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Total Factor Productivity in BRICS⁺ Economies: A Panel Data Analysis

إنتاجية عوامل الإنتاج الكلية في دول البريكس⁺
دراسة تحليلية باستخدام بيانات بانل

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Abstract:

This study investigates the key macro-structural drivers of Total Factor Productivity (TFP) in BRICS+ economies from 1990 to 2023 using a dynamic panel GMM approach. Results reveal that trade openness, FDI, and R&D expenditures significantly enhance TFP, while political stability exerts a negative influence. Human capital, innovation, and corruption control show no statistically significant effect, with trade openness identified as the dominant determinant.

Keywords: Total Factor Productivity; BRICS; Generalized Method of Moments (GMM)

المخلص:

تستكشف هذه الدراسة المحددات الهيكلية الكبرى لإنتاجية عوامل الإنتاج الكلية في اقتصادات البريكس+ خلال الفترة من 1990 إلى 2023، وذلك بالاعتماد على منهجية بيانات بانل الديناميكية (GMM). أظهرت النتائج أن الانفتاح التجاري، وتدفقات الاستثمار الأجنبي المباشر، ونفقات البحث والتطوير تساهم جميعها بشكل ملحوظ في رفع إنتاجية عوامل الإنتاج، بينما يؤثر الاستقرار السياسي سلباً عليها. كما لم يظهر كل من رأس المال البشري، والابتكار، والرقابة على الفساد أي أثر معنوي إحصائي، ليرز بذلك دور الانفتاح التجاري كعامل رئيسي في تعزيز الإنتاجية في هذه الاقتصادات.

الكلمات المفتاحية: إنتاجية عوامل الإنتاج الكلية؛ البريكس+؛ منهجية العزوم المعممة (GMM)؛ الانفتاح التجاري؛ الاستثمار الأجنبي

1. INTRODUCTION

Productivity, conventionally delineated as the allocative and technical efficiency with which goods and services are generated, is intrinsically governed by a triadic configuration of macro-structural forces: economic, technological, and political. This investigation probes the principal determinants of productivity within the BRICS+ constellation by disentangling the intricate interdependencies among capital accumulation, technological diffusion, and the politico-institutional architecture.

The strategic salience of total factor productivity (TFP) as a catalyst for sustained economic development is particularly accentuated in the BRICS context. Initially comprising Brazil, Russia, India, and China, the bloc evolved into BRICS with South Africa's accession in 2011. The 15th BRICS Summit¹ heralded a significant enlargement, incorporating Egypt, Iran, the UAE, Indonesia, and Ethiopia into the BRICS+ formation as of 2024.

According to the IMF's 2025 *World Economic Outlook*, BRICS+ economies collectively account for over 41% of global GDP in purchasing power parity (PPP) terms and generate approximately 61% of global growth. India and Ethiopia are projected to lead global growth with respective rates of 6.2% and 6.6%, while China is expected to remain the dominant engine of expansion, contributing an estimated 15% of global output by 2029².

Against this backdrop, identifying the structural underpinnings of TFP growth in BRICS+ economies become imperative—not merely for academic exposition, but also to inform policy formulation in similarly positioned emerging markets. Prevailing theoretical paradigms suggest that macro-level TFP dynamics are primarily shaped by technological advancement, institutional quality, human capital intensity, FDI inflows, and trade openness.

This study unfolds across three

analytically distinct sections. The first offers a critical literature synthesis of theoretical and empirical contributions. The second delineates the empirical specification, encompassing model structure, variable operationalization, and diagnostic testing. The final section is devoted to interpretative analysis and discussion of the estimation results.

2. DETERMINANTS OF TOTAL FACTOR PRODUCTIVITY IN BRICS+ COUNTRIES: A LITERATURE REVIEW

While extensive literature exists on TFP determinants, few studies focus explicitly on BRICS economies. Most highlight investment appeal³ and trade liberalization⁴. Young-Hee Kang et al. (2018), using World Bank data on 8,885 firms, found external audits boost productivity, while informal competition harms it⁵. Corruption showed mixed effects—positive in India and Russia, negative in Brazil. These results underscore institutional complexity in shaping firm-level outcomes within BRICS⁶.

A broader investigation by Rehman and Islam (2023)⁷ employs a CS-ARDL framework to explore the interplay between financial infrastructure development and TFP, alongside FDI flows, trade openness, innovation, human capital accumulation, and institutional quality across BRICS countries over the 1990–2019 period. The results underscore a robust, dual-horizon (short- and long-term) positive impact of financial infrastructure on TFP, further highlighting the catalytic role of outward FDI, trade integration, innovation capability, and human capital as complementary drivers of productivity dynamics⁸.

Given the limited volume of BRICS-specific literature on TFP, this review incorporates cross-national and country-level studies to extract generalizable insights regarding its core determinants. Technological progress and innovation are widely recognized as foundational engines of TFP growth, with process innovations often yielding transformative gains in

production efficiency. China's large-scale adoption of robotics in manufacturing epitomizes this dynamic⁹. Indicators commonly employed to proxy innovation—R&D expenditure, patent counts, and inbound FDI—are central to such analyses. Empirical work by Benhabib, Perla, and Tonetti (2021)¹⁰ and Wang and Dass (2017)¹¹ confirms that R&D investment exerts a direct and statistically significant influence on TFP. Crass and Peters (2014), utilizing German firm-level panel data, demonstrate a positive relationship between intangible capital and productivity. However, Ahn (2001) posits that actual assimilation of frontier technologies, rather than R&D expenditure per se, constitutes the more proximate driver of productivity gains¹².

Foreign direct investment, serving as a conduit for technological spillovers and knowledge transfer, positively affects TFP, particularly in economies lacking indigenous innovation capacity. Griffith, Redding, and Simpson (2003) propose two key transmission mechanisms: direct technology infusion and heightened domestic market competition, which incentivizes technological upgrading¹³. Supporting studies include Crespo and Fontoura (2007), Girma and Wakelin (2007), and Zhou et al. (2002), who show—using a dataset of 450,000 Chinese firms—that FDI's productivity impact is context-contingent: firms in high-FDI regions exhibit elevated productivity, while those in high-FDI sectors may experience diminished returns due to competitive displacement¹⁴.

Beyond innovation and FDI, multiple macroeconomic variables emerge as pivotal determinants of TFP: trade openness, infrastructure development, institutional quality, and human capital¹⁵. Trade liberalization enhances TFP through diverse channels, measurable via indices such as the Balassa index, Squalli and Wilson's composite trade openness index (2011), Anderson and Neary's trade restrictiveness index (1994), and the conventional trade-to-GDP ratio¹⁶.

Oliveira de Almeida et al. (2024) employ a VECM model to assess the long- and short-run effects of trade openness on Brazilian TFP, finding that a one-point increase in trade openness correlates with a 26.28% long-term and 9.17% short-term rise in TFP¹⁷. Yu et al. (2013), analyzing disaggregated Chinese trade data with an augmented Olley-Pakes approach¹⁸, find that trade liberalization disproportionately boosts productivity among producers of complex, differentiated goods¹⁹, while negatively affecting producers of standardized goods. For the BRICS context, Iftikhar et al. (2025) adopt a GMM approach to demonstrate that trade openness exerts a significant and positive effect on TFP, amplified by innovation, which serves as a moderating variable. Tariff reduction facilitates resource reallocation and market access, reinforcing productivity gains²⁰.

In addition to economic variables, political and institutional determinants profoundly shape TFP outcomes by modulating the broader regulatory and governance environment. Transparency-enhancing institutional frameworks tend to foster more efficient business ecosystems²¹. Theoretical and empirical evidence links corruption to diminished institutional quality, allocative inefficiency, and competitive distortions. BRICS+ countries grapple with entrenched corruption, impeding their economic potential²². Demir et al. (2022) introduce a corruption index based on local investigations and show that a one standard deviation increase in corruption reduces firm-level TFP by 3.8%. Similarly, Kouramouda (2017) finds that corruption, especially when coupled with high tax burdens, exacerbates productivity losses²³.

Political stability, often presumed to be growth-enhancing, may yield paradoxical effects in certain BRICS+ contexts. In Brazil, periods of political unrest have deterred investment and undermined productivity. Conversely, persistent but rigid stability—e.g., in Russia—has been associated with institutional inertia and the

entrenchment of unproductive state-owned enterprises. Human capital, too, plays a central role in enhancing innovation capacity and technological absorption²⁴. Männasoo et al. (2018) and Yigiteli&Ozturk (2022), analyzing OECD countries, construct composite indices—economic stability, innovation, technological diffusion, education, and economic freedom—and find that the technology diffusion index is the most potent predictor of TFP, while economic stability and liberalization exhibit comparatively modest effects²⁵.

Infrastructure development—both logistical and financial—is also a nontrivial determinant of TFP. In India, government-led upgrades in transport and urban infrastructure have significantly lowered transaction costs, enhancing aggregate productivity²⁶. In South Africa, Akanbi et al. (2017) empirically establish a positive linkage between institutional quality and TFP via enhanced investment, technological dynamism, and improved economic performance²⁷.

4. RESULTS AND DISCUSSION

This study investigates the macroeconomic drivers of Total Factor Productivity (TFP) in BRICS+ economies using a dynamic panel model. Due to the endogenous nature of variables like trade openness, FDI, R&D, and governance, the Generalized Method of Moments (GMM) is applied. GMM handles autocorrelation, endogeneity, and country-specific effects effectively²⁸. The panel includes 8 countries over 28 years, making System GMM—combining differenced and level equations—the most suitable method²⁹.

4.1. Model Variables:

The selection of explanatory variables is informed by both the theoretical underpinnings established in the literature and data availability. The empirical sample includes Brazil, Russia, India, China, South Africa, Indonesia, Iran, and Egypt, covering the period 1996–2023³⁰.

The dynamic panel model is specified as follows:

$$PTF = f(OC, IDE, CH, BI, DRD, SP, CC)$$

$$PTF = \alpha_1 OC + \alpha_2 IDE + \alpha_3 CH + \alpha_4 BI + \alpha_5 DRD + \alpha_6 SP + \alpha_7 CC$$

TFP: Total Factor Productivity, derived from World Bank data for the period 1996–2018. Values for 2019–2023 were extrapolated by the authors following the World Bank's methodology, based on a Solow-type growth decomposition using log-differences³¹.

Aggregate Cobb-Douglas production function:

$$Y = A K^\alpha L^{1-\alpha}$$

where:

Y: Real GDP

K: Physical capital

L: Labor input

A: Total factor productivity

α : Capital share in output

TFP growth in log-difference form is computed as:

$$\Delta \ln A = \Delta \ln Y - \alpha \Delta \ln K - (1 - \alpha) \Delta \ln L$$

OC: Trade openness index, proxied by the average of exports and imports as a share of GDP.

IDE: Foreign Direct Investment inflows.

CH: Human capital, measured as the average years of schooling for individuals aged 15 and older, sourced from Barro and Lee (2023).

BI: Innovation proxy, captured by the number of patent registrations.

DRD: Gross domestic R&D expenditures.

SP: Political stability index.

CC: Corruption control index.

Institutional indicators (SP and CC) are extracted from the World Bank Governance Indicators (2025 edition).

4.2. Model Diagnostics:

The empirical analysis begins by rigorously verifying the time-series properties of the panel dataset. Establishing the stationarity of variables is essential for any dynamic panel approach, as the presence of unit roots may lead to spurious regression results unless cointegration exists. Table (1) presents the results of a comprehensive suite of first-generation panel unit root tests, namely Levin, Lin & Chu (LLC), Im, Pesaran & Shin (IPS), ADF-Fisher, PP-Fisher, and the Hadri Z-statistic.

According to the findings in Table (1), only Total Factor Productivity (TFP) and Political Stability (SP) display level stationarity across the BRICS+ sample. The remaining variables (OC, IDE, CH, BI, DRD, CC) are non-stationary at level, indicating the necessity of first-differencing before further analysis. This outcome highlights the need to investigate possible cointegrating relationships among these non-stationary variables.

Table (1): Unit Root Test at Level

	LLC	IPS	ADF-F	PP-F	Hadri Z-stat
PTF	-9.92**	-9.29**	105.7**	102.0**	2.199*
OC	-1.428	-1.155	19.3772	15.72	4.244**
IDE	0.221	-0.723	15.1832	22.706	1.03261
CH	-1.916*	-0.334	11.5715	23.32	0.823**
BI	6.593	3.758	14.758	11.74	9.667**
DRD	1.11612	1.59733	10.7589	9.782	8.369**
SP	-3.1**	-2.23**	32.23**	20.814	7.504**
CC	-1.527	-1.138	24.2276	16.9128	9.122**

Source: Prepared by the researcher based on outputs generated using EViews 12.

To address the non-stationarity observed in most variables, Table (2) summarizes the results of unit root tests after applying first differences. All variables that were non-stationary at level become stationary at first difference, confirming their integration of order one, $I(1)$, as shown in Table (2). This outcome provides statistical justification for proceeding to cointegration testing, as the necessary precondition of $I(1)$ variables is satisfied.

Table (2): Unit Root Test at First Difference

	LLC	IPS	ADF-F	PP-F	Hadri Z-stat
OC	-14.18**	-12.71**	141.53**	139.81**	0.08075
IDE	-12.90**	-15.16**	148.99**	154.31**	1.38827
CH	-5.205**	-4.26**	43.76**	98.559**	1.08533
BI	-3.788**	-6.984**	80.96**	111.77**	3.8891**
DRD	-9.114**	-7.525**	79.83**	80.082**	1.20677
CC	-6.827**	-7.255**	79.50**	105.95**	-0.65166

Source: Prepared by the researcher based on outputs generated using EViews 12.

The subsequent step involves assessing the existence of long-run equilibrium relationships among the panel variables through the Pedroni (1999) cointegration test³², the results of which are detailed in Table (3). The test statistics in Table (3) consistently fail to reject the null hypothesis of no cointegration at

conventional significance levels. Thus, the analysis finds no evidence of a stable long-term relationship linking the macroeconomic variables in the context of BRICS+ economies. This finding shapes the subsequent modeling strategy by ruling out error correction representations and focusing on short- and medium-term dynamics.

Table (3): Pedroni Cointegration Test

Statistic	Value	Prob.
Panel v-Statistic	-0.3319	0.6300
Panel rho-Statistic	1.6221	0.9476
Panel PP-Statistic	-0.1445	0.4425
Panel ADF-Statistic	0.2343	0.5926
Group rho-Statistic	2.5975	0.9953
Group PP-Statistic	-0.4681	0.3199
Group ADF-Statistic	0.8225	0.7946

Source: Prepared by the researcher based on outputs generated using EViews 12.

Building upon the stationarity and cointegration diagnostics, the dynamic panel model is estimated using the System GMM approach to account for potential endogeneity and dynamic effects. Table (4) reports the estimation results, including coefficient estimates, t-statistics, and p-values for each explanatory variable. As presented in Table (4), trade openness (OC), foreign direct investment (IDE), and research & development expenditure (DRD) all exert significant positive impacts on TFP in the BRICS+ context, suggesting their pivotal role in productivity enhancement. By contrast, political stability (SP) demonstrates a statistically significant negative effect on TFP, a counterintuitive result that may reflect unique institutional or transitional features within the BRICS+ group³³. Variables such as patent registrations (BI), human capital (CH), and corruption control (CC) do not exhibit statistically significant effects on productivity, as indicated by their coefficients and associated p-values in Table (4).

Table (4): GMM Dynamic Panel Estimation

Variable	Coefficient	t-Stat	P-value
OC	4.1629	1.8885	0.0412**
IDE	1.4916	-2.7670	0.0065*
DRD	1.7150	1.7899	0.0481**
BI	5.1253	0.6303	0.5038
CH	-0.2404	-1.3185	0.1897

SP	-1.1078	-1.9824	0.0401**
CC	-0.02959	-0.3438	0.7315
Constante	-0.9973	-0.8826	0.3791

Source: Prepared by the researcher based on outputs generated using EViews 12.

4.3. Discussion of Results

The estimation results reveal that trade openness exerts a positive and statistically significant influence on Total Factor Productivity (TFP) across BRICS+ economies, corroborating prior empirical findings³⁴. Given that the coefficient associated with trade openness (OC) is the largest among all regressors, the analysis confirms its primacy as the most influential determinant of TFP³⁵. The underlying mechanism reflects the productivity-enhancing effects of market integration, including access to economies of scale, cost minimization, and broader market outreach³⁶.

Foreign direct investment (FDI) significantly boosts TFP by introducing advanced technologies, efficient practices, and management expertise. It also creates positive spillovers through demonstration effects that benefit local firms³⁷. Likewise, R&D expenditures—used as a proxy for innovation—show a strong positive effect on TFP, highlighting their structural role³⁸.

Conversely, the effect of human capital on TFP is statistically insignificant. Although human capital is theoretically central to productivity growth, its empirical impact may be mitigated when the workforce's skill composition is misaligned with the specific demands of productive sectors³⁹. The divergence from existing studies—such as Rehman and Islam (2023)—can be attributed to differences in variable specification⁴⁰: while prior research used secondary school enrollment rates, this study adopts the average years of schooling for individuals aged 15 and older⁴¹, potentially capturing different dimensions of educational quality and applicability. Patent counts, often employed as a proxy for innovation output, do not exhibit a significant effect on TFP in the BRICS+ context. High patenting activity does not inherently translate into widespread

technological adoption or productive application at scale, especially in institutional environments where innovation absorption remains weak⁴².

Corruption control shows no statistically significant impact on TFP, suggesting its effects are diluted by broader structural rigidities. In BRICS+ economies, institutional reforms may be undermined by inefficient regulation and entrenched monopolies. Russia exemplifies this, where anti-corruption efforts are offset by systemic governance failures⁴³.

Unexpectedly, political stability shows a significant but negative impact on TFP, suggesting that in some BRICS+ countries, it reflects institutional inertia rather than reform. In Russia, long-term stability has preserved inefficient, state-led sectors⁴⁴. Likewise, in South Africa, stability has coincided with stalled reforms, especially in infrastructure⁴⁵. By contrast, transitional instability in India and Brazil has sometimes enabled liberalization and structural changes⁴⁶. Thus, in BRICS+, stability may hinder productivity when tied to rigid institutions and economic stagnation.

5. CONCLUSION

This study aligns methodologically and conceptually with the prevailing body of literature, adopting a theoretically grounded and empirically robust framework to investigate the structural determinants of Total Factor Productivity (TFP) within BRICS+ economies. The findings underscore the multifactorial and interdependent nature of TFP dynamics, shaped by economic, technological, and institutional dimensions. While factors such as technological innovation, human capital, and anti-corruption measures are frequently posited as pivotal, our results indicate that these variables do not exert statistically significant effects on TFP within the BRICS+ context. It must be acknowledged, however, that corruption control remains a vital precondition for institutional efficacy, though its productivity-enhancing impact may be obscured in the presence of deeper structural rigidities. Trade openness emerges

unequivocally as the most potent driver of TFP growth across the examined economies. Additional macroeconomic variables—namely, outward FDI, political stability, and R\&D expenditures—also exhibit relevance, albeit with heterogenous impacts reflecting cross-country disparities in economic structure and development trajectories⁴⁷.

Despite the robustness of the findings, this study is not without limitations. The exclusion of countries such as Ethiopia and the United Arab Emirates, due to data unavailability, may constrain the generalizability of the results. Nonetheless, the analysis offers valuable empirical insights into the predominant levers of productivity growth in emerging markets. Future research avenues may incorporate alternative explanatory dimensions, including the sophistication of financial institutions, macroeconomic stability, and the fiscal policy environment.

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