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Research Article / *Araştırma Makalesi*

EFFECTS OF PRODUCTIVE CAPACITIES ON ECONOMIC GROWTH: EVIDENCE FROM MM-QR

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ABSTRACT

This study examines the long-term impact of physical capital, labor, and productive capacity on economic growth in the BRICS countries from 2000 to 2022. The cointegration relationship was established for this purpose, and the long-term coefficients were derived using the Moment Quantile Regression Method (MM-QR). The results indicate that economic growth is statistically significant and positively influenced by physical capital and labor in all quantiles. Nevertheless, it was noted that the quantile level increased, resulting in a decrease in the positive effect. The Productive Capacity Index, which is the focal point of the investigation, has a generally beneficial impact on economic growth; however, it was not determined to be statistically significant in the lower quantile groups (0.1, 0.2, and 0.3). With the exception of the 0.8 quantile, the PCI's positive impact gains strength as the quantile level increases in the upper quantile groups. This research makes a substantial contribution to the existing body of literature by offering a novel viewpoint on the dynamics of economic growth in the BRICS countries. Examining the implications of productive capacity at the quantile level can be particularly beneficial for policymakers. The findings are valuable due to the fact that the study is one of the first in this discipline.

Keywords: *Productive Capacities Index, Economic Growth, MM-QR, BRICS*

JEL Classification: *D24, O11, C10*

ÜRETKEN KAPASİTENİN EKONOMİK BÜYÜME ÜZERİNE ETKİSİ: MM-QR'DAN KANITLAR

ÖZET

Bu çalışma, 2000-2022 yılları arasında BRICS ülkelerinde fiziki sermaye, işgücü ve üretken kapasitenin ekonomik büyüme üzerindeki uzun vadeli etkisini incelemektedir. Bu amaçla eşbütünleşme ilişkisi kurulmuş ve uzun dönem katsayıları Moment Kantil Regresyon Yöntemi (MM-QR) kullanılarak elde edilmiştir. Sonuçlar, ekonomik büyümenin tüm kantillerde fiziki sermaye ve işgücü tarafından istatistiksel olarak anlamlı ve pozitif olarak etkilendiğini göstermektedir. Bununla birlikte, kantil seviyesi arttıkça pozitif etkinin azaldığı görülmüştür. Araştırmanın odak noktası olan Üretken Kapasite Endeksi'nin ekonomik büyüme üzerinde genel olarak olumlu bir etkiye sahip olduğu; ancak alt kantil gruplarında (0,1, 0,2 ve 0,3) istatistiksel olarak anlamlı olmadığı tespit edilmiştir. PCI'ın olumlu etkisi, 0,8'lik kantil haricinde, üst kantil gruplarında kantil seviyesi arttıkça güç kazanmaktadır. Bu araştırma, BRICS ülkelerindeki ekonomik büyümenin dinamiklerine ilişkin yeni bir bakış açısı sunarak mevcut literatüre önemli bir katkı sağlamaktadır. Üretken kapasitenin kantil düzeyindeki etkilerinin incelenmesi politika yapıcılar için özellikle faydalı olabilir. Bulgular, çalışmanın bu disiplinde ilklerden biri olması nedeniyle değerlidir.

Anahtar Kelimeler: *Üretken kapasite, Ekonomik Büyüme, MM-QR, BRICS*

JEL Sınıflandırması: *D24, O11, C10*

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1. Introduction

Developing countries constitute a significant portion of the global economy. These emerging nations are continuously endeavoring to achieve developed status. Attaining economic growth (EG) is a crucial requirement for a country to be classified as developed. EG serves as the most reliable indicator of an economy's performance (Dayıoğlu & Aydın, 2020; Kartal et al., 2023). EG is the process of improving the economic situation of a country towards a better level (Roedyhantoro & Cahyono, 2018). The determinants of economic growth have been among the most debated and researched topics in every period of the historical development of economics (Esen et al., 2023). There are many growth theories (such as neoclassical, semi-endogenous, endogenous growth and institutional structure theories) in the economic literature. While various growth theories explain economic progress (Göger, 2022), recent studies have increasingly focused on the role of productive capacity (PC) in driving sustainable development.

PC refers to the combination of human, physical and natural resources used in production and services (UNCTAD, 2006). Productive capacity, in general, evaluates a nation's potential for economic development and points out areas where policy changes can assist realize that potential. Economic diversification can result from investments in productive capacities like infrastructure and industrial expansion (Doğan et al., 2019). PC are essential for achieving sustainable development, as they empower nations to generate the required resources to fulfill their own requirements and enhance their quality of life. Hence, it is imperative to enhance PC in order to attain sustainable development and foster economic progress (Yii et al., 2018; Guo & Madni, 2024).

Increasing productive capacities has been the subject of intense discussions at several international conferences. These discussions have focused on how to develop and sustain PC in developing countries. For this, it was emphasized that the analysis should be aimed at identifying where the challenges related to the development of PC for EG and development in developing countries lie and how to address them (Gnangnon, 2021a). According to UNCTAD (2020), there are three primary justifications for the necessity of enhancing PC. Initially, diminutive and undeveloped economies have undergone a substantial decline in employment generation, alleviation of poverty, and enhancement of productivity during challenging economic periods. Furthermore, these economies encounter challenges in fostering industrialization and technological advancement. Furthermore, the sluggish rate of growth in these economies renders them susceptible to foreign economic, political, and social disturbances (Prendı et al., 2022).

Due to its significance, the contemporary development economics literature has prioritized enhancing the productive capacity of economies, particularly in developing nations, as the primary means of achieving sustainable growth, reducing poverty, and creating jobs. As a result, there has been an increasing amount of research focusing on how PC contribute to economic growth, improve the ability of countries to withstand shocks, and decrease economic vulnerability (Gnangnon, 2021a; UNCTAD, 2020; Mandala, 2024). Therefore, studies emphasize the importance of PC in ensuring EG and development.

This study examines the impact of PC on EG in BRICS countries (China, India, Brazil, Russia, and South Africa). Following the main objective, answers to some important questions are sought as follows:

- What is the impact of PC on GDP per capita? Is there a notable disparity in overall outcomes among countries?
- Is there a long-term relationship between productivity and GDP per capita?

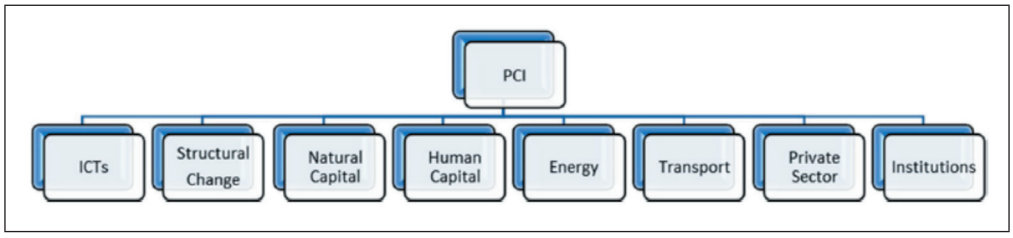
Analyzing the BRICS nations is crucial. Since these nations make up a sizeable portion of the world's population and economy, their social and economic policies may have a big influence on how the world develops. Furthermore, the BRICS nations provide distinct features and obstacles, including elevated inequality rates, reliance on natural resources, and heterogeneous political and cultural frameworks, necessitating tailored policy strategies (Li et al., 2022; Zhang et al., 2022; Li et al., 2023). Previous studies have generally considered the impact of factors such as physical capital, labour force and PC on EG, but detailed analyses of how these effects vary at different quantile levels have been limited. For example, Göger 2022, Guo & Madni 2024, Gnangnon 2021a, 2021b and Prendi et al. 2022 have analysed the general effects of PC on EG. However, it is not detailed how this effect changes according to the quantile levels. In conclusion, by analysing the effects of physical capital, labour force and PC on EG in BRICS countries at the quantile level, our study fills an important gap in the literature and makes significant contributions to the existing knowledge in this field. These findings provide both a new basis for academic research and valuable implications for policy makers.

The structure of the paper is as follows: Section 2 examines the body of current research. Section 3 presents the dataset, methodology, and empirical findings. The report is finally concluded in Section 4, which offers policy recommendations to address the current problem.

2. Productive Capacity-Growth Relationship and Literature

There are eight sub-categories of productive capacities (see Figure 1) (UNCTAD, 2020; Gnangoni, 2021b; Göger, 2022). Within these eight sub-headings, the economies of the 193 countries identified by UNCTAD are scored separately and the averages of the scores are used to create an overall productive capacity index (PCI) (UNCTAD, 2020). The PCI includes all the areas in Figure 1. This index is designed to capture differences in socioeconomic development between countries, mainly determined by gaps in their PC (Le Clech, 2023).

Figure 1: Components of PCI



Source: UNCTADSTAT (2021)

Detailed information on these eight sub-categories in the index is provided in Table 1.

Table 1: PCI Components and Their Descriptions

PCI	***Energy***	Energy is a very important factor in economic growth because many production processes include energy as a basic input
	Human Capital	Human capital refers to the economic values of the experience and ability of employees to contribute to the economy
	ICT's	ICT's (Broadband and mobile telephones,) or information and communication technology, is the infrastructure and components that enable modern computing
	Institutions	Institutions, refer to the effectiveness of government and law enforcement
	Structural change	Structural change (economic complexity and gross fixed capital formation). A movement or modification in the fundamental ways that an economy or market operates is referred to as a structural change in economics.
	Transport	Transport (it is defined as the capillarity of the roads and railways network, and the air connectivity). A good transport system offers economic, social and political advantages such as easy Access to the market, increased investment, mobility of resources from one country to another, etc.
	Private sector	Private sector (domestic credit and cost, and time to import and export)
	Natural capital	Natural capital (agriculture and material intensity). Natural capital includes the reserves of a country with natural assest, such as geology, land, water and all living creatures

Source: UNCTAD

Research on PC and its sub-components shows that it has a very close relationship with EG (Gnangnon, 2021; Freire, 2011; UNCTAD, 2020). It is therefore important to examine how each subcategory of PC affects EG Gnangon (2021b):

- *The effect of physical capital on EG:* In the literature, a great deal of research has been done on how productive resources, like physical capital and resource accumulation, affect economic growth. Higher worker productivity, particularly increases in productivity in the private sector, is what causes this effect to materialize, Gnangon (2021b).
- *The effect of human capital on EG:* Human capital refers to the intangible resources that are inherent in the labor force and enhance its productivity (Teixeira & Queirós, 2016). Human capital refers to the collective value of attributes possessed by the workforce, including knowledge, skills, experience, and motivation, which contribute to the more efficient and effective utilization of other production elements. These qualities contribute to the development, efficient utilization, and widespread acceptance of new technology, thereby serving as a catalyst for economic progress (Manga et al., 2015). Health and education are two cornerstones of human capital. Theoretically, education can improve labor quality and worker productivity, promote the diffusion of new knowledge (Wang & Liu, 2016; Wolff, 2000).
- *The relationship between natural resources and EG:* Research on this topic has been conducted since the 1990s, according to Gnangon (2021b). One of the main conclusions in the literature on economics is that nations with abundant natural resources typically have slower rates of economic growth than nations with limited resources; this is known as the "natural resource curse" or "Dutch diseaseé (Gerelmaa & Kotani, 2016).

- *The impact of institutional quality and entrepreneurial capabilities on EG:* An atmosphere that supports economic activity, creativity, growth, and development is produced by good institutions. Economic stagnation is frequently caused by bad institutions (Butkiewicz & Yanikkaya, 2006). The growth literature has firmly shown that there is a positive relation between superior institutional quality and faster economic growth. Entrepreneurial aptitudes, which are a crucial aspect of productive capacities, can also have an impact on economic growth. UNCTAD (2006) states that entrepreneurial qualities play a crucial role in converting inputs into outputs, making investments, introducing innovations, improving product quality, and even establishing new markets (Gnangon, 2021b; UNCTAD, 2006).
- *The effect of structural change on EG:* Numerous studies have examined how structural change affects economic growth. According to Herrendorf et al. (2014), the so-called structural change can be narrowly understood as the reallocation of economic activity among three main sectors (agricultural, manufacturing, and industry) in terms of the sectoral make-up of the economy. Structural change, in a broader context, encompasses the progress of the financial sector, population dynamics, urbanization, migration, and other related factors (Greenwood & Seshadri, 2005; Gnangon, 2021b).

There are studies on PC in different fields. For instance, PC and environmental degradation (Oluc et al. (2023)), renewable energy (Li et al. (2023)), energy efficiency (Demiral & Demiral (2023)), fiscal space volatility (Gnangnon (2023)).

The present study focuses on the relationship between EG and PC, a topic that has been studied from the inception of the subcategory of PC. Several scholars in the field have emphasized the noteworthy influence of PC on EG, its sustainability, and economic development. Below is a compilation of research undertaken on the issue in various time periods and with different countries or groups of countries, within the given context.

Our classification of the research investigating PC and EG is based on the methodologies employed to establish a certain standard. In research, Shiferaw (2017) used time series analysis to investigate the process of generating PC and the responsibilities of different participants in this process in Ethiopia. This paper presents a comprehensive analysis of Ethiopia's economic expansion and the transformation in the domestic economic framework. Nevertheless, the findings of this study have inherent limitations in terms of their generalizability due to the specific country in which it was carried out. Furthermore, the lack of contemporaneity in the timeframe examined in the study prompts inquiries on the extent to which these results accurately represent current circumstances. Panel data analytical approaches are commonly employed in studies investigating PC and EG. In study, Freire (2011) argued that while developing economies have the ability to enhance their productive capacity, the influence of low-income economies on GDP per capita is constrained. Although this study offers a broad evaluation, it lacks the backing of more current data and methodologies. Gnangnon (2021a) investigated the influence of PC on the level of economic complexity. Although the findings demonstrate a beneficial impact, the technique and the extent of the dataset employed in the study give rise to inquiries on the generalizability of the results to other time periods or diverse countries. In a separate investigation, Gnangnon (2021b) analyzed the impact of production capacity on both EG and expansion variability. While this study presents significant results within the framework of developing nations, it lacks adequate evidence regarding the generalizability of these findings

to countries experiencing significant degrees of structural economic fragility. Göger (2022) examined how industrial capacities impact macroeconomic growth in OECD countries. While the research is grounded on a substantial sample, its conclusions may lack validity for underdeveloped or emerging nations due to its exclusive focus on OECD countries. Furthermore, the study lacks a comprehensive explanation of the causal connection between production capacities and EG, which could undermine the validity of the findings. The study conducted by Prendi et al. (2022) investigated the impact of production capacities on the quality of life in the Balkan countries. The results indicate that there is a positive correlation between production capacity and GDP per capita. Nevertheless, the study's focus on the Balkan countries may restrict the applicability of the findings to other geographical areas. In their study, Guo & Madni (2024) investigated how institutional quality and production capacities moderate the impact on sustainable development in economies participating in the Belt and Road Initiative (BRI). While the results achieved using the two-stage GMM approach demonstrate a robust correlation, the study's exclusive emphasis on BRI countries restricts the applicability of the evidence.

Conclusively, while this literature presents significant results, studies have mostly focused on the impact of variables such as physical capital, labor force, and PC on EG. However, they have not investigated the variations in these impacts at different quantile levels. This scenario is somewhat notable as a major inadequacy given the diverse composition of the countries. Furthermore, given the swift transformations witnessed in the present day, the absence of current data or the restriction of analysis to certain areas in earlier studies could impact the applicability and credibility of the results. The aforementioned factors indicate that the study on the issue is anticipated to contribute to the existing body of knowledge.

3. Data Set, Methodology and Empirical Findings

The impact of physical capital, labor force and PCI on EG is investigated for BRICS countries using panel data methodologies for the period 2000-2022. Significant developments have occurred in the BRICS countries and on a global scale between 2000 and 2022. As a result, there may be more than one regional and global rationale for scrutinizing the period in question. The acceleration of EG is the initial regional justification. The economic development rates of the BRICS countries were exceptional on a global scale during this period. During this period, countries including China, India, Brazil, Russia, and South Africa began to exert a more significant influence on global economic balances. The second category is socio-economic transformations. The BRICS countries underwent substantial changes in labor markets, accelerated urbanization, and demographic changes during this period. EG was substantially affected by these socio-economic variables. The initial global justification pertains to the worldwide economic transformations. During the 2000s, there were significant changes in the areas of global trade, investment flows, and technology transfers. During this period, the BRICS countries implemented substantial reforms and fortified their positions in the global economy. The second is the effect of financial crises. The economic performance and policy responses of BRICS countries are critically examined during the critical time period of the global financial crisis of 2008, the technology peak in the early 2000s, and the subsequent recovery period. In addition to the aforementioned reasons, the period in question is also significant in terms of data consistency and availability. The period 2000-2022 is particularly appropriate for

panel data analyses due to the increased consistency of data and the more reliable measurement of economic indicators during this time. For these reasons, the period 2000-2022 is an opportune and strategic time frame for assessing and comprehending the economic expansion of the BRICS countries.

First, this study presents the information and descriptive statistics of the variables. Then, to test CSD, Breusch-Pagan's (1980) CD lm and Pesaran et al. (2008) LM adj tests were applied. To investigate at the variables' degrees of stationarity, Peseran (2007) developed the Cross-Sectionally Augmented IPS (CIPS) and ADF (CADF) unit root tests. The homogeneity test by Pesaran and Yagamata (2008) was employed to ascertain if slope coefficients varied among units. To ascertain whether there was a cointegration relationship between the variables, Westerlund (2008) devised the Durbin-Hausman (D-H) cointegration test. Finally, the MM-QR model developed by Machado & Silva (2019) was also estimated, providing more comprehensive results. The variables used to examine the effect in question, their explanations and sources are included in Table 2.

Table 2: Description of Data

Variable	Definition (Measurement)	Sources
GDP	Economic Growth (Gdp Per Capita, Constant 2015 US$)	World Bank
CAP	Capital (Gross Fixed Capital Formation, Constant 2015 US$)	World Bank
LABOR	Labor Force, Total	World Bank
PCI	Productive Capacities Index With Averages of Human Capital, Natural Capital, Energy, Transport, Information and Communication Technology, Institutions, Private Sector, and Structural Change Sub-Categories.	UNCTAD

Note: To acquire more resilient outcomes, the variables are converted into their natural logarithmic form.

Table 3: Summary Statistics

	LNGDP	LNCAP	LNLABOR	LNPCI
Mean	3.689575	1.373704	8.148109	5.536617
Median	3.794710	1.322121	7.980929	5.676570
Maximum	4.062967	1.648543	8.893100	5.782862
Minimum	2.878224	1.120038	7.268153	4.617692
Std. Dev.	0.328820	0.155775	0.566450	0.346434
Skewness	-1.134626	0.384460	-0.028118	-1.990551
Kurtosis	2.984397	1.816642	1.637279	5.156118
Jarque-Bera (J-B)	24.67588*	9.542969*	8.913318**	98.21967*
Probability	0.000004	0.008468	0.011601	0.000000
Sum	424.3011	157.9759	937.0326	636.7109
Obs.	115	115	115	115

Note: J-B *, **, and *** represent respectively the rejection of the null of normality at 1%, 5%, and 10% significance levels.

The determination of whether the variables have a normal distribution is based on the examination of the skewness and kurtosis results, which should be near to 0 and 3, respectively. A series is considered to have positive kurtosis when its kurtosis value exceeds 3, whereas a series is considered to have negative kurtosis when its kurtosis value is less than 3. A skewness value of zero suggests a distribution that is perfectly symmetrical. A positive number implies a left skewness in the series, while a negative value shows a right skewness in the series (Cutcu et al., 2024). Table 3 demonstrates significant deviations from the values of 0 and 3. Therefore, as all the variables have values greater than zero, it may be concluded that the distribution is left-skewed. Upon examining the kurtosis values, it is observed that the LNGDP, LNCAP, and LNLABOR variables exhibit a flattened distribution as their values are less than 3. On the other hand, the LNPCI variable displays a tapered distribution as its value exceeds 3. According to the results of the J-B test, the other variables show statistically non-normal distributions at significance levels of 1%, the variable LNLABOR displays a statistically non-normal distribution at significance levels of 5%.

Table 4: Correlation Matrix

	LNGDP	LNCAP	LNLABOR	LNPCI
LNGDP	1.0000			
LNCAP	-0.2899	1.0000		
LNLABOR	-0.5124	0.7474	1.0000	
LNPCI	0.1195	0.0449	-0.0357	1.0000

Source: Authors' estimation.

The calculated correlation coefficients vary between -0.51 and 0.74. In other words, positive and negative correlations were observed between the variables. For example, there is a correlation of -0.282 per cent between LNGDP and LNCAP, a correlation of -0.51 per cent between LNGDP and LNLABOR, and a correlation of 0.11 per cent between LNGDP and LNPCI. Therefore, there is a positive correlation between productive capacity and economic growth, which is the main subject of the study.

A multicollinearity test was conducted to enhance the validity of the regression analysis (Table 5). Regression models can experience issues with multicollinearity. This can lead to a scenario where the independent variables exhibit a strong correlation and the probability values are skewed. The Variance Inflation Factors (VIF) test was employed to assess the existence of multicollinearity. VIF measures how much the variance of an estimated regression coefficient increases due to multicollinearity in the model. By regressing each of the independent variables against the remaining independent variables, the VIF of that variable is calculated using the formula R squared and VIF = 1/1 - R^2. 1/VIF is the inverse of VIF, which expresses multicollinearity, and is used to measure the rate at which other independent variables explain an independent variable (Wooldridge, 2015).

Table 5: Multicollinearity Test (dependent variable: LNGDP)

Variables	VIF	1/VIF
LNCAP	2.29	0.436227
LNLABOR	2.29	0.436550
LNPCI	1.01	0.987119
Mean VIF	1.87	

Source: Authors' estimation

Based on VIF test, multicollinearity is not present, as indicated by the average VIF (1.87) and the individual VIFs of the independent variables. The VIF values for each variable are all below 5. These results indicate that the issue of multicollinearity has been resolved in the model. The subsequent stage involves examining the Cross-Sectional Dependence (CSD) of the variables. The rationale behind this is that the tests employed in panel data analysis can be categorized into two generations. The first generation tests do not consider CSD, while the second generation tests do. First-generation tests operate on the assumption that the error terms of the panel's cross-sections are independent and that a shock occurring in one cross-section does not have an impact on the others. Hence, employing first-generation tests will yield biased outcomes when dealing with CSD. To overcome this limitation, we employ Pesaran's CD test, which examines the presence of cross-sectional reliance. The LM (Breusch & Pagan, 1980) test, LMadj (Pesaran et al., 2008) test, and CDLM (Pesaran, 2004) test were used to analyze CSD. These tests were chosen since the time dimension (T) is greater than the cross-sectional dimension (N). Observations: The null hypothesis, which assumes the absence of cross-sectional dependency, was rejected based on the CDLM test at a significance level of $p<0.05$. This indicates that there is indeed CSD between the series. The results are displayed in Table 6.

Table 6: CSD Result

Test	Statistic	Prob.
LM (Breusch & Pagan, 1980)	28.87	0.016
LM_{adj} (Pesaran et al., 2008)	5.444	0.000
CD_{LM} (Pesaran, 2004)	-.3703	0.711

The second issue in panel data analysis is to ascertain whether the slope coefficients exhibit homogeneity or not, following the examination of cross-section dependency. The strong null hypothesis posits that there is no causal relationship between one variable and another when similar restrictions are applied to the full panel, as stated by Granger (2003). Furthermore, the assumption of parameter homogeneity fails to capture the heterogeneity caused by region-specific traits (Breitung 2005). To investigate the homogeneity of the cointegration coefficients, the delta tilde and corrected delta tilde tests by Pesaran & Yamagata (2008) and Blomquist-Westerlund (2013) were employed.

Table 7: Homogeneity Tests

Test	Pesaran-Yamagata (2008)		Blomquist-Westerlund (2013)	
	Value	Prob.	Value	Prob.
Delta (Δ)	7.087	0.000	4.741	0.000
Delta Adjusted (Δ_{adj})	8.011	0.000	5.359	0.000

Based on the findings showed in Table 7, it was determined that there is a variation in the slopes peculiar to each country among the selected countries. With a significance level of 5%, the null hypothesis was rejected, leading to this conclusion. Once the presence of CSD and heterogeneity has been established using appropriate tests, the stationarity of the series can be assessed using the second generation unit root test. This test effectively accounts for both dependence and heterogeneity, leading to more reliable and consistent results. In order to achieve this aim, we conducted CADF and CIPS panel unit root tests (Pesaran 2007), and the outcomes are showed in Table 8.

Table 8: Panel Unit Root Tests

Variable	CADF		CIPS	
	Z [t-bar]	P-value	Z [t-bar]	CV (5%)
At level (intercept and trend)				
LNGDP	-0.246	0.403	-2.175	-2.33
LNCAP	0.144	0.557	-2.278	-2.33
LNLABOR	-1.106	0.134	-1.794	-2.33
LNPCI	-2.210	0.014	-4.209	-2.33
At first difference (intercept and trend)				
ΔLNGDP	-2.287	0.011	-2.845	-2.33
ΔLNCAP	-3.225	0.001	-3.853	-2.33
ΔLNLABOR	-4.471	0.000	-3.700	-2.33
ΔLNPCI	-5.646	0.000	-5.372	-2.33

The Schwarz information criteria was used to determine the ideal lag length, even though the CADF test suggests that the maximum lag length be two. At the 0.05 significance level, the null hypothesis is considered statistically insignificant. The unit root test findings show that all of the series, with the exception of LNPCI, have unit roots and are not level stationary. However, the variables are stationary when considering their initial difference, denoted as I(1). The CIPS test data provide evidence that all series become stationary after being differenced once.

3.1. Durbin-Hausman Cointegration Test Results

In this paper, the long-term relationship between variables was analyzed while taking CSD into consideration using the D-H cointegration test, as developed by Westerlund (2008). In order to utilize the technique, it is necessary for the dependent variable to exhibit stationarity

at first difference. However, the independent variables can exhibit stationarity either at the level or at first difference, as stated by Westerlund (2008). The D-H cointegration test provides test findings that account for both homogeneity and heterogeneity. The D-H panel group statistic provides results that consider heterogeneity, whereas the D-H panel test statistic provides test results that consider homogeneity. The null hypothesis, denoted as H0, posits that there is no cointegration link among all units. Conversely, the alternative hypothesis, denoted as H_A, suggests that there exists a cointegration relationship among some units. The results of the D-H cointegration test are showed in Table 9. Given that the homogeneity test indicates that the coefficients are not uniform, the statistical results of the D-H Group test are considered in the cointegration test.

Table 9: D-H Cointegration Test Results

Test stats.	Stats. value	Prob. value
D-H Group stats.	9.422	0.000
D-H Panel stats.	4.599	0.000

Table 9 demonstrates that the D-H Group statistic decisively rejects the null hypothesis (H0) at a significance level of 1%, indicating that the variables exhibit a long-term association. Tari (2010) explains that cointegration analysis suggests that although individual variable series may not be stationary, there could exist a combination of these series that is stationary. If such a combination exists, it can be identified. The significance of establishing the long-term correlation between variables is highlighted by the fact that the consequences of measures targeted at enhancing PCwill only become apparent over an extended period of time.

3.2. Moment Quantile Regression Method (MM-QR) Prediction Model

The concept that mean-based estimating approaches may provide inaccurate or misleading outcomes is often referenced (Anwar et al., 2021). It is important to recognize that mean-based estimation methods cannot account for unobserved variability. Conversely, quantile-based models are advantageous for researchers as they can accommodate unobserved variability and varying covariate effects (Canay, 2011). Consequently, this research use the MMQR. Recent years have seen the emergence of the MM-QR method as a novel approach in the field of econometric modeling and data analysis. It was designed with the explicit purpose of addressing some constraints of conventional quantile regression techniques. The primary objective of this approach is to provide more comprehensive and adaptable estimations that consider the impact of independent variables at various quantiles of the dependent variable throughout the whole distribution of the dataset. Panel data analysis employs the MM-QR approach, which incorporates fixed effects[1] by combining time series and CS data. Incorporating the attributes of units (such as countries) that stay consistent throughout time enables the model to capture the effects that vary at quantile levels (Machado and Silva, 2019). Quantile regression extends beyond traditional mean regression and is employed to evaluate the impact of independent variables within a fixed quantile of the dependent variable, such as the median or the

1 According to the results of the Hausman test (chi2= 69.27; Prob = 0.000), the effective model is the fixed effect model.

10% or 90% quantile. This approach, initially devised by Koenker and Bassett (1978), yields more dependable outcomes, particularly in situations when the data exhibit heterogeneity and involve distributions with outliers. The conventional approach to quantile regression assumes a fixed effect structure while measuring the impact of independent variables on various quantiles. Thus, individual estimates are generated for each quantile, disregarding any smooth transition between quantiles (Machado & Silva, 2019).

A panel quantile regression illustrates the correlation between variables across different quantiles (Sarkodie and Strezov, 2019). The method was first proposed by Koenker and Hallock (2001) to assess quantile asymmetries or predict different quantiles of response variables based on specific values of exogenous variables. Particularly, the quantile estimation method is more resistant to the presence of extreme values in the estimate. Moreover, it is the most appropriate method in a scenario when there is no or just a weak connection between the conditional means of the variables (Binder & Coad, 2011). One limitation of simple quantile regression is that it does not provide non-intercepting estimates when the estimators are computed for several percentiles. This results in an incorrect distribution for the response. By creating the MM-QR method, Machado and Silva (2019) presented a novel approach to quantile regression. A smoother and more realistic simulation of the transition between quantiles is made possible by this approach. The MM-QR approach enables the investigation of effects spanning the whole distribution function of the data, while considering the fixed effects employed in panel data study. This methodology demonstrates the variations in the coefficients and intercepts (and) that are particular to the quantiles of the dependent variable across different quantiles. An excellent approach to address the conventional challenges of quantile regression is the MM-QR method. In particular, it provides more efficient techniques for addressing heterogeneity and endogeneity problems and nonlinear models. When data sets are heterogeneous, units such as various countries or time periods may provide distinct responses. The heterogeneity is modeled using MM-QR, which considers the variations in different quantiles of the dependent variable. Simultaneously, it effective addresses endogeneity issues. An endogeneity problem occurs when the independent variables are associated with the error term, leading to potentially misleading estimate findings. In order to tackle this difficulty, the MM-QR approach employs suitable moment conditions. Although conventional quantile regression approaches primarily aim to analyze linear relationships, the MM-QR approach is also suitable for nonlinear models. This facilitates computation in models including several endogenous variables and enhances the quality of the estimations. Given these characteristics, the MM-QR Method offers certain benefits. Primarily, MM-QR offers a smooth and precise transition between quantiles, therefore capturing the complex interactions between them more effectively. Furthermore, this approach is applicable to both linear and nonlinear models. The flexibility of this approach allows for a broad spectrum of applications in econometric modeling. Lastly, it considers the impact of endogenous factors and reduces the influence of outliers. To summarize, the MM-QR approach presents a novel viewpoint in the analysis of quantile regression and offers notable benefits in the study of panel data structures. The method's capacity to handle heterogeneity, endogeneity, and nonlinear structures renders it particularly suitable for intricate data sets and economic analytical tasks (Cutcu, et. al., 2024; Hieu and Mai, 2023; Zhou and Li, 2019). The present paper obtained the 10th percentile as Equation (1) delineates quantile assessments that rely on a specific scale for a certain region.

$$Q_{y_{i,t}Ix_{i,t}} = \alpha_\tau + x'_{i,t}\beta_\tau + \varepsilon_{i,t,\tau} \quad (1)$$

In the equation, $y_{i,t}$ represents the dependent variable, namely LNGDP, and $x_{i,t}$ represents the independent variables vector, namely LNCAP, LNLABOR and LNPCI. τ represents the conditional quantile of interest. α_τ and β_τ are the quantile-specific intercept and coefficient parameters, respectively, and $\varepsilon_{i,t,\tau}$ is the error term. The MM-QR estimation method developed by Machado and Silva (2019) has the advantage of being applied to nonlinear models and can be used especially in models with multiple endogenous variables. It is much simpler in terms of (Cutcu et al., 2024; Hieu & Mai, 2023).

Table 10: MM-QR Estimation Results

	0.10	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**
LNCAP	1.395 (0.001)	1.341 (0.000)	1.277 (0.000)	1.218 (0.000)	1.166 (0.000)	1.134 (0.000)	1.062 (0.000)	1.012 (0.003)	0.9641 (0.017)
LNLABOR	2.488 (0.000)	2.427 (0.000)	2.356 (0.000)	2.289 (0.000)	2.231 (0.000)	2.195 (0.000)	2.118 (0.000)	2.059 (0.000)	2.004 (0.000)
LNPCI	0.0226 (0.644)	0.0306 (0.453)	0.0398 (0.225)	0.0276 (0.080)	0.0561 (0.032)	0.0608 (0.027)	0.0709 (0.027)	0.0306 (0.041)	0.0856 (0.060)

Note: The probability value in parentheses indicates.

Upon examining the results in Table 10, it is evident that the impact of LNCAP on LNGDP is consistently significant and favorable across all quantiles. The data indicates that the observed benefit is more pronounced in countries belonging to the lower quantile groups (0.1 and 0.2). However, as the quantile level increases, the beneficial effect diminishes. This association aligns with what was anticipated. The reason for this is that the accumulation of physical capital is the primary component of production and is thus anticipated to enhance economic growth. In all quantiles, the LNLABOR variable has a significant and positive impact on LNGDP. Empirical evidence shows that the aforementioned benefit is more pronounced in countries belonging to the lower quantile groups (0.1 and 0.2). However, as the quantile level increases, the beneficial effect diminishes. This association aligns with the anticipated outcome. The labor force is considered a fundamental factor of production, similar to physical capital. Consequently, an increase in the labor force is anticipated to result in economic growth. Ultimately, the LNPCI variable is the main focus of the investigation. The anticipated impact of the LNPCI variable on LNGDP is also favorable. The findings corroborate the anticipated outcome. On the other hand, there is no statistically significant variation in the data for the first quantile groups (0.1, 0.2, and 0.3). In countries belonging to the other quantile group, it has been noted that as the level of quantile grows, the positive effect similarly increases, with the exception of the 0.8 quantile.

The findings are generally consistent with the existing literature (such as Göger 2022, Guo & Madni 2024, Gnangnon 2021a, 2021b and Prendi et al. 2022), which strengthens the reliability and validity of the findings. In this context, these studies investigated the general effects of PC on EG, but did not elaborate on how this effect varies by quantile levels. In this respect, the findings are more valuable.

Figure 2. MM-QR panel quantile regression

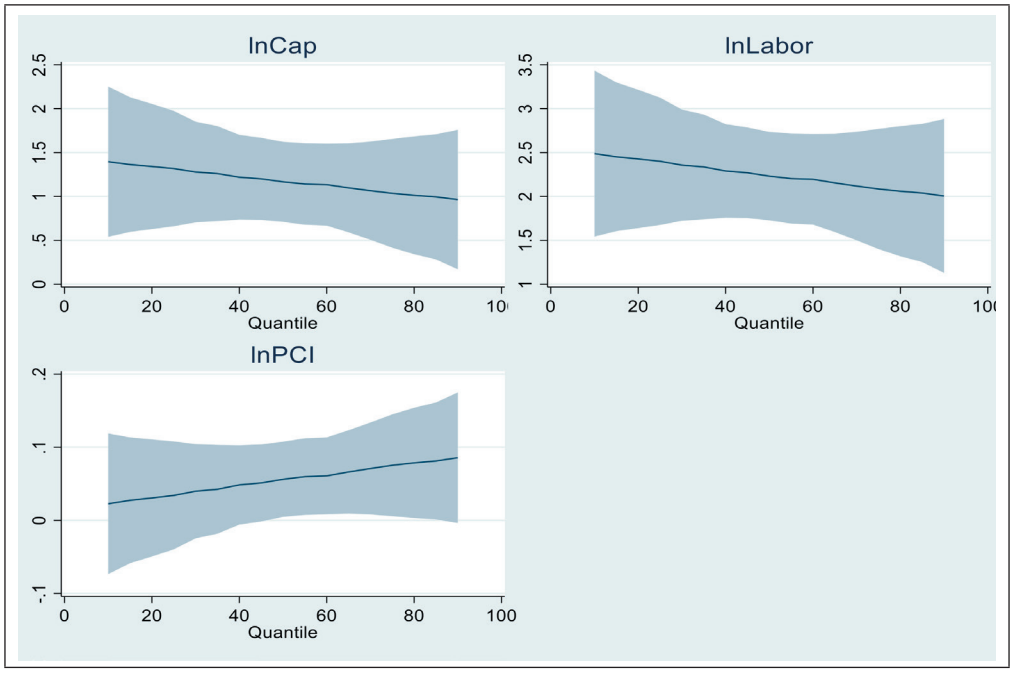


Figure 2 shows the quantile effects of the variables. While the effect of the LNCAP and LNLABOR variables has a decreasing trend from the first quantile to the last quantile, it is seen that the LNPCI variable has an increasing trend.

4. Discussion

The lack of statistical significance of the PCI on EG at lower quantiles (0.1, 0.2, and 0.3) may suggest that this factor is either ineffectively utilized in countries with lower growth rates or is comparatively less impactful than other growth determinants. The positive and statistically significant effect at the upper quantiles (excluding the 0.8 quantile) indicates that PC is more influential in countries exceeding a specific growth threshold. The consistency of the findings with the current literature (e.g., Göger 2022, Guo & Madni 2024, Gnangnon 2021a, 2021b, and Prendi et al. 2022) enhances their dependability and validity. In contrast to prior literature, the study presents novel research avenues to enhance the comprehension of EG dynamics in BRICS nations. This research has examined the overall impact of PC on EG; however, it has not elaborated on how this influence varies across different quantile levels. Your research offers a novel and significant addition to the literature by demonstrating that PC exerts a positive and substantial influence in the upper quantiles, while lacking statistical significance in the lower quantiles. This finding indicates that the significance of PC in the growth process must be assessed not only at a general level but also in relation to the growth rate.

5. Conclusion

This study employed a panel data approach to investigate the impact of PC on economic growth in BRICS nations from 2000 to 2022. The study employed the LM (Breusch & Pagan, 1980) test, LMadj (Pesaran et al., 2008) test, and CDLM (Pesaran, 2004) test to assess the presence of CSD among the variables. A significance level of 1% was used to determine the horizontal cross-sections among all variables included in the model. It was determined that there was cross-sectional interdependence. Two types of second generation unit root tests were used to evaluate the stationarity of the variables: the CADF and CIPS tests. Except for LNPCI, the data showed that all of the variables were stationary at the I(I) level. Based on the delta test results, the slope coefficients exhibit variation among different units. Put simply, it was determined that the factors were diverse. The study utilized the D-H cointegration test to ascertain the impact of PC on economic growth. The results indicated that the variables in the model exhibit a long-term relationship. The outcome of this investigation aligns with the anticipated results and is substantiated by the relevant research and theory. The long-term impact of enhancements in PC will be experienced. This finding further underscores the significance of establishing the enduring correlation between PC and economic growth. Ultimately, once the long-term link between the variables was established, the MM-QR estimation method was employed to analyze the influence of the dependent variable on the independent variables.

The results obtained from the MM-QR estimation approach indicate that the impact of physical capital and labor force on economic growth is statistically significant and positive across all quantiles. However, it is seen that the beneficial impact diminishes as the quantile level rises. The study finds a favorable correlation between the producer capacity variable and economic growth. However, the results are not statistically significant in the first quantile categories (0.1, 0.2, and 0.3). In countries belonging to the higher quantile group, the positive effect becomes more pronounced as the quantile level increases, with the exception of the 0.8 quantile.

Based on the findings, several policy recommendations can be proposed for BRICS nations. Physical capital and labor positively influence EG; however, this effect diminishes as the quantile level rises. This suggests that the marginal returns on investments in physical capital and labor may diminish in nations experiencing strong growth rates. In this setting, these nations should formulate strategies to enhance the marginal productivity of investments in physical capital and labor. For instance, promoting innovation and technology-driven investments in physical capital can be accomplished by enhancing the workforce's proficiency in sophisticated technology and digital skills. Ultimately, whereas the influence of PC on EG is negligible in the lower quantile groups, it exhibits a robust positive effect in the upper quantiles. This circumstance suggests that the lack of a statistically significant influence of PC in the lower quantiles (0.1, 0.2, and 0.3) implies the necessity for more tailored measures to stimulate growth in these countries. Policies to enhance support for small enterprises in the lowest quantiles can disseminate PC throughout the base and expedite EG. The growing influence of PC in the upper quantiles suggests that these nations ought to implement more sophisticated growth plans, including green technologies, sustainable production, and enhanced international commerce and collaboration. Hence, by improving their capacity to generate commodities and services in a manner that is sustainable over time, companies can achieve their economic and social goals while minimizing negative impacts on the environment and promoting a more sustainable future.

Contribution Statement of Researchers

The authors acknowledged their contribution to this study and approved it for publication. The authors' contributions to the article are half and half.

Conflict of Interest Statement

There are no conflicts of interest with any institution or individual within the scope of this study.

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