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DIGITALIZATION AND ECONOMIC PERFORMANCE OF TWO FAST-GROWING ASIAN ECONOMIES: INDIA AND THE PEOPLE'S REPUBLIC OF CHINA

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Abstract

This paper aims to identify the role of digitalization and infrastructure in two fast-growing Asian economies, namely India and the People's Republic of China (PRC), within the growth framework from1990 to 2019 by using panel 2SLS and the NARDL technique. The results show that internet and mobile density (a proxy for telecommunication infrastructure/ digitization), expected years of schooling (a proxy for human capital), foreign direct investment inflow, gross capital formation, per capita electricity power consumption (a proxy for electricity infrastructure), research and development expenditure, and the consumer price index have a positive impact on the per capita GDP of India and the PRC. Further, the study reveals that the PRC extracts relatively more from these growth-promoting factors than India, probably indicating greater allocative efficiency. The results imply the need to enhance the digitization movement in both economies and transform the population into human resources so that the higher research and development expenditure can exert the greatest possible positive effect on economic performance.

Keywords: digitalization, infrastructure, economic growth, panel data

JEL Classifications:H54, O47, C33

Contents

1. INTRODUCTION

The literature has documented well the role of infrastructure in the growth process of any economy as it helps in production diversification, trade expansion, coping with the pressure of demographic and environmental challenges, and ultimately improving the quality of human life. Infrastructure is "an umbrella term for many activities referred to as Social Overhead Capital (SOC) by the development economists" (World Bank 1994). In addition to its role as an engine of growth, infrastructure also helps to maintain the growth of an economy. However, the macroeconomic policies of an economy determine the course of its infrastructure development and ultimate growth trajectory. Economies like the People's Republic of China (PRC) have been experiencing rapid growth, and India, with its moderate economic growth during the last couple of decades, needs not only to maintain the policy task at hand but also to work towards accelerating its growth further. The PRC, the most populous country, and India, the second-most populous country, are the two economic giants in Asia that have transitioned from a centrally planned socialistic economy to a market-led open economy. The PRC started economic reforms before India and registered high economic growth. India followed the PRC and opted for economic liberalization as a result of the economic crisis. The economic advancement of both countries will create a new milestone in the 21st century. Though the lack of adequate infrastructure seems to be exerting an adverse effect on the economic growth of India, there is a visible gap between the potential demand for infrastructure and the actual level of infrastructure in the country (Rastogi 2006). Both economies require adequate infrastructure to achieve sustainable economic growth since the lack of adequate infrastructure facilities creates an obstacle to their achievement of higher economic growth.

Against this backdrop, the present paper aims to analyze the role of infrastructure in the economic performance of two fast-growing countries, specifically India and the PRC, and the policy concerns that it engenders using annual data from 1990 onward, which the authors collected from the World Development Indicators (WDI) (World Bank2020). The rest of the paper proceeds as follows: section 2 reviews the relevant literature; section 3 deals with the theoretical framework for the impact of selected independent variables on the dependent variable, the per capita gross domestic product (GDP); section 4 discusses the data sources; section 5 analyzes the stylized facts of the macroeconomic situation of both the economies in comparison with other economies; section 6 presents the results and findings; andsection7 concludes the paper with policy implications.

2. REVIEW OF THE LITERATURE

Though the indicators of infrastructure are different, several studies have identified the positive contribution of infrastructure to economic growth across the globe (Munnell 1990; Devarajan, Swaroop, and Zou 1996; Roller and Waverman 2001; Wang 2002; Canning and Pedroni 2004; Zhang and Fan 2004; Chakraborty and Guha 2009; Sahoo and Dash 2009; Sahoo 2012; Sahoo, Dash, and Nataraj 2012; Szymańska and Biegańska 2012; Batuo 2015; Mohanty and Bhanumurthy 2019). These studies have reinforced the importance of infrastructure across different regions over different periods with variations in the magnitude of their impact on various growth dynamics.

Sahoo and Dash (2009) found that infrastructure plays an important role in the economic growth of India. This study found unidirectional causality from infrastructure development and economic growth in India. Similarly, Sahoo, Dash, and Nataraj (2012) explained that the encouraging growth story of the PRC over the last two decades owes its origin to the physical and social infrastructure in the country. According to Elhance and Lakshmanan (1988), the infrastructure (both physical and social) investment in India is the main factor in the reduction of production costs in manufacturing. The state-level analysis that Ravallion and Datt (1999) conducted proved that the Indian states that have experienced significant growth have better infrastructure. Sahoo and Saxena (1999) also concluded that electricity, transport, the water and gas supply, and communication facilities have significant positive effects on economic growth. According to Ghosh and De (2000), the different endowments of physical infrastructure are responsible for the regional disparity in South Asian countries. Sahoo (2006) also concluded that infrastructure is an important determinant of FDI inflow in South Asian countries.

In addition to this physical infrastructure, studies have identified the positive and significant contribution of other infrastructure to the growth performance of economies (see e.g. Levine 1999; Cooray 2009; Estrada, Park, and Ramayandi 2010; Bist 2018; Mohanty and Bhanumurthy 2019 on financial infrastructure and growth; Sridhar and Sridhar 2007; Veeramacheneni, Vogel, and Ekanayake 2008; Sahoo 2012; Chu 2013; Erumban and Das 2016; Hodrab, Maitah, and Smutka 2016; Pradhan et al. 2016; Sajjad 2016; Maurseth 2018; Haftu 2019 on information and communication technology, that is, ICT infrastructure and growth; Beenstock and Willcocks 1981; Samouilidis and Mitropoulos 1984; Yu and Choi 1985; Erol and Eden 1987; Asafu-Adjaye 2000; Stern 2000; Yang 2000; Ghosh 2002; Gylfason 2002; Gylfason and Zoega 2006; Kasperowicz 2014a; Sahoo, Sahoo, and Sahu 2014a; Sahoo and Sahu 2014; Sahoo et al. 2014b; Sahoo, Sahu, and Sahoo 2015; Sandonato and Willebald 2018; Iddrisu 2019 on natural infrastructure/capital, that is, energy use and mineral resources and growth; Mincer 1981; Romer 1983, 1986, 1987, 1993; Lucas Jr. 1989; Fernandez and Mauro 2000; Pelinescu 2015; Dinda 2016; Altiner and Toktas 2017; Ali, Egbetokun, and Memon 2018 on human capital and growth; Helliwell and Putnam 1995; Rupasingha, Goetz, and Freshwater 2000; Hjerppe 2003; Chakrabarty 2013; Dinda, 2016 on social capital and growth; and Stoneman 1975; Sahoo, Mathiyazhagan, and Parida 2002; Sahoo and Mathiyazhagan 2003; Prasad, Rajan, and Subramanian 2007; Leitão and Rasekhi 2013; Mowlaei 2018 on foreign capital and growth).

Biswas and Saha (2014) found that exports, gross domestic capital formation, employment, the money supply, and FDI positively affect the GDP growth of India. Marelli and Signorelli (2011) conducted a study on both India and the PRC that found that foreign direct investments and trade openness have positive impacts on the economic growth of both the economies. According to Bloom et al. (2006), the growth in India and the PRC was due to a rise in life expectancy, increased trade openness, and an expansion of the share of the working population.

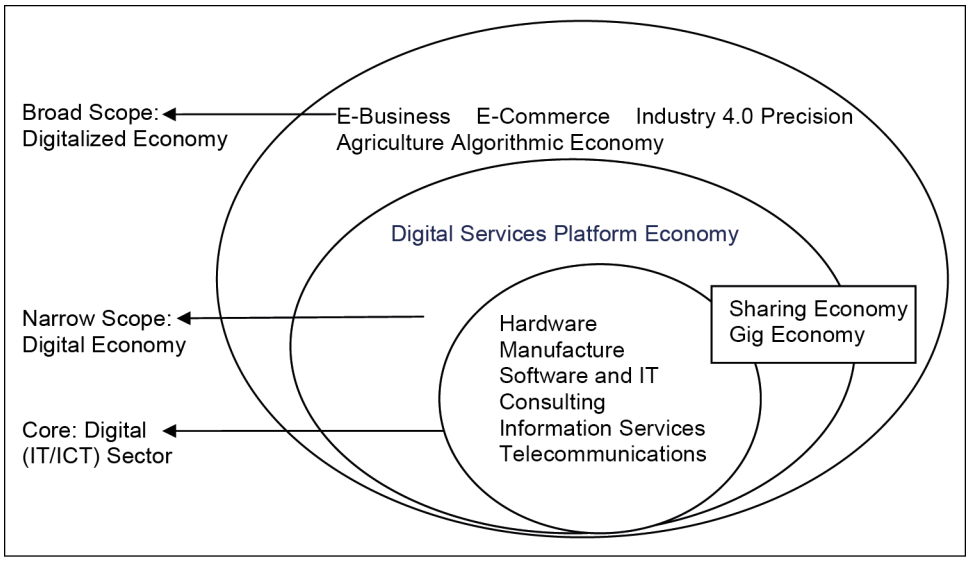
Most researchers have found a positive effect of information and communication technology (ICT) on economic growth (Joseph2002 on India; Hodrab, Maitah, and Smutka 2016 on Arab countries). Joseph (2002) established the positive contribution of ICT to the Indian economy. Heshmati and Yang's (2006) study inferred that the PRC has reaped huge benefits from ICT development. Torero, Chowdhury, and Bedi (2002) concluded that there is a positive causal link from telecommunications to the GDP. Sridhar and Sridhar (2007) assessed the effects of ICT on the economic growth of developing economies and found that ICT is an effective enabler of economic development. Veeramacheneni, Vogel, and Ekanayake (2008) noted that ICT has a positive influence on the economic growth of India. Erumban and Das's (2016) study concluded that ICT plays a significant role in driving the aggregate economic growth in India. Ghosh (2002) stated that, in India, Granger causality runs from economic growth to electricity consumption without any feedback effect.

However, the precise relationship between infrastructure development and economic growth in India is not yet clear. The objectives of this study are to analyze the economic growth process and the impact of infrastructure on the economic growth of India and the PRC. The above survey of the literature has highlighted the role of infrastructure in ushering in economic growth across different parts of the world through the creation, preservation, maintenance, and exploitation of different kinds of means of production, that is, capital, and they fall broadly into the physical, financial, foreign, human, social, and natural capital categories. The literature has identified the key infrastructure variables for all these forms of capital as mobile density (MD), internet density (ID), fixed telephone density (FTD), ICT service exports(ICTSE), per capita electricity power consumption (PEC), research and development expenditure (R&D), general government final consumption expenditure (formerly general government consumption, GCE), gross capital formation (GCF), expected years of schooling (EYS), exports (EX), and foreign direct investment (FDI) inflows. With these identified variables, the following section develops an analytical framework to explain the growth dynamics of India and subsequently the PRC.

3. CONCEPTUALIZING DIGITILIZATION

As Bukht and Heeks (2017) discussed, the economic changes in the 1990s mainly concerned the emergence of the internet, and this remains a foundation for the growth of the digital economy. Further, the authors added that the meaning and metrics of the digital economy are both limited and divergent. Accordingly, the core of the digital economy is the "digital sector," which is the IT/ICT sector that produces foundational digital goods and services. The true "digital economy" consists of the digital sector plus emerging digital and platform services, and the widest scope of the digital economy is the "digitalized economy," which implies the use of ICT in all economic fields (Bukht and Heeks 2017). The narrow definition of the digital economy includes digital services, and, due to the data access constraints on all aspects of the digital economy, this study considers this narrow concept of digitization. The variables that the literature has used to capture this narrow concept of digitalization are the mobile density, internet density, fixed telephone line density, and ICT export services. The figure below shows this concept of digitization, which Bukht and Heeks (2017) conceived.

Figure 1: Scoping the Digital Economy



Source: Bukht and Heeks (2017).

4. THEORETICAL FRAMEWORK

The gross domestic product (GDP) is one of the key indicators that most studies have used to measure the health of an economy (though some studies, like those by Dua and Rasid (1998) and Sahoo and Mathiyazhagan (2003), used the Index of Industrial Production (IIP) as a representative of the GDP). It is the total of the value of all the goods and services produced within the geographic boundaries of a country during a specific period. The GDP per capita, which measures the growth of an economy, is useful for comparing the relative economic performance of countries. This study takes the per capita GDP to measure the economic growth of India and the PRC. The paragraphs below explain the theoretical relationship of the explanatory (infrastructure) variables (from the literature) with economic growth.

4.1 Mobile Density (MD)

The development of telecommunications is essential for the enhancement and improvement of the transaction process. According to Matalqah and Warad (2017), a 10% increase in telecom subscribers leads to 3% growth of the GDP in non-oil-producing countries. Haftu (2019) found that 10% growth in mobile phone penetration results in a 1.2% change in the per capita GDP. Wainaina (2012) identified bidirectional causality between mobile density and economic growth in sub-Saharan Africa. There is an expectation that the penetration rate of mobile services will enhance economic activities and therefore that mobile density will have a positive impact on economic growth.

4.2 Internet Density (ID)

The internet, through information dissemination, has transformed the production process and thus facilitated the improvement of efficiency and the expansion of economic activities through e-commerce, reducing the geographical barrier(s). The

literature on internet density has argued that internet penetration makes a positive contribution to the achievement of higher economic growth (Pradhan et al. 2016).

4.3 Fixed Telephone Density (FTD)

Fixed telephone density, an indicator of ICT, plays an important role in the economy. Andrianaivo and Kpodar (2011) found that the penetration of fixed telephones has a positive impact on the economic growth in Africa. Hence, the authors expect a positive impact of fixed telephone density on economic growth.

4.4 ICT Service Exports (ICTSE)

ICT service exports include computer and communication services and information services (World Bank 2020). Exports positively influence the income level of economies and play a comparatively better role in the growth of the Indian economy than FDI (Sahoo and Mathiyazhagan 2003). Therefore, the authors expect that ICT service exports will promote the growth of an economy.

4.5 Per Capita Electricity Power Consumption (PEC)

Economic growth is highly dependent on energy inputs; accordingly, electricity (from any source) plays an important role in economic growth as it is a crucial input into many productive activities. According to Kasperowicz (2014b), there is bidirectional causality between electricity consumption and economic growth in Poland. Both India and the PRC rely on electricity for manufacturing goods and services. Thus, PEC will fuel the growth of these two Asian economic powers.

4.6 Research and Development Expenditure (R&D)

Investment in R&D is a key input for economic growth. According to Romer (1994), research and development plays an important role in innovation, increased productivity, and economic growth. R&D expenditure has a statistically significant impact on the economic growth of the European Union (Freimane and Bālina 2016). Hence, theoretically, there is a positive effect of R&D expenditure on economic growth.

4.7 General Government Final Consumption Expenditure (GFCE)

The general government final consumption expenditure (GFCE, formerly general government consumption) consists of all the current expenditures of the government for the purchase of goods and services, including compensation for employees (World Bank 2020). It also includes expenditures on national security and defense but excludes government military expenditures, which are part of government capital formation (World Bank 2020). Since a higher GFCE is an indication of an expansionary fiscal policy, there is an expectation that it will boost the economic growth of any economy, though some empirical literature has found the opposite relationship (Devarajan, Swaroop, and Zou 1996).

4.8 Exports (EX)

Exports influence the level of economic growth, employment, and balance of payments. In the recent period, globalization, a reduction in transportation costs, and tariffs have made exports an important part of national incomes. The growth of exports has played a substantial role in the economic growth of India (Agrawal 2015). Studies like that of Sahoo and Mathiyazhagan (2003) have suggested opening export-oriented sectors to achieve higher economic growth. Thus, the literature has supported the positive contribution of EX to the economic growth of any country.

4.9 Gross Capital Formation (GCF)

Gross capital formation consists of the outlays in addition to the fixed assets plus net changes in the level of inventories in the economy. The empirical literature has supported the view that GCF is the key driver of economic growth in many economies. Ongo and Vukenkeng (2014) revealed that private investment is a significant and positive determinant of economic growth in the CEMAC sub-region.

4.10 Expected Years of Schooling (EYS)

Human capital is a critical factor for economic growth (Romer 1986; Lucas Jr. 1988; Barro 1996). Human capital may influence the growth of an economy by expanding the knowledge and skills of the people. Human capital has a positive impact on economic growth (Ojha and Pradhan 2010). Considering the expected years of schooling as an important component of human capital, the authors expect it to exert a positive impact on economic growth.

4.11 Foreign Direct Investment (FDI) Inflows

Foreign direct investment is the preferred source of external funds for many developing economies because of the associated benefits. Along with financial capital, it brings technology and skills. Moreover, the non-debt nature of this investment has made it a safe source of foreign funds for the host economy. According to Sahoo, Mathiyazhagan, and Parida (2002), FDI is a positive and significant determinant of the GDP in the PRC. Sahoo and Mathiyazhagan (2003) also found a long-term relationship between FDI and the GDP in India. The Government of India has continued the reform process to attract more and more FDI and sustain higher economic growth. Thus, theoretically, a positive effect of the FDI inflow on economic growth is likely.

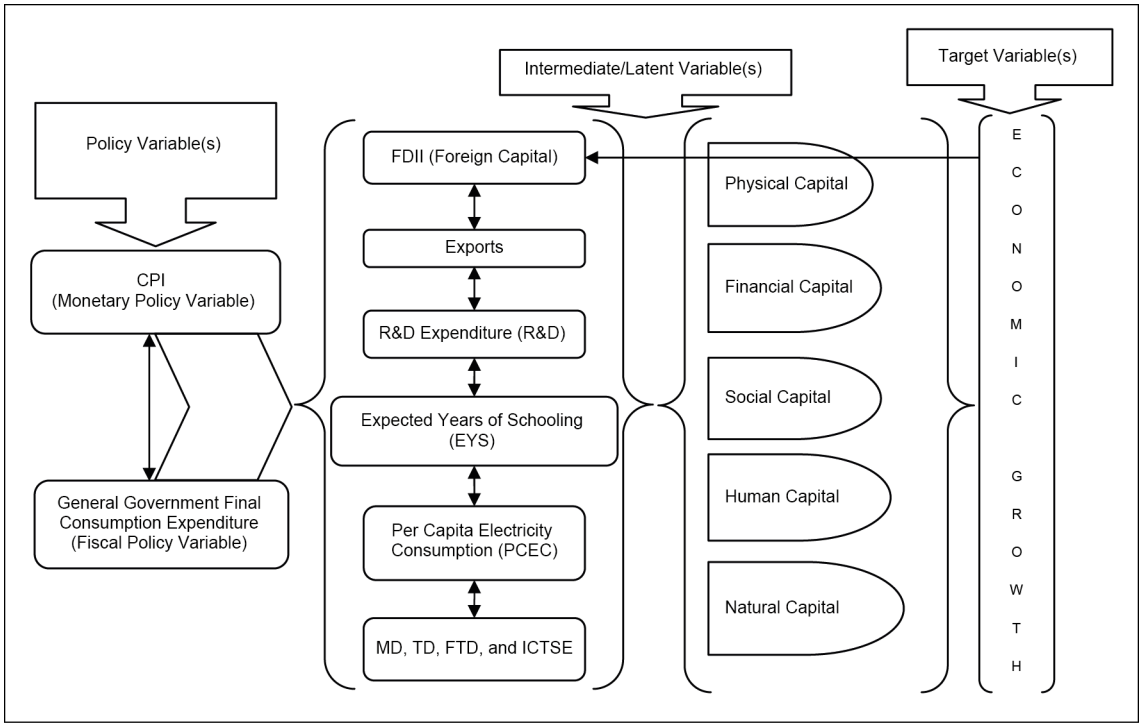
Further, the macroeconomic policies (both fiscal and monetary) of the government affect these variables. Though fiscal consolidation is the call of the day for most of the economies across the world, indicating the downsizing of revenue expenditure (RE) and fiscal deficit (FD) (the Government of India has a Fiscal Responsibility and Budget Management (FRBM) Act that requires the reduction of RE to 0% and FD to 3% of the GDP), the RE of the government is essential in maintaining the capital expenditure (CE) under fiscal policies. Therefore, GCE, which is a fiscal policy variable, is essential to achieve and sustain economic growth. The literature has also supported the assertion that an expansionary monetary policy with controlled mild inflation acts as a tonic for economic growth by raising the business sentiment in the economy. On the other hand, hyperinflation can destabilize the economy by affecting the business environment (Mohanty and Bhanumurthy 2019). The present paper uses the

consumer price index (CPI) as one of the explanatory variables to account for the monetary policy.

4.12 Consumer Price Index

The price level of an economy influences its growth. As Fischer (1993) discussed, the growth of an economy has a negative association with rising price levels. The author argued that inflation deters growth by reducing investment and productivity. On a similar line, Barro (1996) argued that higher growth of economies is conditional on a lower level of inflation. Therefore, the assumption is that a higher price level, which a higher consumer price index (CPI) indicates, will deter growth, though the literature has also supported the reverse relationship (Mahmoud 2015). The price of goods and services in an economy continues to fluctuate, but changes in the price that are too large and too fast are not favorable for the economy. Though research has not considered an increase in the price level to be good for an economy, a mild increase is beneficial for its growth. According to Mahmoud (2015), there is a positive relationship between the CPI and the GDP and unidirectional causality runs from inflation to economic growth in Mauritania. The following figure shows the theoretical relationship between the explanatory variables and the per capita GDP:

Figure 2: Theoretical Relationship



Source: Authors' construction from the literature.

The functional form below can express the relationship of the explanatory variables with the PCGDP (the key indicator of economic growth for any country):

$$PCGDP = F(MD, ID, FTD, ICTSE, PCEPC, R\&D, GFCE, EX, GCF, EYS, FDII, CPI) \quad (1)$$

Similarly, the literature on the determinants of FDII has supported the assertion that the size of the market, which the PCGDP indicates, attracts more FDI to a destination (Sahoo 2004). Therefore, it is possible to express the relationship of the explanatory variables with the FDII as follows:

$$FDII = F(MD, ID, FTD, ICTSE, PCEPC, R\&D, GFCE, EX, GCF, EYS, PCGDP, CPI) \quad (2)$$

Equations 1 and 2 show the feedback relationship between PCGDP and FDII: the variables affect each other, resulting in a simultaneous relationship between the two. Table 1 shows the expected relationships of the explanatory variables with PCGDP and FDII.

Table 1: Expected Relationship of the Explanatory Variables with PCGDP and FDII

Dependent Variable(s)	Explanatory Variables	Expected Relationship with Per Capita Gross Domestic Product (PCGDP)
PCGDP	Mobile Density (MD)	+
	Internet Density (ID)	+
	Fixed Telephone Density (FTD)	+
	ICT Service Exports (ICTSE)	+
	Per Capita Electricity Power Consumption (PCEPC)	+
	Research and Development Expenditure (R&D)	+
	General Government Final Consumption Expenditure (GFCE)	+/-
	Exports (EX)	+
	Gross Capital Formation (GCF)	+
	Expected Years of Schooling (EYS)	+
	Foreign Direct Investment Inflow (FDII)	+
	Consumer Price Index (CPI)	+/–
FDII	Mobile Density (MD)	+
	Internet Density (ID)	+
	Fixed Telephone Density (FTD)	+
	ICT Service Exports (ICTSE)	+
	Per Capita Electricity Power Consumption (PCEPC)	+
	Research and Development Expenditure (R&D)	+
	General Government Final Consumption Expenditure (GFCE)	+
	Exports (EX)	+
	Gross Capital Formation (GCF)	+
	Expected Years of Schooling (EYS)	+
	Per Capita GDP (PCGDP)	+
	Consumer Price Index (CPI)	+/–

Source: Authors' compilation from the literature.

Equations 1 and 2 constitute a simultaneous structural equation system, and it is necessary to estimate them in their reduced form. After repeated cross-checking, the reduced-form estimable simultaneous equation system of the two equations is as follows:

$$\begin{aligned} LnPCGDP_{it} &= \delta + \gamma_1 LnEX_{it} + \gamma_2 LnEYS_{it} + \gamma_3 LnFDII_{it} + \gamma_4 LnID_{it} \\ &+\gamma_5 LnMD_{it} + \gamma_6 LnPCEPC_{it} + \gamma_7 LnR\&D_{it} + \gamma_8 LnCPI_{it} + \gamma_9 (LnEYS_{it} \\ &\times LnR\&D_{it}) + \gamma_{10}(D_C \times LnEX_{it}) + \gamma_{11}(D_C \times LnEYS_{it}) + \gamma_{12}(D_C \\ &\times LnFDII_{it}) + \gamma_{13}(D_C \times LnID_{it}) + \gamma_{14}(D_C \times LnMD_{it}) + \gamma_{15}(D_C \\ &\times LnPCEPC_{it}) + \gamma_{16}(D_C \times LnR\&D_{it}) + \gamma_{17}(D_C \times LnCPI_{it}) + \gamma_{18}(D_C \\ &\times LnEYS_{it} \times LnR\&D_{it}) + \varepsilon_{it} \end{aligned} \quad (3)$$

$$\begin{aligned} LnFDII_{it} &= \alpha + \beta D_C + \beta_1 LnEX_{it} + \beta_2 LnEYS_{it} + \beta_3 LnGCF_{it} \\ &+\beta_4 LnID_{it} + \beta_5 LnMD_{it} + \beta_6 LnPCEPC_{it} + \beta_7 LnCPI_{it} + \beta_8 LnR\&D_{it} \\ &+\beta_9 LnDU_{it} + \varepsilon_{it} \end{aligned} \quad (4)$$

where "i" refers to the country, that is India and the PRC, "t" is the time, "Dc" is the dummy (= 1 for India and 0 for the PRC), andε is the independently and identically distributed (IID) random error term. The authors estimated these equations using the data that they collected from secondary sources[1]through the statistical software STATA 13.0 edition (StataCorp 2013). However, before estimating the reduced form of the simultaneous equation system, it is pertinent to discuss the data sources and variable constructs. Additionally, an overview of the macroeconomic conditions of both economies through the macroeconomic variables would enrich the analysis.

5. DATA SOURCES AND VARIABLE CONSTRUCTS

This study used the data for the two fastest-growing economies of Asia, namely India and the PRC. All the data are secondary in nature and refer to the period 1990 to 2019. The annual data for the dependent variable, per capita GDP (PPP, constant 2017), of India and the PRC come from the World Development Indicators (WDIs) (World Bank (WB) 2020). The WDIs (World Bank 2020) also provided the data for the independent variables, like mobile density, internet density, fixed telephone density, ICT service exports, per capita electricity power consumption, research and development expenditure (% GDP), government final consumption expenditure (% GDP), exports of goods and services (% GDP), gross capital formation (% GDP), and FDI inflow (% of GDP). The authors collected the data on the expected years of schooling from the United Nations Development Programme's (UNDP 2020) Human Development Reports and the consumer price index (CPI) data from the United Nations Conference on Trade and Development (UNCTAD 2020). Table 2 provides the description of the variables that this study used.

[1] See section 4.

Table 2: Variables Used and Data Sources

Economies	Variable	Measurement	Note	Data Source
India and the PRC	Per Capita GDP, PPP (PCGDP)	Constant 2017 US$	GDP divided by midyear population	WDIs, World Bank
	Mobile Density (MD)	Numeric	Number of mobile phones per 100 people	WDIs, World Bank
	Internet Density (ID)	Numeric	Number of internet subscriptions per 100 people	WDIs, World Bank
	Fixed Telephone Density (FTD)	Numeric	Number of fixed telephone subscriptions per 100 people	WDIs, World Bank
	ICT Service Exports (ICTSE)	% of service exports, BoP	Includes computer and communication services and information services	WDIs, World Bank
	Per Capita Electricity Power Consumption (PCEPC)	Kwh	Electric power consumption	WDIs, World Bank
	Research and Development Expenditure (R&D)	% of GDP	Includes both capital and current expenditures	WDIs, World Bank
	General Government Final Consumption Expenditure (GFCE)	% of GDP	Includes all govt. expenditures for the purchase of goods and services	WDIs, World Bank
	Exports (EX)	% of GDP	Exports of goods and services	WDIs, World Bank
	Gross Capital Formation (GCF)	% of GDP	Consists of outlays in addition to fixed assets + net changes in the level of inventories	WDIs, World Bank
	Expected Years of Schooling (EYS)	Number of Years	Expected years of schooling in years	UNDP
	Foreign Direct Investment Inflow (FDII)	% of GDP	Net inflows of investment	WDIs, World Bank
	Consumer Price Index (CPI)	Index	Price of a basket of consumer goods	UNCTAD

Source: Authors' compilation from various sources.

However, a couple of issues relating to the data are worth mentioning. Data on MD were not available for India for the period 1990–1994. Data on ID were unavailable for India for the years 1990, 1991, and 2019 and for the PRC from 1990 to 1992 and from 2018 to 2019. Further, the variables fixed telephone density and ICT service exports have no impact on the dependent variables and thus the subsequent discussions and models do not consider them.

6. SOME STYLIZED FACTS ON THE ECONOMIES OF INDIA AND THE PRC

To present the data that this study used in a meaningful way, Table 3 contains the calculations of the descriptive statistics.

Table 3 shows the descriptive statistics of the variables that this study considered. It shows the characteristics of the data over 30 years, that is, 1990–2019. The average per capita GDP of India is US$3,550.4, the minimum value is US$1,792.0, and the maximum value is US$6,754.3. Similarly, the average per capita GDP of the PRC is US$6,691.8, the minimum value is US$1,423.7, and the maximum value is US$16,116.7. Table 3 reveals that there is a significant difference between the mean per capita GDPs of the two economies. The absolute difference between the mean values of the variables of both the countries, which the mean difference indicated, shows that the gap is significant for all the variables except the CPI.

Table 3: Descriptive Statistics

	PCGDP[a]	MD	ID	FTD	ICTSE[b]	PCEPC	R&D	GFCE	EX	GCF	EYS	FDII	CPI
						India							
Mean	3,550.4	29.6	6.9	2.3	45.7	522.2	0.7	10.9	16.4	31.7	9.8	1.2	81.8
Standard Deviation	1,515.8	35.3	9.2	1.1	4.7	182.0	0.1	0.6	5.7	5.5	1.7	0.8	47.6
Kurtosis	–0.6	–1.5	0.6	–1.0	7.1	–1.5	–0.4	–0.5	–1.4	–1.2	–1.5	0.6	–0.8
Skewness	0.7	0.6	1.3	0.1	–2.1	0.4	0.7	0.4	0.0	0.4	0.3	0.7	0.7
Minimum	1,792.0	0.0	0.0	0.6	30.1	272.1	0.6	9.8	7.1	24.0	7.6	0.0	22.9
Maximum	6,754.3	87.3	32.0	4.4	52.1	804.5	0.9	12.2	25.4	41.9	12.3	3.6	180.4
						PRC							
Mean	6,691.8	40.5	19.4	14.0	5.4	2,036.0	1.3	15.1	22.7	40.5	11.2	3.4	88.3
Standard Deviation	4,606.0	41.2	21.5	8.8	3.8	1,282.9	0.6	1.1	6.2	4.2	2.0	1.4	23.6
Kurtosis	–0.9	–1.2	–1.4	–1.2	–0.8	–1.6	–1.6	–1.1	–0.2	–1.2	–1.7	–0.5	–0.3
Skewness	0.7	0.6	0.6	–0.2	0.7	0.3	0.2	–0.1	0.8	–0.2	0.2	0.0	–0.5
Minimum	1,423.7	0.0	0.0	0.6	0.6	510.6	0.6	13.2	13.6	33.6	8.8	1.0	40.4
Maximum	16,116.7	120.4	54.3	27.5	12.7	3,927.0	2.2	16.8	36.0	46.7	13.9	6.2	125.1
						Mean Difference[c]							
	3,141.47	10.97	12.49	11.7	40.3	1,513.77	0.57	4.24	6.25	8.78	1.42	2.14	6.43
t-statistics[d]	5.59*	5.99*	5.19*	8.09*	30.71*	7.53*	5.26*	22.51*	7.34*	11.21*	20.01*	6.70*	1.28

[a] US$.

[b] The ICTSE data for India are available for the period 2000 to 2017, so the authors calculated the descriptive statistics only for this period.

[c] The difference results from deducting the mean of the variables of India from the mean of the variable of the PRC.

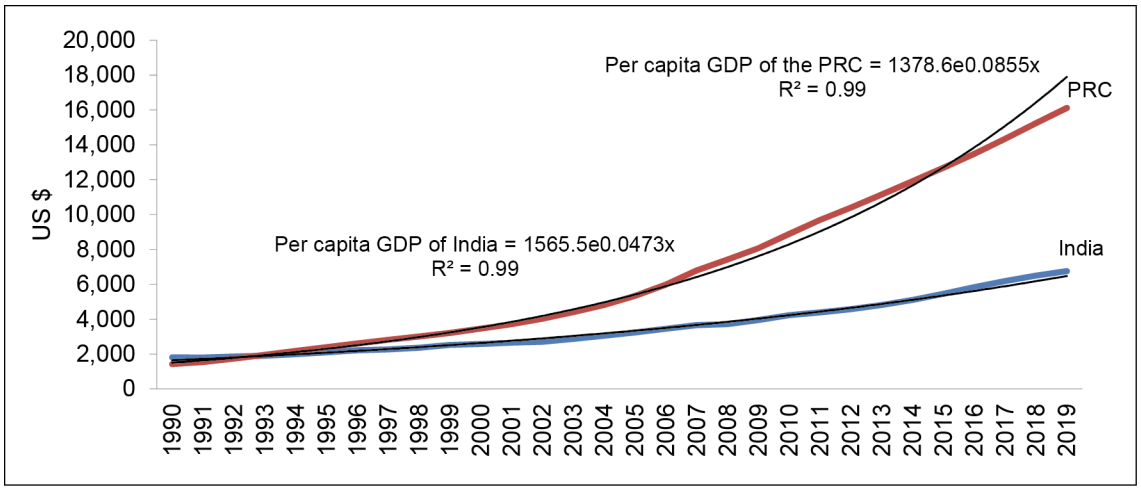
[d] The authors calculated the t-statistics for the mean difference through the formula:

$t = \frac{\bar{x}_1 - \bar{x}_2}{S_V \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$ $S_V = \sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1 + n_2 - 2}}$, where $\bar{x}_1$ s_1, and n_1 are the mean, standard deviation, and sample size in sample one and $\bar{x}_2$, s_2, and n_2 are the mean, standard deviation, and sample size in sample two, respectively. S_V is the pooled standard deviation and $n_1 + n_2 - 2$ is the degrees of freedom.

* Implies significant at the 1% level.

Source: Authors' computation from the WDI, UNCTAD, and UNDP data.

Figure 3: Per Capita GDP (PPP) at a Constant Price (1990–2019)

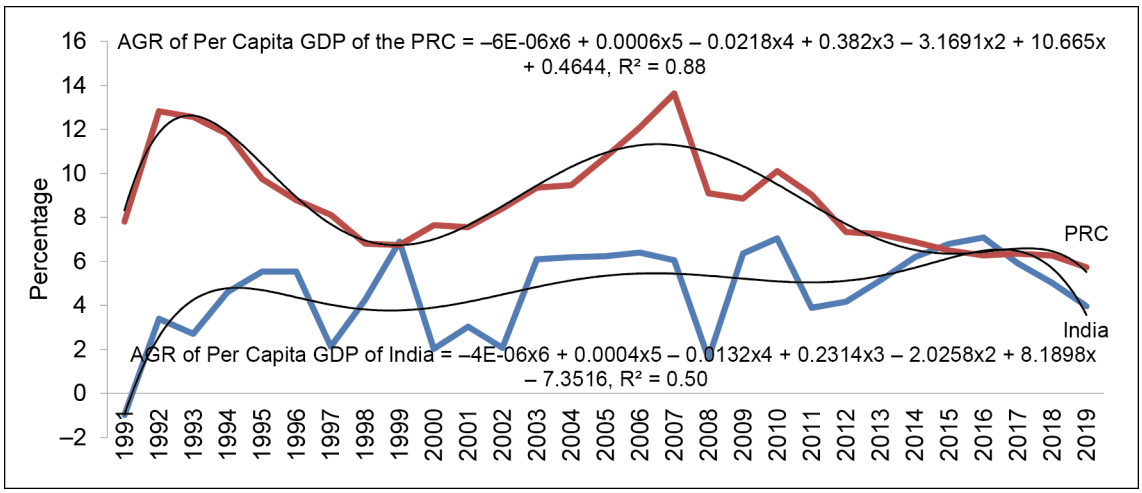


Source: Authors' illustration based on data from the WDI.

Figure 3 shows the trends of the per capita GDP (PPP) in India and the PRC. Measured in constant US dollars, the GDP per capita of India was US$1,809.80 in 1990, rising to US$6,754.28 in 2019.Likewise, the per capita GDP of the PRC increased from US$1,423.70 in 1990 to US$16,116.70 in 2019. In 1990, the per capita

GDP of India was higher than the per capita GDP of the PRC. However, in 2019, the PRC's per capita GDP was around2.38 times greater than that of India. Figure 4 presents the annual growth rates of the per capita GDP of both the economies.

Figure 4: AGR of Per Capita GDP (PPP)



Source: Authors' illustration based on data from the WDIs.

Figure 4 shows the annual growth rate of the per capita GDP of India and the PRC. India attained a maximum growth rate of 7.08% in 2016 and a minimum of –0.98% in 1991. Similarly, the PRC attained a maximum growth rate of 13.63% in 2007 and a minimum of 5.73% in 2019. Both these countries are prominent economies in Asia. The annual average growth rates (AAGR) of the PCGDP of both India and the PRC over the period 1990–2019 are ahead of those of economies like Brazil, the Russian Federation, South Africa, Japan, and the United States as well as the world economy (see Table 4 and Table 5).

Table 4: AAGR of Some Variables of Some Important Economies (%)

Period	Brazil	Russian Federation	South Africa	Japan	United States	World
Per Capita GDP (PCGDP)						
1991–2000	1.00	–3.52	–0.18	1.04	2.19	1.39
2001–2010	2.54	5.21	2.14	0.57	0.82	2.31
2011–2019	–0.13	1.34	0.03	1.12	1.55	2.23
1991–2019	1.18	1.00	0.69	0.90	1.52	1.96
Mobile Density (MD)						
1991–2000	242.97	281.27	144.49	61.04	34.26	50.00
2001–2010	22.73	61.52	19.19	6.26	9.12	20.33
2011–2019	1.14	0.07	6.27	4.00	3.51	3.50
1991–2019	91.97	118.23	58.39	24.45	16.05	25.34
Internet Density (ID)						
1991–2000	111.10	271.14	86.83	118.19	52.01	110.26
2001–2010	33.15	38.39	20.87	10.54	5.44	15.75
2011–2019	5.69	7.85	10.28	1.88	2.33	5.58
1991–2019	51.51	109.17	40.33	44.98	20.53	45.19

continued on next page

Table 4 *continued*

Period	Brazil	Russian Federation	South Africa	Japan	United States	World
Per Capita Electricity Power Consumption (PCEPC)						
1991–2000	2.656	–2.41	0.89	2.02	1.56	1.16
2001– 2010	2.35	2.15	–0.02	0.40	–0.16	2.19
2011–2019	0.96	0.30	–0.71	–0.90	–0.33	0.57
1991–2019	2.02	0.006	0.08	0.55	0.38	1.33
Research and Development Expenditure (R&D)						
1991–2000	0.01	0.70	1.80	0.58	0.64	–
2001–2010	1.11	1.17	–0.07	0.80	0.43	–
2011–2019	1.11	–0.49	1.25	0.29	0.29	–
1991–2019	0.73	0.49	0.99	0.57	0.46	–
General Government Final Consumption Expenditure (GFCE)						
1991–2000	0.29	–1.63	–0.03	2.21	–1.23	–0.07
2001–2010	0.17	2.43	1.02	1.49	1.81	0.95
2011–2019	0.73	–0.19	0.58	0.17	–1.81	–0.33
1991–2019	0.39	0.22	0.52	1.33	–0.36	0.20
Exports (EX)						
1991–2000	3.40	33.26	1.62	0.53	1.52	3.05
2001–2010	1.31	–3.79	1.18	4.41	1.74	1.26
2011–2019	3.46	–0.06	0.52	1.90	–0.44	0.67
1991–2019	2.70	10.14	1.13	2.30	0.99	1.70
Gross Capital Formation (GCF)						
1991–2000	–0.11	–3.28	–1.38	–2.27	1.00	–0.58
2001–2010	1.80	2.79	2.00	–2.36	–2.12	–0.03
2011–2019	–3.78	0.35	–1.07	1.32	1.13	–0.01
1991–2019	–0.60	–0.06	–0.12	–1.19	–0.04	–0.22
Expected Years of Schooling (EYS)						
1991–2000	1.60	–0.22	1.33	0.73	–0.17	0.95
2001–2010	–0.18	1.15	–0.15	0.48	0.71	1.57
2011–2019	1.10	1.14	0.76	0.15	0.07	0.82
1991–2019	0.83	0.67	0.64	0.46	0.20	1.12
Foreign Direct Investment Inflow (FDII)						
1991–2000	51.02	29.02	338.82	–688.02	16.93	17.90
2001–2010	6.80	16.70	202.91	122.52	5.60	0.06
2011–2019	2.54	50.78	21.33	290.24	2.75	–3.47
1991–2019	20.72	31.52	193.42	–189.4	8.62	5.12
Consumer Price Index (CPI)						
1991–2000	549.18	156.51	8.99	0.83	2.80	–
2001–2010	6.69	12.58	5.30	–0.26	2.39	–
2011–2019	5.91	6.85	5.28	0.60	1.79	–
1991–2019	193.51	60.44	6.57	0.38	2.35	–

Source: Authors' computation from the WDI, UNCTAD, and UNDP data.

Table 5 presents the annual average growth rates of the per capita GDP of India and the PRC during different sub-periods. Further, the authors tested the relative performance of both the economies with respect to the per capita GDP using the dummy variable regression technique.[2]

Table 5: AAGR of Per Capita GDP (PPP) of India and the PRC (%)

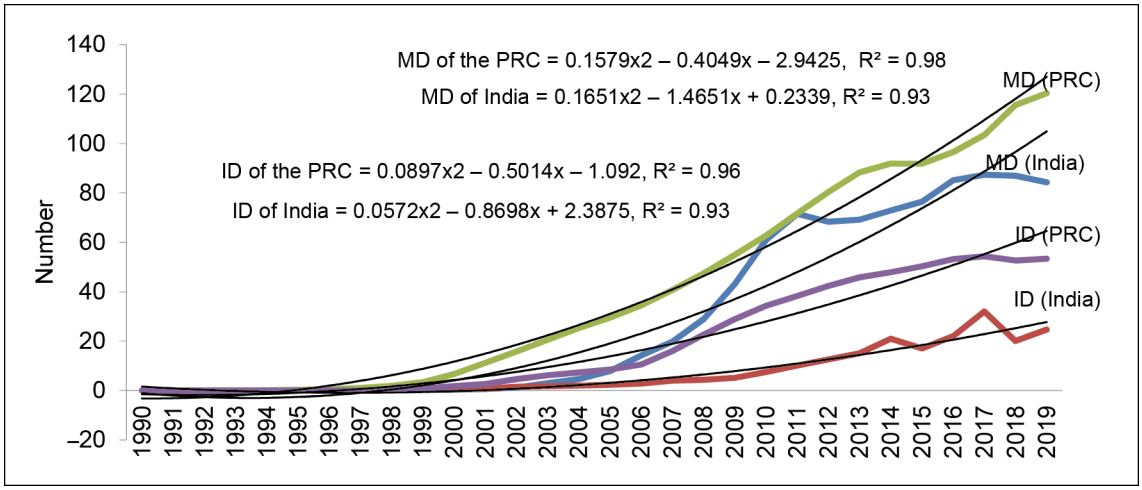
Period	India	PRC	Difference/Intercept	Coefficient
1991–2000	3.60	9.27	3.60* (4.96)	5.67* (5.52)
2001–2010	5.10	9.92	5.10* (8.38)	4.82* (5.60)
2011–2019	5.35	6.84	5.35* (14.68)	1.49** (2.89)
1991–2019	4.66	8.74	4.66* (11.94)	4.08* (7.39)

* and ** imply significant at the 1% and 5% levels, respectively. (The figures in the parentheses represent the t-statistics.)

Source: Authors' estimation from the WDI data.

Table 5 depicts the annual average growth rates of the per capita GDP of India and the PRC during different periods. Over the period from 1991 to 2019, the annual average growth of India and the PRC is 4.66 and 8.74, respectively. During the period 1991–2000, the per capita GDP of India grew at an average rate of 3.60 and the per capita GDP of the PRC grew at an average rate of 9.27. India was able to raise the growth rate steadily over the period, whereas the PRC maintained its high growth rate, albeit showing some periodic fluctuations. Further, there is significant difference in the growth performance (the AAGR of the PRC is higher than that of India) of the two economies across different sub-periods.

Figure 5: Trend of Mobile and Internet Density



Source: Authors' illustration based on WDI data.

[2] The estimated regression equation for the dummy variable technique is $y = \alpha + \beta D + \varepsilon$, where "$y$" represents the variable concerned in the difference test; "D" is the dummy variable, "0" for India and "1" for the PRC; and "ε" is the error term. This dummy variable technique tests the difference in the performance for digitization for the whole period, i.e., 1990–2019, and for the different sub-periods, i.e., 1990–2000, 2001–2010, and 2011–2019. This exercise will provide an understanding of the temporal variation in the performance of y.

Figure 5 shows the trends of the mobile density and internet density of both India and the PRC, and Table 6 provides the annual average growth rate of the digitization variables, that is, mobile density and internet density, for both India and the PRC. Further, the authors used a dummy variable regression technique to test the difference in digitalization performance of the two economies. Figure 5 reveals that the PRC is ahead of India in absolute digitization, and a further perusal of Table 6 shows that the growth performance of the PRC in digitization is significantly higher than that of India during all the sub-periods.

Table 6: AAGR of MD and ID

	India		PRC		Difference/Intercept		Coefficient	
Period	**MD**	**ID**	**MD**	**ID**	**MD**	**ID**	**MD**	**ID**
1991–2000	62.94	325.36	138.71	211.15	62.94** (2.14)	325.36 *** (1.94)	75.77*** (1.82)	–114.21 (–0.48)
2001–2010	70.93	33.83	26.17	35.54	70.93* (8.09)	33.83* (3.66)	–44.76* (–3.61)	1.71 (0.13)
2011–2019	3.87	17.75	7.59	5.12	3.87** (1.96)	17.75** (2.69)	3.72 (1.34)	–12.63 (–1.35)
1991–2019	47.36	129.37	59.20	126.66	47.36* (3.52)	129.37** (2.14)	11.84 (0.62)	–42.71 (–0.50)

*, **, and *** imply significant at the 1%, 5%, and 10% levels, respectively. (The figures in the parentheses represent the t-statistics.)

Source: Authors' estimation from the WDI data.

The expansion of digitalization measured in terms of mobile density and internet density in Table 6 shows that the annual average growth rates of these two variables in the PRC are higher than those in India during the period 1991 to 2019. However, the gap in the growth rates of mobile density in the two economies is smaller than those of internet density. During the first decade of the 21st century, the growth of mobile penetration in India was far ahead that of the PRC. However, during the period 2011–2019, both the economies faced low growth of mobile penetration. Similarly, Figure A1 through Figure A5 in Appendix A depict the trends of the remaining explanatory variables, like PCEPC, R&D, EYS, GFCE, GCF, EX, FDII, and CPI, of both India and the PRC. Table A1 through Table A5 in the same appendix report the annual average growth rates of the same explanatory variables and the results of their dummy variable regression model.

To sum up, it is possible to state that the economic performance of India and the PRC has been better than that of other major economies of the world (Table 4). The performance of these two rising economic giants is associated with their relatively better performance in ushering in other proactive policies to create growth-promoting capital. As Table 4 revealed, both India and the PRC have been well ahead of other economies in the key variables for promoting growth. Thus, it is pertinent to explore the impact of these key variables on the growth performance of India and the PRC, which the following section reports.

7. RESULTS AND DISCUSSION

The authors explored the impact of the explanatory variables on the economic performance of India and the PRC by estimating equations 3 and 4. However, before discussing the estimated result of the two equations, they studied the coefficient of correlation between the variables to obtain a preliminary understanding of the relationship between the explanatory variables and the per capita GDP. This would also help in quantifying the degrees to which the per capita GDP is related to the other

variables. Table 7 presents the correlation coefficients of the per capita GDP with the other variables.

Table 7 shows that both MD and ID have a high positive correlation with the per capita GDP in both India and the PRC. Likewise, CPI has a very high positive correlation with the per capita GDP in both countries. The relationship between PCEPC and PCGDP is stronger in the PRC than in India. There is a negligible positive relationship between R&D and PCGDP, whereas, in the case of the PRC, the relationship is very strong. There is a negative relationship between GFCE and PCGDP in both countries. EX and GCF have a positive relationship with PCGDP in both countries. FDII has a positive relationship with PCGDP in India, whereas, in the case of the PRC, there is a negative relationship between these two variables.

Table 7: Correlation between Per Capita GDP and Macroeconomic Variables

Variables	Per Capita GDP: India	Per Capita GDP: PRC
MD	0.95*	0.99*
ID	0.94*	0.98*
PCEPC	0.97*	0.97*
R&D	0.003	0.97*
GFCE	–0.155	0.62*
EX	0.74*	0.26
GCF	0.44**	0.72*
EYS	0.97*	0.97*
FDII	0.65*	–0.54*
CPI	0.99*	0.91*

* and ** imply that the correlation coefficient is significant at the 1% and the 5% level, respectively.
Source: Authors' computation from the WDI, UNCTAD, and UNDP data.

The correlation analysis gives only the mere associations among the variables. To determine the impact of these explanatory variables on economic growth, the authors estimated equations 3 and 4 within a simultaneous framework. Additionally, they subjected the data to time series analysis to draw a relevant conclusion. For the simultaneous equation framework, since they performed the estimation for balanced panel data, they carried out the test for the poolability of data and the Hausman test for the choice of models (fixed effect (FE) and/or random effect (RE)); Table 8 presents the results. The result of the poolability test confirmed that the coefficients are stable across cross-section units (thus, they are poolable), and the result of the Hausman test revealed that the RE model is preferable to the FE model. However, the paper presents the results of both the RE and the FE model. Further, it reports the results of the first-difference model (this will give an idea about the short-run effect of the explanatory variables on the dependent variable(s)). Further, before carrying out the time series analysis of the data, the authors tested the time series properties (i.e., through the unit root test) of all the variables. Table B1 in Appendix B presents the results of the unit root test of all the variables.

Table 8: Results of the Poolability Test and the Hausman Test for Equations3 and 4

	Poolability Test	Hausman Test
For Equation 3	F (1, 37) = 1.94 Prob> F = 0.172	χ^2 = 1.94 Prob> χ^2 = 1.000
For Equation 4	F (1, 38) = 0.40 Prob> F = 0.5307	χ^2 = 0.40 Prob> χ^2 = 1.000

Source: Authors' computation from the WDI data.

Table 9: Test for Endogeneity of PCGDP and FDII

Wald Test for PCGDP			
Test Statistic	**Value**	**Df**	**Probability**
t-statistic	–1.003	19	0.328
F-statistic	1.007	(1, 19)	0.328
Chi-square (χ2)	1.007	1	0.316
Null Hypothesis: Coefficient of the residual is zero			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		**Value**	**Std Err.**
Coefficient		–3.577	3.565
Restrictions are linear in coefficients.			
Wald Test for FDII			
Test Statistic	**Value**	**Df**	**Probability**
t-statistic	–1.003	19	0.328
F-statistic	1.007	(1, 19)	0.328
Chi-square (χ^2)	1.007	1	0.316
Null Hypothesis: Coefficient of the residual is zero			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		**Value**	**Std Err.**
Coefficient		–0.014	0.014
Restrictions are linear in coefficients.			

Source: Authors' computation from the WDI data.

Since the study estimated equations 3 and 4 within a simultaneous equation framework, it performed a test of endogeneity of the two variables PCGDP and FDII, and Table 9 reports the results. Although the test results do not confirm the endogeneity of the variables, the literature has supported the simultaneous feedback relationship between the two. Therefore, the study estimated both equation 3 and equation 4; Table 10 and Table 11 present the results.

Table 10 shows the results of the two-stage least square estimates of equation 3. The high values of R^2 and Wald χ^2, for both the FE and the RE model, suggest the goodness of fit of the models. The study found that the expected years of schooling, foreign direct investment inflow, gross capital formation, internet density (in FE model), mobile density, per capita electricity power consumption, and research and development expenditure have a positive impact on the per capita GDP of India and the PRC. However, the consumer price index promotes growth in the short run in the PRC but retards the growth in India. The impact of exports, mobile density, R&D, and years of schooling on growth performance is comparatively greater in the PRC, indicating better productivity of human capital in the PRC. However, FDII exerts a relatively stronger impact on the growth performance of India than on that of the PRC.

This may be because the FDII into India is comparatively low, resulting in higher marginal productivity.

Table 10: Two-Stage Least Square Estimate of Equation 3

Dependent Variable: LOG (PCGDP)			
Independent Variables	**Random Effect**	**Fixed Effect**	**First Differenced**
Constant	5.745*	5.633*	0.055*
	(0.64)	(0.659)	(0.006)
LOG(FDII)	0.108*	0.110*	0.023
	(0.037)	(0.037)	(0.016)
LOG(EX)	0.326*	0.276**	–0.008
	(0.108)	(0.125)	(0.055)
LOG(EYS)	2.210*	2.258*	0.530***
	(0.608)	(0.614)	(0.272)
LOG(R&D)	7.669*	6.658*	–0.637
	(1.423)	(1.921)	(0.888)
LOG(ID)	0.013	6.017*	0.001
	(0.011)	(0.012)	(0.004)
LOG(PCEPC)	0.572**	0.507***	0.120
	(0.268)	(0.282)	(0.111)
LOG(MD)	0.161*	0.152*	0.009
	(0.024)	(0.027)	(0.015)
LOG(CPI)	0.046	0.103	0.161**
	(0.164)	(0.180)	(0.076)
DU × LOG(EX)	–0.591*	–0.532*	–0.115***
	(0.126)	(0.147)	(0.066)
DU × LOG(EYS)	–0.678	–0.897	–0.356
	(0.782)	(0.833)	(0.355)
DU × LOG(FDII)	0.0115*	0.119*	–0.023
	(0.039)	(0.040)	(0.018)
DU × LOG(ID)	0.018	0.022	0.002
	(0.013)	(0.014)	(0.006)
DU × LOG(MD)	–0.150*	–0.139*	–0.013
	(0.025)	(0.029)	(0.015)
DU × LOG(PCEPC)	0.260	0.203	0.055
	(0.358)	(0.366)	(0.162)
DU × LOG(R&D)	10.124*	10.171*	1.708
	(3.514)	(3.531)	(1.630)
DU × LOG(CPI)	0.335	0.254	–0.369*
	(0.205)	(0.230)	(0.113)
LOG(EYS) × LOG(R&D)	3.355*	2.923*	0.274
	(0.599)	(0.814)	(0.379)
DU × LOG(EYS) × LOG(R&D)	–4.318*	–4.364*	–0.773
	(1.528)	(1.537)	(0.714)
R^2 (Within)	0.998	0.998	0.473
R^2 (Overall)	0.998	0.745	0.208
Wald χ^2	30,549.57	5.11e+06	182.50

*, **, and *** imply significant at the 1%, 5%, and 10% levels. (The numbers in parentheses are standard errors.)
Source: Authors' computation from the WDI, UNCTAD, and UNDP data.

Table 11 provides the results of the two-stage least square estimate of equation 4. The values of R^2 and Wald x^2 are indicative of the goodness of fit of the models. The results show that exports, gross capital formation, and the consumer price index are positive determinants of the inward FDI flows to India and the PRC. This implies that the FDI inflows to these economies are export-promoting in both the short and the long run. Higher revenue/profit due to increased prices also attracts FDI to India and the PRC. Further, the promotion of infrastructure through capital formation makes these two economies favorable FDI destinations.

Table 11: Two-Stage Least Square Estimate of Equation 4

Dependent Variable: LOG (FDII)			
Independent Variables	**Random Effect**	**Fixed Effect**	**First Differenced**
Constant	–12.419**	–12.364**	0.056
	(5.482)	(5.510)	(0.173)
LOG(PCGDP)	–0.034	–0.034	0.943
	(1.159)	(1.159)	(2.528)
LOG(EX)	1.369**	1.369**	1.394**
	(0.541)	(0.541)	(0.687)
LOG(EYS)	–7.632*	–7.632*	–3.859
	(1.702)	(1.702)	(3.825)
LOG (GCF)	2.805*	2.805*	1.599***
	(0.618)	(0.618)	(0.871)
LOG(ID)	0.040	0.040	–0.092
	(0.056)	(0.056)	(0.072)
LOG(MD)	–0.204*	–0.204*	–0.094
	(0.077)	(0.077)	(0.120)
LOG(PCEPC)	0.732	0.732	–0.332
	(0.964)	(0.964)	(1.833)
LOG(CPI)	2.816*	2.816*	0.974
	(0.830)	(0.830)	(1.435)
LOG(R&D)	–0.069	–0.069	–0.281
	(1.105)	(1.105)	(1.202)
DU	0.110	–	–
	(0.606)		
R-squared (Within)	0.850	0.850	0.381
R-squared (Overall)	0.905	0.903	0.447
Wald χ^2	466.81	370.14	11.61

*, **, and *** imply significant at the 1%, 5%, and 10% levels. (The numbers in parentheses are standard errors.)
Source: Authors' computation from the WDI, UNCTAD, and UNDP data.

As the paper mentioned earlier, the data are a panel set and thus the authors conducted panel unit root tests of all the variables before analyzing the data through an appropriate model(s). They undertook a total of seven panel unit root tests for all the variables, namely the augmented Dickey–Fuller (ADF) (Fisher χ^2), augmented Dickey–Fuller (Choi Z stat), Levin–Lin–Chu, Im–Pesaran–Shin, Breitung–Philips–Perron (Fisher χ^2), and Philips–Perron (Choi Z stat) tests. Table 17 in Appendix B presents the panel unit root test results. The first, second, fourth, sixth, and seventh tests assumed the null hypothesis of a unit root with an individual unit root process, whereas the third and fifth tests assumed the null hypothesis of a unit root with a common unit root process.

The results of the panel unit root test reveal that PCGDP and R&D are stationary at first difference I (1) in all the seven tests. MD is stationary at level I(0) according to the ADF (Fisher χ^2), ADF (Choi Z stat), Im–Pesaran–Shin, PP (Fisher χ^2), and PP (Choi Z stat) tests, while it is stationary at first difference according to the ADF (Fisher χ^2), ADF (Choi Z stat), Levin–Lin–Chu, Im–Pesaran–Shin, PP (Fisher χ^2), and PP (Choi Z stat) tests. The results for ID are mixed; that is, it is stationary both at level and at first difference in all the tests except ADF (Choi Z stat), in which it is not stationary at first difference. However, PCEPC is only stationary at first difference according to the PP (Fisher χ^2), and PP (Choi Z stat) tests. GFCE is stationary at level in all the tests except the Breitung, PP (Fisher χ^2), and PP (Choi Z stat) tests and stationary at first difference in all the tests. In addition, the Levin–Lin–Chu test supports EX as being stationary at level, but all the other tests support it as stationary at first difference. GCF is stationary at first difference according to all the tests except the Levin–Lin–Chu and Breitung tests, while EYS is stationary at first difference according to all the tests except the Levin–Lin–Chu test. Besides, the result for FDII, CPI, FTS, and ICTSE are mixed. Since the model includes a combination of I (0) and I (1) variables, it was appropriate to use the panel nonlinear autoregressive distributed lag (panel NARDL) model to analyze the data and draw the relevant conclusions and policy implications.

Table 12 shows the results of the panel NARDL model for equations 3 and 4. In equation 3, the positive change in FDII and negative change in MD lead to a negative impact on PCGDP in the long run. Both positive and negative changes in EX tend to have a positive and significant impact on PCGDP. Besides, the positive change in ID has a positive impact on PCGDP in the long run. In the short run, both positive and negative changes in FDII have a positive impact on PCGDP. On the other hand, a positive change in R&D has a negative impact on PCGDP in the short run. In equation 4, positive changes in ID and CPI lead to a negative effect on FDII in the long run. In addition, in the long run, both positive and negative changes in GCF have a negative effect on FDII. In the short run, a negative shock to R&D leads to a negative impact on FDII. Similarly, both positive and negative changes in ID and GCF lead to a negative impact on FDII in the short run. Moreover, in both equation 3 and equation 4, long-run relationships exist between the variables; that is, the cointegration equation coefficients in equation 3 (–0.091) and equation 4 (–0.403) are negative and significant.

Table 13 evaluated the long-run and short-run asymmetric relationships. The result of equation 3 reveals the long-run asymmetric relationships between positive shocks and negative shocks in ID, PCEPC, and FDII and short-run asymmetric relationships between positive shocks and negative shocks in MD and R&D. In equation 4, long-run asymmetric relationships exist between positive shocks and negative shocks in GCF, while short-run asymmetric relationships exist between positive shocks and negative shocks in ID.

Table 12: Panel Nonlinear ARDL Model of Equations3 and 4

	Dependent Variable: LPCGDP		Dependent Variable: LFDII	
Variables	**Coefficients**	**Probability**	**Coefficients**	**Probability**
Long run				
FDII_POS	–0.488	0.004*	–	–
FDII_NEG	–0.598	0.125	–	–
EX_POS	1.346	0.000*	13.188	0.223
EX_NEG	1.246	0.000*	12.371	0.206
EYS_POS	4.099	0.317	–0.471	0.317
EYS_NEG	4.057	0.317	0	0
RD_POS	0	0	–4.589	0.317
RD_NEG	–1.439	0.704	5.471	0.190
ID_POS	0.351	0.016*	–1.752	0.034**
ID_NEG	0.243	0.346	–28.780	0.313
PCEPC_POS	–3.631	0.420	–14.121	0.485
PCEPC_NEG	–3.566	0.473	–2.731	0.683
MD_POS	–0.216	0.155	0.209	0.942
MD_NEG	–0.806	0.097***	1.144	0.848
CPI_POS	1.310	0.335	–0.898	0.002*
CPI_NEG	0	0	0	0
PCGDP_POS	–	–	18.453	0.308
PCGDP_NEG	–	–	–19.784	0.317
GCF_POS	–	–	–3.185	0.002*
GCF_NEG	–	–	–3.345	0.001*
Short run				
DFDII_POS(-1)	0.045	0.000*	–	–
DFDII_NEG(-1)	0.056	0.000*	–	–
DEX_POS(-1)	–0.323	0.387	0.122	0.770
DEX_NEG(-1)	–0.328	0.395	0.238	0.317
DEYS_POS(-1)	0.048	0.275	–0.366	0.489
DEYS_NEG(-1)	0	0	0	0
DRD_POS(-1)	–0.492	0.088***	–6.306	0.339
DRD_NEG(-1)	–0.335	0.399	–7.380	0.011*
DID_POS(-1)	–0.002	0.907	–2.190	0.000*
DID_NEG(-1)	0.017	0.638	–2.390	0.000*
DPCEPC_POS(-1)	–0.092	0.296	–0.307	0.277
DPCEPC_NEG(-1)	–0.115	0.317	0	0
DMD_POS(-1)	0.051	0.617	0.640	0.760
DMD_NEG(-1)	0.106	0.424	0.253	0.852
DCPI_POS(-1)	–0.257	0.187	0.076	0.317
DCPI_NEG(-1)	–0.225	0.317	0	0
DPCGDP_POS(-1)	–	–	–10.279	0.317
DPCGDP_NEG(-1)	–	–	0	0
DGCF_POS(-1)	–	–	–6.864	0.000*
DGCF_NEG(-1)	–	–	–6.976	0.000*
Constant	0.992	0.318	–28.077	0.000*
ECT	–0.091	0.000*	–0.403	0.001*

*, **, and *** imply significant at the 1%, 5%, and 10% levels, respectively.

Source: Authors' computation from the WDI, UNCTAD, and UNDP data.

Table 13: Long-Run and Short-Run Asymmetric Tests

	Dependent Variable: LPCGDP				Dependent Variable: LFDII			
	Long-run Asymmetry		Short-run Asymmetry		Long-run Asymmetry		Short-run Asymmetry	
Variables	χ^2	Probability	χ^2	Probability	χ^2	Probability	χ^2	Probability
LPCGDP	–	–	–	–	1.02	0.313	1.00	0.317
LMD	0.64	0.423	3.76	0.053**	0.09	0.764	0.27	0.602
LID	2.61	0.106***	0.89	0.344	0.85	0.358	10.03	0.001*
LPCEPC	3.49	0.062***	0.80	0.370	0.71	0.399	1.18	0.277
LR&D	1.18	0.278	5.34	0.021**	1.32	0.251	0.08	0.772
LEX	0.05	0.826	0.13	0.722	0.62	0.432	0.41	0.523
LEYS	1.00	0.317	1.00	0.318	1.00	0.317	0.48	0.489
LFDII	36.32	0.000*	0.69	0.406	–	–	–	–
LCPI	0.22	0.638	0.98	0.323	9.21	0.002	1.00	0.317
LGCF	–	–	–	–	6.09	0.014*	0.67	0.412

*, **, and *** imply significant at the 1%, 5%, and 10% levels, respectively.

Source: Authors' computation from the WDI, UNCTAD, and UNDP data.

8. CONCLUSIONS AND POLICY IMPLICATIONS

To conclude, it is possible to state that both internet and mobile density (proxies for telecommunication infrastructure/digitization) have significant positive impacts on the economic growth of India and the PRC. The study found that the expected years of schooling (a proxy for human capital), foreign direct investment inflow, gross capital formation, per capita electricity power consumption (a proxy for electricity infrastructure), research and development expenditure, and consumer price index have positive impacts on the per capita GDP of India and the PRC. It also showed that the PRC extracts relatively more from these growth-promoting factors than India, probably indicating greater allocative efficiency.

The findings of the study may have some policy implications for both the upcoming giant economies of Asia. Both countries should enhance their digitization movement to provide internet facilities. Both the economies have huge population strength, which they should transform into human resources through education and by imparting skills. India needs to attract a huge amount of FDI inflows to develop its physical infrastructure, which will boost the economic growth. Further, India and the PRC need to increase their R&D expenditure to achieve innovation and economic development.

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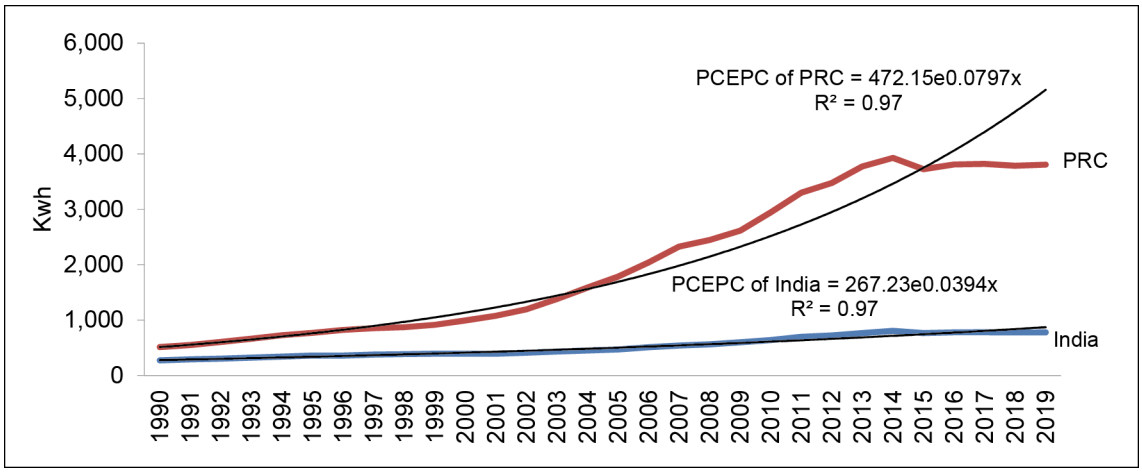
APPENDIX A

Figure A1: Trend of Per Capita Electricity Power Consumption



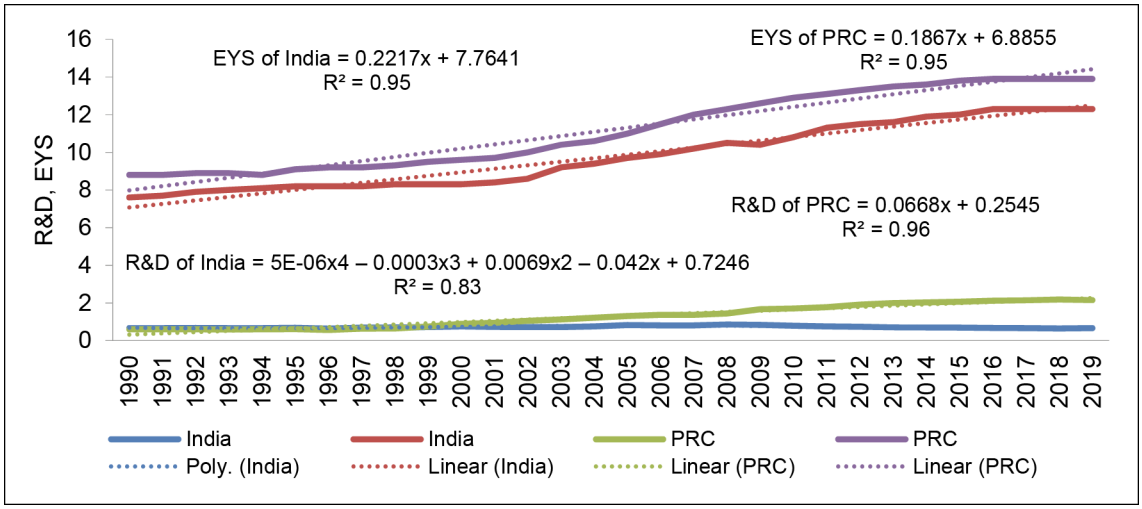
Source: Authors' illustration based on the WDI data.

Table A1: AAGR of PCEPC

	India	PRC		
Period	**PCEPC**	**PCEPC**	**Difference/Intercept**	**Coefficient**
1991–2000	3.79	6.91	3.79* (4.68)	3.12**(2.72)
2001–2010	5.01	11.53	5.01* (5.18)	6.52 (4.76)
2011–2019	2.26	3.00	2.26(1.45)	0.74 (0.34)
1991–2019	3.74	7.29	3.74* (4.71)	3.55* (3.17)

* and**imply significant at the 1% and 5% levels, respectively. (The figures in parentheses represent the t-statistics.)
Source: Authors' estimation from the WDI data.

Figure A2: R&D and EYS Trends



Source: Authors' illustration based on data from the WDI and UNDP.

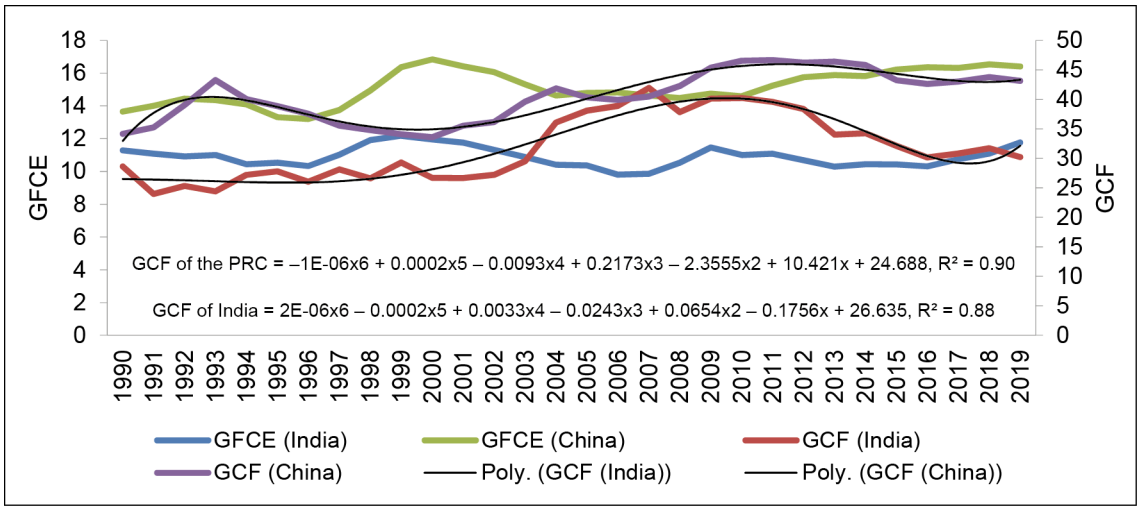
Table A2: AAGR of R&D and EYS

	India		PRC		Difference/Intercept		Coefficient	
Period	R&D	EYS	R&D	EYS	R&D	EYS	R&D	EYS
1991–2000	1.35	0.89	4.35	0.88	1.35 (0.64)	0.89** (2.58)	3.00 (1.01)	–0.007 (–0.014)
2001–2010	0.51	2.68	6.81	3.00	0.51 (0.35)	2.68* (5.19)	6.30* (3.09)	0.32 (0.44)
2011–2019	–1.90	1.47	2.58	0.84	–1.90** (–2.47)	1.47* (3.62)	4.48* (4.11)	–0.63 (–1.10)
1991–2019	0.05	1.69	4.65	1.60	0.05 (0.06)	1.69* (5.75)	4.60* (3.50)	–0.09 (–0.21)

* and ** imply significant at the 1%and 5% levels, respectively. (The figures in the parentheses represent the t-statistics.)

Source: Authors' estimation from the data from the WDI and UNDP.

Figure A3: Trends of GFCE and GCF



Source: Authors' illustration based on the WDI data.

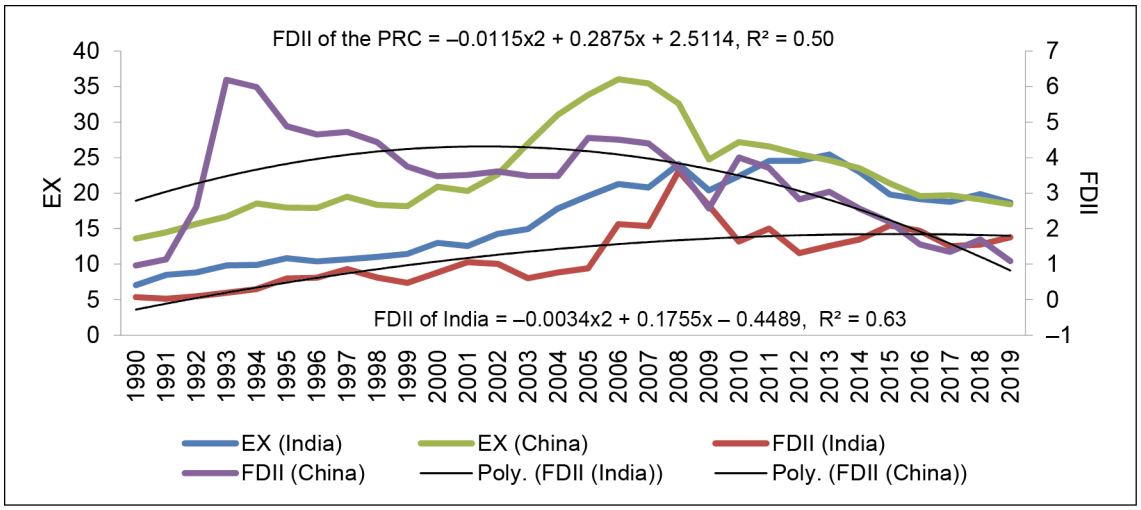
Table A3: AAGR of GFCE and GCF

	India		PRC		Difference/Intercept		Coefficient	
Period	GFCE	GCF	GFCE	GCF	GFCE	GCF	GFCE	GCF
1991–2000	0.65	–0.31	2.21	0.01	0.65 (0.47)	–0.31 (–0.13)	1.56 (0.80)	0.32 (0.09)
2001–2010	–0.71	4.47	–1.40	3.39	–0.71 (0.59)	4.47** (2.20)	–0.69 (–0.41)	–1.08 (–0.38)
2011–2019	0.79	–3.03	6.32	–0.82	0.79 (0.88)	–3.03** (–2.54)	5.53 (0.42)	2.21 (1.31)
1991–2019	0.22	0.49	0.69	0.91	0.22 (0.32)	0.49 (0.40)	0.47 (0.47)	0.42 (0.24)

**implies significant at the 5% level. (The figures in the parentheses represent the t-statistics.)

Source: Authors' estimation from the WDI data.

Figure A4: Trends of EX and FDII



Source: Authors' illustration based on the WDI data.

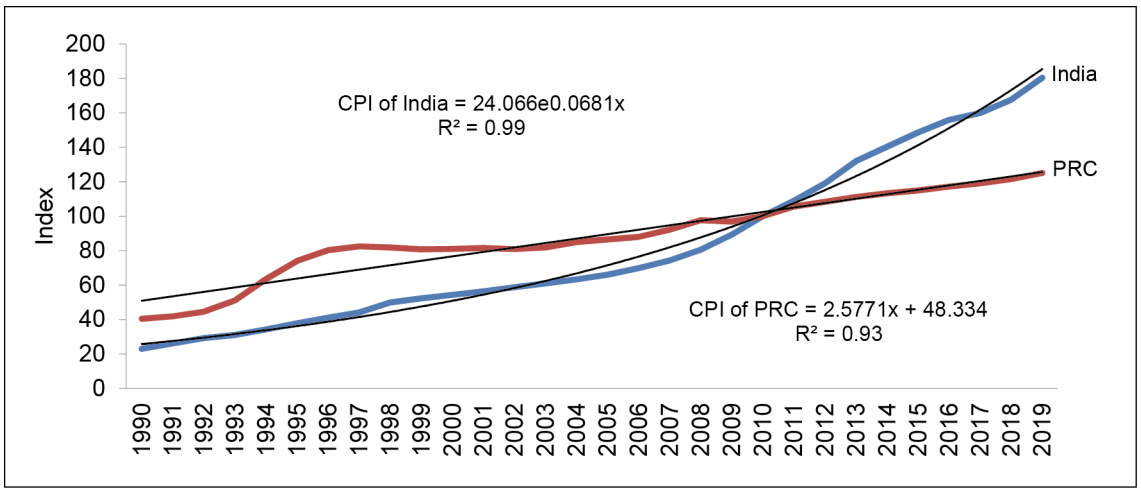
Table A4: AAGR of EX and FDII

	India		PRC		Difference/Intercept		Coefficient	
Period	**EX**	**FDII**	**EX**	**FDII**	**EX**	**FDII**	**EX**	**FDII**
1991–2000	6.52	49.90	4.58	23.04	6.52* (2.20)	49.90***(2.07)	–1.94 (–0.62)	–26.86 (–0.79)
2001–2010	6.08	18.30	3.45	3.71	6.08 (1.64)	18.30 (1.34)	–2.63 (–0.50)	–14.59 (–0.76)
2011–2019	–1.76	2.83	4.20	–11.82	–1.76 (–0.93)	2.83 (0.43)	–2.44 (–0.91)	–14.65 (–1.59)
1991–2019	3.80	24.40	1.47	5.56	3.80** (2.24)	24.40** (2.45)	–2.33 (–0.97)	–18.84 (–1.34)

*, **, and *** imply significant at the 1%, 5%, and 10% levels, respectively. (The figures in the parentheses represent the t-statistics.)

Source: Authors' estimation from the WDI data.

Figure A5: Trend of CPI



Source: Authors' illustration based on the UNCTAD data.

Table A5: Annual Average Growth Rate of CPI

	India	PRC		
Period	**CPI**	**CPI**	**Difference/Intercept**	**Coefficient**
1991–2000	9.05	7.48	9.05* (4.40)	–1.57 (–0.54)
2001–2010	6.33	1.56	6.33* (7.44)	–4.17* (–3.47)
2011–2019	6.81	2.53	6.81* (9.96)	–4.28* (–4.43)
1991–2019	7.41	3.26	7.41* (8.71)	–3.31* (–2.75)

* Implies significant at the 1% level. (The figures in the parentheses represent the t-statistics.)

Source: Authors' estimation from the WDI data.

APPENDIX B

Table B1: Results of the Panel Unit Root Tests

	ADF (Fisher χ^2)		ADF (Choi Z stat)		Levin–Lin–Chu		Im–Pesaran–Shin	
Variables	Level	First Difference	Level	First Difference	Level	First Difference	Level	First Difference
LPCGDP	0.830	17.725*	2.970	–2.549*	–0.139	–2.322*	2.952	–2.932*
LMD	13.627*	12.883*	–2.576*	–2.195*	–0.801	–3.378*	–2.516*	–2.304*
LID	39.400*	14.326*	–5.426*	–2.698	–7.252*	–1.940**	–6.459*	–2.656*
LPCEPC	0.910	6.223	1.238	–0.917	–0.820	0.570	0.751	–0.100
LR&D	1.027	25.461*	1.206	–4.135*	0.119	–3.166*	1.173	–4.568*
LGFCE	10.224**	11.184**	–2.010**	–2.029**	–1.240***	–1.616**	–1.908**	–2.017**
LEX	5.815	13.687*	–0.951	–2.493*	–1.970**	–1.432***	–0.901	–2.508*
LGCF	3.582	13.336*	–0.214	–2.525*	–0.683	–1.090	–0.221	–2.499*
LEYS	1.099	11.025**	1.270	–1.301***	–0.700	–1.031	1.036	–1.479***
LFDII	3.094	29.956*	1.642	–4.443*	1.759*	–5.460*	1.588	–5.237*
LCPI	0.226	27.252*	2.261	–4.060*	0.834	–4.576*	1.769	–4.596*

	Breitung		PP (Fisher χ^2)		PP (Choi Z stat)	
Variables	Level	First Difference	Level	First Difference	Level	First Difference
LPCGDP	1.400	–1.483***	2.379	19.065*	3.124	–2.775*
LMD	0.893	–1.017	18.882*	18.291*	–2.050**	–2.244*
LID	–1.463***	–6.735*	12.898*	24.752*	–1.981**	–4.023*
LPCEPC	1.238	–1.017	1.983	10.053**	0.397	–1.773**
LR&D	0.804	–3.568*	1.355	26.214*	0.980	–4.219*
LGFCE	–0.930	–3.471*	3.807	13.169*	–0.408	–2.471*
LEX	2.216	–5.545*	5.926	28.323*	–1.015	–4.365*
LGCF	–0.670	–2.856*	3.063	28.723*	–0.075	–4.289*
LEYS	1.506	0.132	0.338	15.570*	1.978	–2.809*
LFDII	2.292	–2.393*	8.612***	28.531*	–1.658**	–4.286*
LCPI	–1.313***	–1.165	8.941***	9.744**	–1.271***	–1.831**

*, **, and *** imply significant at the 1%, 5%, and 10% levels, respectively.

Source: Authors' computation from the WDI, UNCTAD, and UNDP data.