using the appropriate block bootstrapping technique. This is important, because developing countries often have strong economic linkages. Bootstrapping is useful for overcoming the problem of country heteroscedasticity.

Combining quantile regression with fixed effects and bootstrapping allows researchers to obtain more robust and accurate estimates of the effects of public debt on economic growth in developing countries. Quantile regression with fixed effects allows the analysis of the effects of public debt on different levels of economic growth by controlling for country heterogeneity, while bootstrapping addresses the problems of the violation of the normal distribution assumption and cross-sectional dependence. By using quantile regression, we can produce findings that are more relevant to policy-making in developing countries.

We examined the relationship between public debt and economic growth in developing countries using quantile regression with fixed effects and bootstrapping divided into quantiles from 10% to 90% (Q1 to Q9). The advantages of quantile regression with fixed effects and bootstrapping include being able to analyze the effects of public debt at various

quantiles of economic growth levels and being more resistant to outliers because it focuses on distribution quantiles, so that the analysis results are more robust and reliable, and there is modeling flexibility in analyzing more complex relationships between variables. In addition, we also analyzed aspects of governance with the Corruption Perception Index proxy. Previous studies have not analyzed corruption as one of the factors influencing economic growth.

3. Methodology

3.1. Data Description

We examined how public debt affects economic growth in developing countries using quantile regression techniques. Panel data from 127 developing countries from 2012 to 2019 were used in this analysis (Appendix A, Table A1). Data sources include Transparency International 2012–2019, World Bank, and World Development Indicators (WDI) 2012–2019.

The year 2012 was chosen as the initial period because one of the independent variables, namely, the corruption variable with a proxy for the Corruption Perception Index, used a new measurement methodology since 2012. Since 2012, the scale for measuring the Corruption Perception Index has changed to 0 to 100 from the original scale of 0 to 10. In addition, the survey questions asked to sources measuring the Corruption Perception Index in 2012 and after placed more emphasis on issues of accountability and public service. This was to provide a more comprehensive picture of the perception of corruption in a country.

On the other hand, 2019 was chosen as the final research period because that year was the end of the normal economic situation before the COVID-19 pandemic occurred. During the COVID-19 pandemic, there was a large-scale increase in public debt in various countries. However, the increase in the amount of debt was mostly used to handle health problems, for example, purchasing vaccines, medicines, and medical equipment, and improving health facilities. The increase in public debt during the COVID-19 pandemic was also used for social assistance for affected communities, such as cash assistance programs and subsidies for small and medium enterprises (SMEs) to stay afloat. The increase in public debt during the pandemic was also used to finance the education sector, for example, providing large internet quotas to educators and students at all levels of education who were learning online. Thus, the increase in public debt during the COVID-19 pandemic was not aimed at encouraging economic growth.

In analyzing the effects of public debt on economic growth in developing countries, the potential for heterogeneity and cross-sectional dependency issues pose significant econometric challenges. Heterogeneity arises because of differences in economic, political, and social characteristics across countries, which cause the response of economic growth to public debt to vary. Cross-sectional dependency occurs because a country's debt policy can affect other countries through trade, finance, and investment channels. In this context, quantile regression offers advantages in overcoming these problems.

In the context of analyzing the effects of public debt on economic growth in 127 developing countries over the period 2012–2019, quantile regression with fixed effects and bootstrapping presents itself as a robust methodological solution to address the country heterogeneity inherent in panel data samples. Developing countries have very diverse economic characteristics, ranging from economic structure, income levels, institutional quality, to vulnerability to external shocks. Quantile regression recognizes and accounts for this heterogeneity by not only focusing on the average effect but on the effects at different points in the distribution of economic growth.

Fixed-effects quantile regression and bootstrapping allow researchers to break down economic growth data into quantiles ranging from the 10% to the 90% quantile, representing

groups of countries with different growth rates. This allows researchers to estimate the effects of public debt separately for countries with low, medium, and high economic growth categories. This is important because the effects of public debt are not expected to be uniform. For example, low-growth countries may be more vulnerable to the negative impacts of debt due to limited fiscal capacity, while high-growth countries may be able to manage debt more effectively.

Cross-country economic data often contain outliers that can distort the results of ordinary least squares regressions that focus on the mean. Quantile regressions that focus on quantiles are more robust to outliers, thus providing more robust and representative estimates. Compared to OLS regressions that provide only one estimate of the mean effect, quantile regressions with fixed effects and bootstrapping produce a set of estimates that reflect the variation in the effects of public debt across the distribution of economic growth.

To analyze the impact of public debt on economic growth in developing countries, combining quantile regression with fixed effects and bootstrapping is a good choice. This approach allows researchers to see the effects of debt at different levels of growth, control for differences across countries, and overcome statistical problems such as non-normal data distributions and inter-country dependencies.

Quantile regression does not require the assumption of normal distribution on disturbance variables, which is often violated in economic data. This flexibility makes quantile regression more suitable for analyzing economic data that often have non-normal distributions. Thus, quantile regression provides a more comprehensive and accurate picture of the effects of public debt on economic growth in developing countries, which is very useful for policymakers in designing effective debt management strategies.

In analyzing the effect of public debt on economic growth in 127 developing countries for the period 2012–2019, the issue of cross-sectional dependence is an important concern. Cross-sectional dependence refers to an econometric problem that arises when the error residuals are correlated across units (or sections). On the other hand, country heterogeneity occurs when the impact of public debt differs across units in the sample. This dependence occurs when the economic conditions of a country are affected by the economic conditions of other countries, for example, through international trade, capital flows, or external shocks that are global in nature.

Quantile regression with fixed effects and bootstrapping offers a more robust approach to addressing the problem of cross-sectional dependence for several reasons. First, fixed effects in quantile regression help control for unobserved but time-varying factors that may cause correlation between cross-sectional units. These factors, such as regional policies or concurrent economic shocks, are often major sources of cross-sectional dependence. By controlling for these factors, fixed effects reduce the risk of bias caused by cross-sectional dependence.

Second, bootstrapping provides a way to account for cross-sectional dependence explicitly through techniques such as block bootstrapping. This technique allows researchers to estimate the sampling distribution of a test statistic while preserving the dependence structure in the data. Thus, bootstrapping provides more accurate standard errors and confidence intervals that account for cross-sectional dependence.

Third, the combination of quantile regression and bootstrapping allows researchers to analyze the effects of explanatory variables at different quantiles of the dependent variable distribution, not just the mean. This is especially important in the context of cross-sectional dependence because the effects of explanatory variables may differ across different parts of the distribution. By using quantile regression, researchers can gain a more comprehensive understanding of how cross-sectional dependence affects the relationships between the variables of interest.

Overall, quantile regression with fixed effects and bootstrapping provides a more powerful and flexible approach to addressing cross-sectional dependency issues compared to traditional methods such as OLS regression. This approach allows researchers to obtain more reliable and accurate estimates that account for heterogeneity and dependency in the data.

Although quantile regression with fixed effects and bootstrapping offers a powerful solution in dealing with cross-sectional heterogeneity and dependence, it is not without its limitations. First, fixed effects only remove heterogeneity that is constant over time, so that variations across countries that change over time are not accommodated. Second, bootstrapping techniques, such as block bootstrapping, require assumptions about the cross-sectional dependence structure that may not always be accurate. Third, quantile regression with fixed effects and bootstrapping can be computationally intensive, especially with large panel data. Finally, although quantile regression allows the analysis of effects across quantiles, the interpretation of the results can be more complex compared to mean regression. In this study, the variables, variable descriptions, measurements, expectations, and data sources can be observed in Table 1 below.

Table 1. Description of variables and sources of data.

Variables	Deskripsi	Measurement	Expectation	Source
Growh	Economic growth is GDP growth per year expressed in percent.	GDP at cash local currency (constant 2015 US dollars) market values.	-	The World Bank, World Development Indicators 2012–2019
Trade	The gross domestic product is used to calculate the proportion of goods and services that are imported and exported.	The value of trade is measured as a percentage of GDP.	Positive	The World Bank, World Development Indicators 2012–2019
Education	The percentage represents the total amount spent by the government on capital, transfers, and education.	Government spending on education as a percentage of GDP.	Positive	The World Bank, World Development Indicators 2012–2019
Inflation	A consumer price index called inflation shows how much the average cost of goods and services has changed.	Inflation is measured from the consumer price index as an annual percentage using the Laspeyres formula.	Negative	The World Bank, World Development Indicators 2012–2019
Government expenditure	All government spending is included in government final consumption expenditures.	Final consumption spending by the government as a proportion of GDP.	Positive	The World Bank, World Development Indicators 2012–2019
Private debt	Debt from the private sector in previous periods through trade credit, loans, and acquisition of nonequity securities.	Private sector debt in previous periods as a percentage of GDP.	Positive	The World Bank, World Development Indicators 2012–2019
Public debt	The amount of government debt for the previous period is reduced by the quantity of government shares and financial derivatives.	Previous period central government debt as a percentage of GDP.	Positive	The World Bank, World Development Indicators 2012–2019

Table 1. *Cont.*

Variables	Deskripsi	Measurement	Expectation	Source
Corruption	The Corruption Perception Index, which has been rescaled to indicate that the higher the index, the highger the degree of corruption, serves as a stand-in for the actual level of corruption.	Corruption is created with an inverted rescale from 0 towards 100.	Negative	Transparency International 2012–2019
Tax	Transfers from taxpayers to the federal government for public use are referred to as tax revenues.	Total government tax revenue as a percentage of GDP.	Positive	The World Bank, World Development Indicators 2012–2019
Labor force participation	ILO-reported economically active labor force participation rate as a proportion of the overall population.	Labor force participation rate between 15 and 65 years old expressed as a percentage.	Positive	The World Bank, World Development Indicators 2012–2019
Investment	New investment inflows less foreign investor disinvestment, divided by GDP, is known as net foreign direct investment.	Net foreign direct investment as a percentage of GDP.	Positive	The World Bank, World Development Indicators 2012–2019

3.2. The Relationship Between Government Debt and Government Expenditures

A nation's expenditures for government consumption and principle and interest payments on its debt are limited (Casares, 2015). Government spending is funded by taxes and government debt. The national budget constraint can be expressed using the following equation:

$$\dot{D}_G = rD_G + G_T - T_T \tag{1}$$

where $\dot{D}_G$ represents the national debt's gradual rise, D_G is the government's foreign loans, rD_G is loan interest, G_T is government consumption of traded goods, and T_T is tax income.

The constant fractions θ_G and Y_T are used to measure the amount of foreign public debt, specifically $D_G = \theta_G Y_T$ where $\theta_G > 0$. $\dot{D}_G = \theta_G \dot{Y}_T$. Next, it is assumed that $G_T = \varnothing_T Y_T$, where $0 < \varnothing_T < 1$. The assumption is that the level of tax income (T_T) is adjusted residually (Brauninger, 2005; Casares, 2015; Heijdra, 2002; Serven, 2007).

Substitute into Equation (1) as follows: $\dot{D}_G = rD_G + G_T - T_T$. $\theta_G \dot{Y}_T = r\theta_G Y_T + \varnothing_T Y_T - T_T$, so that

$$T_T = r\theta_G Y_T + \varnothing_T Y_T - \theta_G \dot{Y}_T \tag{2}$$

The government covers consumption expenditure on non-traded goods. This consumption is funded by a flat tax levied on households. Therefore, the function of the state budget for tradable goods is $T_N = p_N G_N$. Assuming that $p_N G_N = \varnothing_N p_N Y_N$, then the following equation is obtained:

$$T_N = \varnothing_N p_N Y_N \tag{3}$$

Therefore, governments simply borrow money from other countries or international financial institutions to purchase tradable goods.

3.3. Economic Growth Model

The Cobb–Douglas production function serves as the foundation for this research model (Assoum & Alinsato, 2023), which was modified and defined as follows:

$$Y_{it} = F(A_{it}, L_{it}, K_{it}, G_{it}) = A_{it} K_{it}^{\alpha} L_{it}^{\beta} G_{it}^{1-\alpha-\beta} \tag{4}$$

where Y_{it} is the actual GDP for year t of the nation i. The level of technology and economic efficiency is reflected in A_{it}, or aggregate factor productivity. L_{it} is the workforce.

K_{it} are physical capital inventories. G_{it} refers to public goods that are purchased by the government.

Economic productivity and efficiency can be influenced by debt policy and government governance (Abdullah et al., 2020; Assoum & Alinsato, 2023; Gani, 2011; Khan, 2007; North, 1990; Olson et al., 2000; Woo, 2009). Aggregate factor productivity can be written as follows:

$$A_{it} = A_{0i}exp(\lambda Z_{it})exp(\mu_{it}) \tag{5}$$

where $Z_{it} = (gov_{it})$, gov_{it} represents levels of government, and λ is a vector containing λ_1 and λ_2. Combining Equations (4) and (5) using the natural logarithm, we obtain Equation (6) as follows:

$$y_{it} = \alpha_{0i} + \lambda Z_{it} + \mu_{it} + \alpha k_{it} + \beta l_{it} + (1 - \alpha - \beta)g_{it} \tag{6}$$

where y_{it}, k_{it}, l_{it}, and g_{it} each have a logarithm of Y, K, L, and G, whereas μ_{it} is the error rate of country i in year t. This model assumes that physical capital accumulation follows a process $K_{it} = (1 - \delta)K_{it-1} + I_{it}$. By considering $t \to \infty$, and let us take as an example $\xi = \frac{1}{\eta}$, the equation can be expressed as follows:

$$k_{it} = [1 - \xi B]^{-1} i_{it} \tag{7}$$

where i_{it} denotes investment and $\xi = \frac{1}{\eta}$, and δ represent the rate of capital depreciation. The operator for the reverse shift is *B*. The following long-term per capita product evolution equation is produced by assuming continuous labor growth and putting Equation (7) into Equation (6):

$$y_{it} = \alpha_0 + a_{0i}(1 - \xi) + \xi y_{it-1} + \alpha i_{it} + \sigma t + \lambda gov_{it} + \mu_{it} + (1 - \alpha - \beta)g_{it} - \xi \lambda gov_{it-1} - \xi \mu_{it-1} - \xi(1 - \alpha - \beta)g_{it-1} \tag{8}$$

As a result, the above model is dynamic structurally. The following Equation (8) can be used to express the evolution of product per capita:

$$y_{it} = \beta_0 + \varphi y_{it-1} + \beta_1 gov_{it} + \beta_2 g_{it} + \theta X_{it} + \rho_i + \varepsilon_{it} \tag{9}$$

where X_{it} is a vector of control factors, such as investment (i_{it}), that affect income. The fixed effect ρ_i in Equation (9) takes into account a nation's initial productivity (A_{0i}) as well as other country-specific variables. Natural logarithms can be used to formulate the model in the following way:

$$lny_{it} = \beta_0 + \varphi ln(y_{it-1}) + \beta_1 gov_{it} + \beta_2 g_{it} + \theta X_{it} + \rho_i + \varepsilon_{it} \tag{10}$$

Therefore, the model is dynamic, with y_{it}, gov_{it}, and g_{it}, representing per capita income, government level, and government expenditure in the form of public goods expenditures, respectively. Meanwhile, country i, time dimension, country-specific fixed effects, and error rates are indicated by i, t, ρ_i, and ε_{it}. In this analysis, i = 1, 2, 3, ...127 and t = 2012, 2013, ..., 2019. In addition, according to several previous studies, the vector X_{it} in Equation (10) includes control variables that influence income (Assoum & Alinsato, 2023).

3.4. Econometric Model Specification

This study employed the methods of Kremer et al. (2013) and Seo and Shin (2016) in order to estimate a more robust model. The Kremer et al. (2013) method was used to verify the model's robustness. Equation (10) was utilized to derive the model for the dynamic panel threshold of Seo and Shin (2016) as follows:

$$lny_{it} = (\beta_{01} + \varphi_1 lny_{it-1} + \beta_{11} Debt_{it} + \beta_{21} gov_{it} + \theta_1 X_{it}) I(gov_{it} \leq \gamma) + (\beta_{02} + \varphi_2 lny_{it-1} + \beta_{12} Debt_{it} + \beta_{22} gov_{it} + \theta_2 X_{it}) I(gov_{it} > \gamma) + \rho_i + \varepsilon_{it} \tag{11}$$

where the function indicator is denoted as $I(.)$, the transition variable as gov_{it}, and the threshold parameter as γ. The following model was employed in Kremer et al. (2013)'s dynamic panel threshold framework:

$$lny_{it} = \varphi_1 lny_{it-1} + \delta_1 Debt_{it} I(gov_{it} \leq \gamma) + \delta_2 Debt_{it} I(gov_{it} > \gamma) + \theta X_{it} + \rho_i + \varepsilon_{it} \tag{12}$$

where gov_{it} is the transition variable, γ is the threshold parameter, and $I(.)$ is the indicator function. The Caner et al. (2021) model served as the basis for this research model, which is as follows:

$$y_{it} = \alpha_i + \Psi y_{i,t-1} + \Gamma' D_{it} + \Phi_{11} 1_{\{q_{it} \leq \gamma\}} + \Phi_{21} 1_{\{q_{it} > \gamma\}} + \Phi_{12} x_{it} 1_{\{q_{it} \leq \gamma\}} + \Phi'_{22} x_{it} 1_{\{q_{it} > \gamma\}} + v_{it} \tag{13}$$

where countries and time periods are indicated as $i = 1, 2, 3,\ldots$, n and $t = 1, 2, 3,\ldots$, T does not need to be deleted because in this study t indicates the years 2012–2019, respectively. The GDP growth rate is the dependent variable, and the values of the explanatory variables are lagged. The economic growth model in this research is as follows:

$$Growth_{it} = a_i + \mathcal{O}_{1.1} Trade_{it} + \mathcal{O}_{1.2} Edu_{it} + \mathcal{O}_{1.3} Inflation_{it} + \mathcal{O}_{1.4} Gov.\ Consumption_{it} + \mathcal{O}_{1.5} Private\ Debt_{it-1} + \mathcal{O}_{1.6} Public\ Debt_{it-1} + \mathcal{O}_{1.7} Corruption_{it} + \mathcal{O}_{1.8} Tax_{it} + \mathcal{O}_{1.9} LFP_{it} + \mathcal{O}_{1.10} I_{it} + u_{it} \tag{14}$$

In this study, we modified the Caner et al. (2021) model by removing the variables household debt, corporate debt, banking crisis dummy, and pension funds, and adding the variables corruption, labor force participation, and net foreign direct investment. This action was carried out in order to develop a research model that was appropriate to the available data and eliminate factors that were considered insignificant based on previous findings.

The analysis of the effect of public debt on economic growth in developing countries was carried out using the econometric approach of quantile regression with fixed effects and bootstrapping. Quantile regression offers significant advantages over conventional regression methods, especially with fixed effects and considering the model used in this study. This research model includes various determinants of economic growth, exposing the complexity of the relationship between variables, where the effect of public debt was likely not uniform across the growth distribution. Quantile regression allowed us to break down this heterogeneity by analyzing the effect of debt at various growth quantiles, thus providing a more detailed picture than just the average effect.

In a study of the effects of public debt on economic growth in 127 developing countries for the period 2012–2019, quantile regression with fixed effects and bootstrapping were used sequentially and in an integrated manner to overcome the challenges of country heterogeneity and cross-sectional dependency. First, quantile regression was applied to analyze how the effects of public debt vary across different levels of economic growth. This was carried out by dividing the distribution of economic growth into various starting quantiles and estimating the effects of public debt at each quantile. Thus, we could see whether the effects of public debt differ across countries with low, medium, and high economic growth.

Second, fixed effects were introduced into the quantile regression model to control for unobserved but constant country heterogeneity over time. Fixed effects eliminated cross-country variation caused by factors, such as institutional, cultural, or policy differences, that do not change over the study period. This treatment can reduce bias caused by country heterogeneity and allowed us to focus on the true effects of public debt.

Third, bootstrapping was used to address the problem of cross-sectional dependency and violation of the normal distribution assumption. Bootstrapping is a resampling technique that allows researchers to estimate the sampling distribution of a test statistic without having to make any particular distributional assumptions. In this context, bootstrapping was performed by resampling the data with replacement and estimating a quantile regression model with fixed effects on each resample. This treatment produced an empirical distribution of the regression coefficients, which was then used to calculate more accurate standard errors and confidence intervals.

Appropriate bootstrapping techniques, such as block bootstrapping, can be used to address cross-sectional dependency while preserving the dependence structure in the data. This treatment is performed by resampling adjacent blocks of observations rather than individual observations. By combining quantile regression, fixed effects, and bootstrapping, we could obtain more robust and accurate estimates of the effects of public debt on economic growth in developing countries. This approach allowed us to examine the effects of public debt at different levels of economic growth, control for country heterogeneity, and overcome statistical problems common to macroeconomic data.

4. Empirical Results and Discussion

An empirical model verification was carried out using quantile regression. Quantile regression was used in this study because there was very high data variation for all variables. This method divides data into certain quantiles, which are thought to have different estimated values.

Quantile regression is very useful for data distributions that are not homogeneous and do not have a standard shape, such as those showing asymmetry or tails in the distribution (Koenker & Bassett, 1978). In quantile regression, resampling or bootstrapping is carried out and the coefficients formed are robust against violations of assumptions because they do not use the ordinary least squares principle, so there is no need to test stationarity, multicollinearity, and autocorrelation. Table 2 shows the overall findings using quantile regression analysis:

Table 2. The effect of public debt on economic growth in developing countries using quantile regression with fixed effects and bootstrapping.

	Fixed Effects and Bootstrapping								
Variabel	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**
Trade	0.007 (0.881)	0.024 (0.603)	0.034 (0.377)	0.045 (0.158)	0.055 * (0.068)	0.064 ** (0.040)	0.075 *** (0.000)	0.088 *** (0.001)	0.109 * (0.059)
Education expenditure	−0.032 (0.890)	−0.080 (0.754)	−0.111 (0.492)	−0.140 (0.335)	−0.170 (0.334)	−0.196 (0.517)	−0.229 (0.423)	−0.266 (0.425)	−0.325 (0.499)
Inflation	−0.028 (0.754)	−0.043 (0.587)	−0.053 (0.932)	−0.062 (0.159)	−0.071 ** (0.041)	−0.080 ** (0.028)	−0.090 *** (0.000)	−0.101 *** (0.000)	0.120 *** (0.000)
Government expenditure	−0.193 (0.233)	−0.338 ** (0.020)	−0.432 *** (0.004)	−0.520 ** (0.027)	−0.610 * (0.054)	−0.689 (0.106)	−0.788 * (0.086)	−0.899 (0.149)	−1.079 (0.168)
Private debt *t-1*	−0.042 ** (0.032)	−0.036 (0.104)	−0.031 (0.156)	−0.027 (0.388)	−0.022 (0.458)	−0.019 (0.574)	−0.014 (0.719)	−0.009 (0.852)	0.000 (1.000)
Public debt *t-1*	−0.022 (0.341)	−0.033 (0.263)	−0.041 * (0.073)	−0.048 ** (0.016)	−0.055 ** (0.030)	−0.061 * (0.090)	−0.069 * (0.079)	−0.078 ** (0.036)	−0.092 ** (0.046)
Corruption	−0.072 (0.168)	−0.099 (0.028) **	−0.117 *** (0.006)	−0.133 ** (0.013)	−0.150 * (0.052)	−0.165 * (0.086)	−0.183 * (0.069)	−0.204 * (0.081)	−0.237 (0.171)
Tax revenue	0.105 (0.182)	0.133 (0.237)	0.118 (0.320)	0.122 (0.267)	0.127 (0.491)	0.131 (0.323)	0.136 (0.451)	0.142 (0.345)	0.151 (0.426)

Table 2. *Cont.*

				Fixed Effects and Bootstrapping					
Variabel	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**
Labor Force Participation	−0.017 (0.856)	0.032 (0.682)	0.063 (0.530)	0.093 (0.242)	0.123 (0.251)	0.149 (0.218)	0.182 (0.131)	0.219 ** (0.032)	0.280 (0.149)
Net foreign direct investment neto	165.69 *** (0.000)	134.834 ** (0.000)	114.787 *** (0.000)	95.865 *** (0.000)	76.757 *** (0.000)	59.774 * (0.051)	38.583 (0.354)	14.974 (0.811)	−23.475 (0.789)

Source: secondary data, processed 2024. Note: probability values enclosed in parenthesis *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 2 shows that public debt in the period studied significantly inhibited economic growth in developing countries from the 30% to 90% quantile. Public debt in the period significantly affected economic growth in all quantiles except the 10% and 20% quantiles. The results of this study confirm that public debt that is not managed properly can actually inhibit economic growth. There are several possible factors that cause public debt to tend to inhibit economic growth at the 30% to 90% quantile in developing countries, including high debt interest burdens, crowding out private investment, macroeconomic instability, dependence on foreign debt, debt management quality, and structural factors.

Developing countries often have to pay higher interest rates than developed countries because of their greater credit risk. High interest rates can reduce budget allocations for productive investments, such as infrastructure and education. Public debt can crowd out private investment. When governments borrow heavily, it can raise interest rates, making borrowing more expensive for the private sector. As a result, private investment can decline, which in turn can hinder economic growth. High public debt can lead to macroeconomic instability, such as inflation and currency devaluation. This instability can create uncertainty for investors, which can reduce investment and economic growth.

Many developing countries rely heavily on external debt, making them vulnerable to exchange rate fluctuations and global economic conditions. When the domestic currency depreciates, the burden of external debt in the domestic currency increases, which can burden the government budget. In the period 2012–2019, several developing countries had high debt-to-GDP ratios, exceeding the safe debt threshold of 60%; for example, Albania had a debt-to-GDP ratio of 71.4%, Barbados 132.5%, Bhutan 92.4%, Cabo Verde 120.2%, Colombia 63.9%, Croatia 87.9%, Egypt 89.5%, and Hungary 93.3%.

In the 30% to 90% quantile, public debt hinders economic growth, possibly also due to poor debt management. Poor debt management, such as a lack of transparency and accountability, can increase the risk of default and financial crisis. A financial crisis can cause severe economic contraction and hinder economic growth. Structural factors, such as corruption, inefficient bureaucracy, and lack of economic diversification, can exacerbate the negative impact of public debt on economic growth.

The findings at the 30% to 90% quantile support previous studies conducted by Reinhart and Rogoff (2010), Checherita-Westphal and Rother (2012), and Caner et al. (2021), which showed a negative and nonlinear relationship between public debt and GDP growth. Increasing government debt creates uncertainty and financial stress in the future (Cochrane, 2011). If endogenous debt exceeds the debt ceiling, the government may need to extend the debt repayment period (Ghosh et al., 2013). Public debt has a long-term negative impact on economic growth, as shown by Eberhardt and Presbitero (2015). Due to limited fiscal space, high levels of government debt hamper the effectiveness of private sector deleveraging and slowed down economic recovery during the global financial crisis (Caner et al., 2021). Economic development is negatively affected by public debt, as shown by Cecchetti et al.

(2011). The findings of Musa et al. (2023) showed that public debt hinders economic growth at all quantiles.

Other factors that affect economic growth in developing countries include trade, inflation, government spending, private debt, corruption, labor force participation, and net foreign direct investment. Trade significantly increases economic growth in developing countries in the 50% to 90% quantile. This means that developing countries in the middle to upper economic groups (50% to 90% quantile) experience significant increases in economic growth due to international trade activities.

Several factors that can explain these findings include infrastructure, production capacity, trade policies, and human resources. Developing countries in the middle to upper economic groups (50% to 90% quantile) usually have better infrastructure and production capacity, so they can take advantage of trade opportunities more effectively. These countries may have more open and investment-friendly trade policies, attracting more foreign trade and investment activities. These countries may also have better human resource capabilities, so they can produce goods and services that are competitive in the international market. Other factors that cause trade to be a driver of economic growth include specialization and efficiency, increased access to markets, technology and knowledge transfer, increased investment, increased competition, increased income, and economic diversification.

On the other hand, in developing countries that have economic growth in the 10% to 40% quantile group, trade does not have a significant effect on economic growth. This is likely due to several factors including the dependence of developing countries in the quantile on certain economic sectors, such as agriculture and labor-intensive sectors, regional disparities, logistics inefficiencies, commodity price volatility, protectionist trade policies by other countries, and high levels of corruption that increase transaction costs and create uncertainty.

The results of the study at the 50% to 90% quantiles strengthen the findings of the research of Wuri et al. (2022) and Wuri (2024), which indicated that trade can drive economic expansion. Hummels et al. (2001) showed how a country's involvement in international production networks correlates with its trade, specialization, and economic growth. Ge et al. (2020) showed that countries that prioritize improving the quality of their exports will experience improvements in their trade balance, current account balance, and economic expansion.

Education expenditure does not have a significant impact on economic growth in developing countries at the 10% to 90% quantile. Education expenditure does not have a significant impact on all quantiles of economic growth distribution, which could be caused by several complex factors, including a low quality of education, a mismatch between education output and labor market needs, problems of disparity in access to education, inequality in education quality, and structural and institutional factors. The low quality of education is triggered by an irrelevant curriculum, an inadequate quality of education, and inadequate educational facilities. The mismatch between education output and the labor market occurs because the education system does not produce graduates with the skills needed by the labor market. A lack of collaboration between educational institutions and the private sector results in minimal absorption of graduates by the private sector.

The problem of disparity in access to education contributes to the failure of education spending to impact economic growth. Marginalized groups, such as women, children from poor families, and rural populations, may face barriers in accessing quality education. This disparity in access leads to inequality in human resource development. In addition, the quality of education may differ significantly between urban and rural areas, and between public and private schools, resulting in graduates who do not have the same competitive qualities. Structural and institutional factors, such as corruption in the education sector

and inefficiency and lack of accountability, contribute to the failure of education spending to impact economic growth in developing countries. For example, in the case of Indonesia, in the 2019 APBN, only IDR 21 trillion or 4.3% of Indonesia's total education budget of IDR 492.5 trillion was allocated to education investment (Ministry of Finance of the Republic of Indonesia, 2020).

Inflation rates significantly hamper economic growth in developing countries ranging from the 50% to 90% quantile. High inflation has a significant negative impact on economic growth in developing countries. There are several factors that cause high inflation to hamper economic growth, including falling prices and investment shocks, declining purchasing power and consumption levels, disruptions in financial markets, distortions in resource allocation, and declining competitiveness. High inflation creates a cloud of uncertainty about future prices. Investors tend to shift funds to inflation-safe assets, such as property or gold, which in turn hampers economic growth.

Inflation causes a decrease in consumption and purchasing power. Inflation causes shocks to financial markets in the form of rising interest rates and exchange rate instability. In addition, high inflation can cause instability in the domestic currency exchange rate. Developing countries are often more dependent on imports of basic necessities and raw materials. Global inflation or depreciation of the domestic currency can cause a spike in import prices, which worsens domestic inflation. This can lead to greater volatility in prices and interest rates. Developing countries are often more vulnerable to external shocks, such as commodity price fluctuations or global financial crises. Inflation can exacerbate the impact of these shocks.

This finding supports the results of the studies by Negro and Sims (2015) in OECD countries and Ramzan et al. (2023) in Pakistan that countries facing severe negative economic shocks require economic policy support to control inflation. This result is consistent with the general assumption that high inflation has a negative impact on economic growth in the long and short term (Jouini, 2014). Therefore, to maintain the inflation rate within a reasonable range, the interaction of monetary and fiscal policies must be carried out simultaneously. In contrast, Darku and Yeboah (2017) found that the inflation rate and income growth are positively correlated in high-income countries.

Government spending has a significant negative impact on economic growth in developing countries in the 20% to 50% and 70% quantiles. Government spending that has a significant negative impact on economic growth in developing countries in the 20% to 50% and 70% quantiles can be caused by several factors. First, inefficiency and corruption in the management of public spending often erode funds that should be used for productive investment. Second, this can be caused by inappropriate allocation of spending, for example, more funds being allocated for consumptive spending than for infrastructure or education investment. Third, high debt burdens force governments to divert funds from investment to debt interest payments, thereby reducing the potential for economic growth. Fourth, political instability and inconsistent policies can create uncertainty for investors, thereby reducing private investment and economic growth. Finally, weak institutional quality and lack of transparency in public financial management can reduce the effectiveness of government spending in driving economic growth.

On the other hand, at the 10%, 60%, 80%, and 90% quantiles, government spending does not have a significant effect on economic growth. This is due to several factors including inefficiency and corruption, inappropriate allocation, limited infrastructure, lack of skilled workers, global economic conditions that are experiencing fluctuating commodity prices, and inappropriate government policies such as inappropriate subsidies and an overallocation for government employee salary costs. For example, in Indonesia in 2019, the total state spending was IDR 2,461.1 trillion, while the funds used to accelerate

infrastructure development through creative financing were only IDR 415 trillion (Ministry of Finance of the Republic of Indonesia, 2020).

Previous period private debt did not affect the economic growth of developing countries in the 20% to 90% quantile. This is due to several factors including the use of funds for consumption or asset speculation, a limited infrastructure and business environment, a lack of access to markets and technology, the quality of financial institutions, and economic and political instability that hamper investment and growth, and increase the risk of debt default.

The findings of the analysis at the 20% to 90% quantiles strengthen the findings of Arcand et al. (2015), who found that the impact of private debt on economic growth changed from positive to negative when the ratio of private debt to GDP reached 100%. Evidence of the negative impact of private debt on economic growth was also presented by Cecchetti et al. (2011). Jordà et al. (2016) provided evidence that at standard deviations above the mean, the interaction of private–public debt causes a decrease in the cumulative real GDP per capita growth of 5% in five years.

Corruption significantly hampers economic growth in developing countries in the 20% to 80% quantile. There are several factors that cause high and massive corruption to have a negative impact on economic growth, including distortion of resource allocation, decreased investment, political and social instability, and weak government institutions. Corruption causes inefficient resource allocation. Public funds that should be used for infrastructure development, education, and health are diverted for personal or group interests. Corruption creates an uncertain and non-transparent investment climate. Corruption triggers public dissatisfaction and political instability. Corruption increases transaction costs in various economic sectors in the form of bribes or extortion, which ultimately increase the price of goods and services. Corruption damages the integrity and effectiveness of government institutions, thereby hampering effective economic policies and creating a conducive business environment.

Corruption inhibits economic growth in the 20% to 80% quantiles, supporting the sand-the-wheel theory, which states that corruption can harm the economy. The results of this study support the findings of Egunjobi (2013), Bardhan (1997), Dridi (2013), Dzhumashev (2014), Ehrlich and Lui (1999), Irina et al. (2019), Mauro (1995, 1998), Meon and Sekkat (2005), Mo (2001), and Shleifer and Vishny (1993) that corruption inhibits economic growth. According to Mauro (1995), corruption inhibits economic growth by reducing investment levels. To eliminate the culture of corruption, the mindset of state officials, corporations, and the people must change.

Tax revenues have no significant impact on economic growth in developing countries between the 10% and 90% quantiles. Several factors can cause tax revenues to have no significant impact on economic growth, including low tax administration capacity, a large informal sector, corruption, political and economic instability, an undiversified economic structure, and ineffective tax policies. Weak administrative capacity, lack of trained personnel, and inadequate technological infrastructure can hinder the effectiveness of tax collection. In addition, the informal sector often dominates the economy of developing countries, reducing the tax revenue base. Corruption reduces tax revenues that should go to the state treasury. Many developing countries rely on certain sectors, which are vulnerable to global price fluctuations. When commodity prices fall, tax revenues from these sectors also decline.

Poorly designed tax policies can hinder economic growth. Tax rates that are too high or regulations that are too complex can burden businesses and individuals. Unfair or non-transparent tax policies can reduce tax compliance and create public dissatisfaction. Data from the World Bank for the period 2021 to 2019 show that the ratio of tax revenue to

GDP in developing countries is only 14.8%. This relatively small tax ratio means that tax revenue is unable to drive economic growth. In addition, tax revenue is also used more for routine activities and government operations than for investment.

The labor force participation rate does not have a significant impact on economic growth in developing countries in the 10% to 70% quantiles and the 90% quantile. This is due to several factors including low labor quality, a dominant informal sector, a lack of decent jobs, a mismatch between skills and labor market needs, structural barriers, and gender inequality. The findings at these quantiles confirm the findings of Caner et al. (2021), who found no significant relationship between the labor force participation rate and economic growth in OECD countries.

Net foreign direct investment significantly increases the economic growth of developing countries in the 10% to 60% quantiles. Net foreign direct investment can significantly increase economic growth in developing countries through several key factors including technology and knowledge transfer, job creation, increased capital investment, increased access to global markets, increased tax revenues, and improved infrastructure.

This finding supports Arbia and Sobhi's (2024) study in North African countries, which found that net foreign direct investment significantly increases economic growth, especially when interacting with transmission channels. Growth-based investment strategies outperform value-based investment strategies, according to a study by Monge et al. (2023). The economic landscape in the region is significantly shaped by foreign direct investment (Abor et al., 2018; Adegboye et al., 2020; Arbia & Sobhi, 2024; Arbia et al., 2023; Asongu & Odhiambo, 2020; Hassan et al., 2011; Makdisi et al., 2002; Banday et al., 2021).

However, net foreign direct investment does not have a significant impact on economic growth in developing countries in the 70% to 90% quantiles. This is due to several factors including investment quality, crowding out effects, the repatriation of profits by investors to their home countries, dependence on certain sectors, weak absorptive capacity due to lack of skilled labor, poor infrastructure, weak institutions, governance issues, and policy mismatches. Therefore, it is important for developing countries to have the right policies to attract quality net foreign direct investment and to ensure that such investment provides maximum benefits to the local economy.

Based on WDI data processed by the authors in 2024, the following combined graph shows the pattern of how government debt and other factors influence economic growth.

Based on Figure 1, it can be seen that the pattern of the effect of trade factors on economic growth is lowest at the 10% quantile and highest at the 30% quantile. Education expenditure has the highest effect pattern at the 10% quantile and the lowest at the 70% quantile. The inflation rate has the lowest estimate at the 10% quantile and the highest estimate at the 90% quantile. Government expenditure has the lowest estimate at the 10% quantile and the highest estimate at the 90% quantile. Private debt has the lowest estimate at the 50% quantile and the highest estimate at the 70% quantile. The pattern of government debt effects has the lowest estimate at the 70% quantile and the highest estimate at the 20% quantile.

Based on Figure 2, it can be seen that the effect of corruption on economic growth has the lowest estimate at the 70% quantile and the highest estimate at the 10% quantile. The pattern of tax revenue effects has the lowest estimate at the 90% quantile and the highest estimate at the 10% quantile. Labor force participation has the lowest estimate at the 30% quantile and the highest estimate at the 50% quantile. The pattern of foreign investment effects has the lowest estimate at the 90% quantile while the highest estimate is at the 10% quantile. The constant effect on economic growth has the lowest estimate at the 10% quantile and the highest estimate at the 90% quantile.
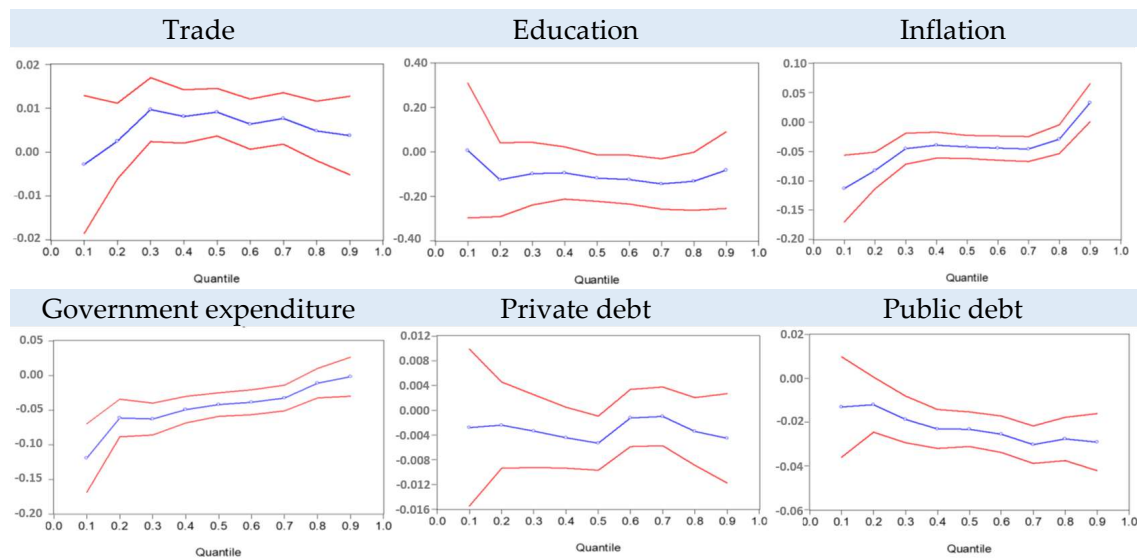
Figure 1. Effect pattern for trade, education, inflation, government expenditure, private debt, and public debt on economic growth. Note: The upper red line chart is the 0.05 upper limit error, the blue line chart is the predicted value, while the lower red line chart is the 0.05 lower limit error.
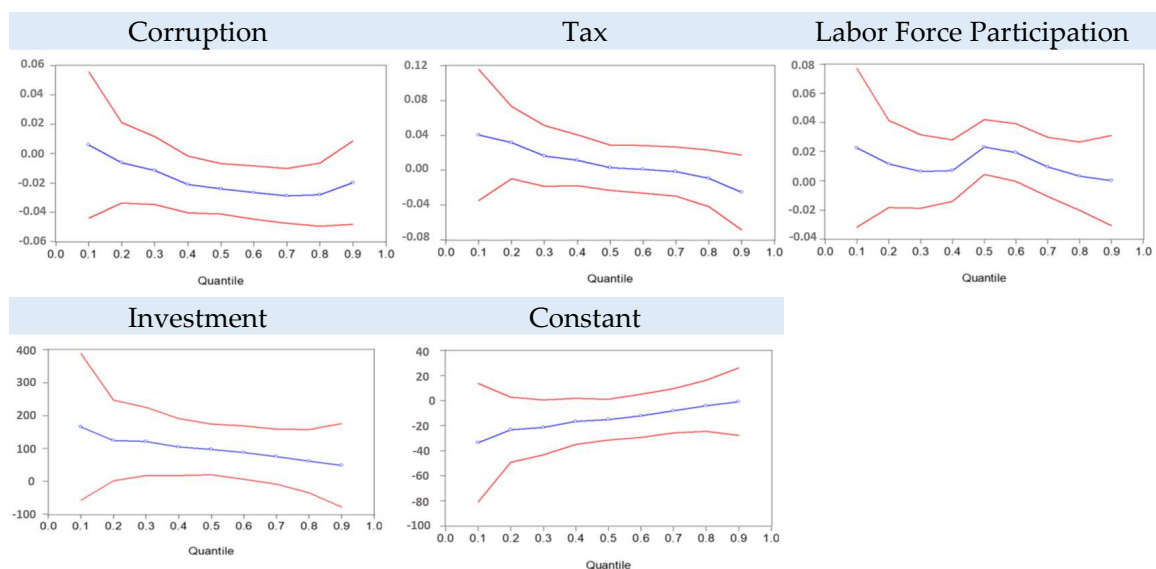
Figure 2. The pattern of effects of corruption, tax, labor force participation, investment, and constant on economic growth. Note: The upper red line chart is the 0.05 upper limit error, the blue line chart is the predicted value, while the lower red line chart is the 0.05 lower limit error.

5. Conclusions

The debate on the effect of public debt on economic growth continues among scholars, with various studies producing mixed conclusions. In an effort to provide a deeper understanding, this study adopted a quantile regression approach with fixed effects and bootstrapping, which allows for a more specific analysis of the impact of public debt on economic growth in developing countries. In addition, this study also included corruption variables to assess the important role of effective governance in driving economic growth. Furthermore, this analysis also included other relevant variables, such as trade, education spending, inflation rate, government spending, private debt, taxes, labor force participation, and net foreign direct investment, to provide a more comprehensive picture of the factors that influence economic growth in developing countries.

This study revealed that the burden of public debt in the previous period significantly hampered economic progress in developing countries, especially in the 30% to 90% quantile range. The negative impact of public debt is not limited to groups of countries with low economic growth, but also applies to most developing countries. The practical implication is that governments in developing countries need to adopt fiscal policies based on the principle of prudence, including limiting unproductive loans and increasing the efficiency of public spending. Transparent, accountable, and sustainable debt management must be a top priority. In addition, developing countries need to reduce dependence on loans as a source of development financing by strengthening tax revenues, attracting private investment, and developing more diverse economic sectors. Strengthening institutions is also very necessary to ensure more focused and responsible debt management.

Trade, the inflation rate, government spending, previous period private debt, corruption, labor force participation, and net foreign direct investment are additional factors that affect the economic growth of developing countries. Meanwhile, education spending and tax revenues do not have a significant effect on the economic growth of developing countries.

The results of this study indicate that trade has a significant impact on driving economic growth in developing countries, especially in the 50% to 90% quantile range. However, interestingly, the impact was not seen in the 10% to 40% quantile range, indicating that the benefits of trade are not evenly distributed across the spectrum of economic growth. Therefore, governments of developing countries in the 50% to 90% quantile range need to design trade policies that are specifically aimed at improving market access, facilitating trade, and promoting exports. In addition, it is important for developing countries to diversify their export markets and products, thereby reducing their dependence on certain markets or products that can be vulnerable to global economic fluctuations.

The finding that education expenditure does not have a significant impact on all spectrums of economic growth in developing countries has important practical implications for policymakers. It suggests that simply increasing education spending is not enough to drive economic growth. Governments need to focus on improving the quality of education, ensuring the relevance of the curriculum to the needs of the labor market, and improving the governance and efficiency of the education system. Investments should be directed towards training quality teachers, providing adequate infrastructure, and developing curricula that are relevant to technological and industrial developments. In addition, governments need to ensure that education is equally accessible to all levels of society, including marginalized groups. Strong coordination between the education sector and industry is also needed to ensure that graduates have the skills needed by the labor market. Thus, education spending can make a more significant contribution to economic growth.

The finding that inflation rates have a significant negative impact on the economic growth spectrum of the 50% to 90% quantile range has very important practical implications for developing countries. Countries in this spectrum, which generally have a medium level of economic development, need to pay special attention to controlling inflation to maintain sustainable economic growth. High inflation can erode people's purchasing power, reduce investment, and create economic uncertainty. Therefore, governments and central banks need to implement appropriate monetary and fiscal policies to maintain price stability. This includes maintaining appropriate interest rates, controlling the money supply, and ensuring fiscal discipline. In addition, it is important to improve the efficiency of the production and distribution sectors so that the supply of goods and services remains stable. Coordination between various government agencies and the private sector is also needed to address structural factors that can trigger inflation, such as supply chain problems and

market imbalances. Thus, effective inflation control will create an economic environment that is more conducive to inclusive and sustainable economic growth.

Government expenditure significantly hampers developing countries' efforts to achieve economic progress, especially in the 20% to 50% quantile range and at the 70% quantile. However, interestingly, the impact was not seen in the 10%, 60%, 80%, and 90% quantiles, indicating differences in economic dynamics in the group of countries with the highest economic growth. The practical implication is that developing country governments need to conduct a comprehensive evaluation of the effectiveness of government spending, identify areas where efficiency can be improved, and allocate resources to programs that have the greatest impact on economic welfare. Government expenditure priorities should be directed to programs that provide long-term benefits to society, such as education, health, and infrastructure, which are essential foundations for sustainable economic growth.

Private debt from the previous period did not have a significant impact on the economic growth spectrum of the 20% to 90% quantile range. Private debt had a significant negative impact only on the 10% quantile. This finding indicates that developing countries in the 20% to 90% quantile range need to take proactive steps to manage private debt prudently. The government needs to strengthen financial sector supervision to identify and manage risks associated with private debt, including careful monitoring of debt levels, loan quality, and the stability of financial institutions. A strong regulatory framework is needed to regulate private lending activities, especially in sectors that are vulnerable to debt accumulation. To ensure that private debt makes a significant positive contribution to economic growth, the government and the private sector need to strengthen the country's economic foundations through infrastructure development, increased investment, and the development of export-oriented processing industries.

Corruption has a significant negative impact on economic growth in developing countries, especially in the 20% to 80% quantile range. The practical implication is that developing countries in the 20% to 80% quantile range need to focus more on efforts to eradicate corruption by strengthening law enforcement institutions, financial supervisory bodies, and audit institutions. In addition, increasing transparency and accountability in public financial management and decision-making processes is also very important to reduce the opportunities for corruption. Concrete steps that can be taken include the publication of budget information openly, the implementation of independent audits, and the involvement of public participation in supervision.

Although the research findings showed that tax revenues do not have a significant influence on economic expansion in developing countries in the 10% to 90% quantile range, this does not mean that the tax system can be ignored. On the contrary, these findings underscore the need to strengthen more effective tax systems to encourage economic growth in all developing countries. The government needs to take proactive steps to increase tax administration capacity, expand the tax base, and eradicate detrimental tax avoidance practices. Additionally, it is important to design pro-growth tax policies, which provide incentives for investment, innovation, and job creation. Transparency and accountability in public financial management are also crucial factors, ensuring that tax revenues are used efficiently and effectively to finance vital development programs in relation to infrastructure, education, and health.

Labor force participation only provides a significant boost to economic growth in developing countries in the 80% quantile. Meanwhile, in countries with lower or higher economic growth rates, labor force participation does not have a significant impact. This finding indicates a complex and nonlinear relationship between labor force participation and economic growth. Therefore, targeted policies are needed to encourage labor force participation in

countries with medium economic growth rates. These policies should include the creation of quality jobs, with decent wages, good working conditions, and career development opportunities. In addition, policies also need to be designed to increase productivity and formalization of the informal sector, which is often the main source of livelihood for people in this group of countries. Investment in education and skills training that is relevant to labor market needs is also very important to ensure that the workforce has the skills needed to contribute to economic growth.

Net foreign direct investment significantly drives economic growth in developing countries in the 10% to 60% quantile range. However, interestingly, the impact is not significant in the 70% to 90% quantile, indicating differences in economic dynamics at various growth levels. This suggests that developing countries in the 10% to 60% quantile range have the potential to experience faster economic growth if they are able to attract more FDI. In this context, a growth-based investment strategy has proven to be more effective than a value-based investment strategy. Therefore, governments of developing countries in the 10% to 60% quantile range need to take proactive steps to attract FDI, including (1) simplifying the licensing process through integrated services; (2) providing attractive and consistent fiscal incentives; (3) building adequate infrastructure by utilizing foreign capital; (4) facilitating industrial waste management; (5) establishing an integrated investment service unit; (6) preparing a clear and targeted investment plan; and (7) carrying out bureaucratic reform to improve the quality of public services.

The complex relationship between public debt and economic growth requires a comprehensive understanding of how other factors affect economic growth in developing countries. The finding that public debt has a significant negative impact on economic growth in the 30% to 90% quantile range in developing countries indicates that public debt management plays a very important role in the sustainability of economic growth in these countries. There are several directions for future research that can be explored, including an analysis of the impact transmission mechanism, the identification of factors that strengthen the impact of public debt, an evaluation of the effectiveness of public debt management policies, the heterogeneous impact of public debt, and the influence of the quality of public debt use. In addition, research using panel data should further focus on addressing the issues of cross-sectional dependence and country heterogeneity through the use of CCE estimation, other panel data regressions, or the application of quantile regression with additional special treatments such as spatial quantile regression, geographically weighted quantile regression, or additional quantile regression using the Driscoll–Kraay standard errors method.

Appendix A

Table A1. List of developing countries in this research.

No.	Continent	Countries
1	Asian	Afghanistan, Armenia, Azerbaijan, Bahrain, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, India, Indonesia, Islamic Republic Iran, Iraq, Kazakhstan, Kuwait, Kyrgyzstan, Laos, Lebanon, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Oman, Pakistan, Papua New Guinea, Philippines, Qatar, Saudi Arabia, Sri Lanka, Tajikistan, Thailand, Timor-Leste, United Arab Emirates, Uzbekistan, Vietnam, Yemen.
2	Africa	Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eswatini (Swaziland), Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Jordan, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Rwanda, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Tunisia, Zambia, Zimbabwe,
3	America	Argentina, Bahamas, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay.
4	Europe	Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Georgia, Hungary, Moldova, Montenegro, North Macedonia, Poland, Romania, Serbia, Turkey, Ukraine.
5	Australia	Fiji, Samoa, Solomon Islands, Tonga, Vanuatu.

Source: author compilation.

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