Do the Chinese provinces have achieved their potential efficiency in Economic Growth?

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ABSTRACT

Most of the economic growth is concentrated on eastern, coastal provinces of China, while the western and central provinces have not yet experienced the expected economic growth. This study addresses the following research questions: have central and western provinces achieved the potential efficiency in economic growth? Have China's provinces used their resources effectively in implementing economic growth strategies? The research design concerns using panel dataset on province-specific economic growth in China over the years of 2000-2020. The methodology used is the stochastic frontier GDP model with time-varying technical efficiency over time. The approach is to use the existing literature to identify the important variables influencing economic growth at the provincial level to model the stochastic frontier GDP model for empirical analysis.

This study concludes that the Central provinces show the highest rate of efficiency in economic growth, though not 100%, followed by Eastern and Western provinces. By increasing and improving skilled education institutes and intensifying supply chain opportunities through FDI, the Central provinces achieving 100% growth efficiency may not be ruled out. The modes of economic governance and policies to increase efficiency-led growth have been rapidly changing from increasing incentives to improving competition. Thus, more unique avenues and expansion of the horizon for impending research on provincial, national, and international macroeconomics would

emerge that would make current methodologies of the growth analysis outdated. To the authors' knowledge empirical analysis examining the Chinese province-specific economic growth efficiency has not been carried out using the recent Chinese panel dataset.
Key words: China’s provincial economic growth, stochastic frontier GDP model, GDP growth efficiency, China.

1. Introduction

Chinese economy has developed fast since the country's entry into WTO in 2001. China successfully reduced its poverty levels from 75.5% in the 1970s to a virtual 0% in 2020 (World Bank, 2023). However, most economic development has been concentrated in the Eastern region of China including Beijing, Shanghai, Jiangsu, and Shenzhen. The existence of inequality of economic development between the Eastern and Western provinces is evident. The economic development of inner Western regions like Ningxia, Qinghai, Tibet, and Hainan is relatively backward. Steps are being taken to develop the Western regions, like infrastructural upgradation and incentives for private industries- one of the landmark achievements has been the building of an elevated rail route that connects Tibet Autonomous Region to Qinghai province, which brings down the average travelling journey by around 80% and connects 34 major cities (Gao and Li, 2022). But the Western provinces are nowhere near the developed Eastern provinces even after the government's upgradation. Meanwhile, recognizing the importance of the central provinces as the geographical and economic links between the eastern and western regions, the Chinese government, in 2004 had announced its plan to accelerate the economic development of the central provinces. Furthermore, in the 13th 5-year plan of 2016, more emphasis was given on economically strengthening the central provinces (Yuan, 2019).

In the light of the above purview, the main objective of this paper is to measure the efficiency of the economic growth process of the 31 Chinese provinces and

examine the factors that can be identified as important at the provincial level in achieving their potential growth. The next section reviews the literature and determines the indicators for the economic growth of the provinces. The methodology is explained within a theoretical framework in the third section. The fourth section discusses the results of the empirical model used to measure the efficiency of the economic growth process for the 31 provinces of China. The fifth section concludes this study by identifying specific economic policies that need to be initiated for the provinces to reach their potential growth levels.

2. Literature Review

Ang (2018) carried out a study on the capital and industrial investments that were taking place in the central and western poorer provinces in China that had started in the early 2000s. The author admits there was a delay in the policies taken by the government for the inner provinces. These investments mainly by the State Owned Enterprises (SOEs) in China's five provinces namely Anhui, Henan, Jiangxi, Hunan, and Hubei and by the collective enterprises through the central government, which started concentrating on the inner provinces' development. In 2004, Chinese premier Wen Jiabao inaugurated the "Rise of Central China" campaign to reduce the income disparities between the central and eastern states (Lai, 2007, p. 121). Provincial Investments became a significant source of regional economic growth in the inner provinces.

Further, on the industries' impact, Cheung (2010) examined the effects of technology on the Chinese domestic industries and their performance in innovation. Cheung argues that the provinces' local state-owned and private firms benefitted from the technology spill over through the foreign firms. Along with foreign firms, the technology-led exports by the local industries increased, thereby increasing the value-added GDP. Due to increased competition, many private firms made efforts through R&D to produce international quality innovative products to survive and profit in the domestic market. Cheung concluded that with the increased R&D and

technological advancements, domestic and private enterprises could imbibe the ability to develop Chinese homegrown indigenous technology and innovations. It was expected that those developments would lead to the GDP development of local provinces and, subsequently, the GDP development of China.

Foreign direct investment (FDI) is crucial for a developing country. China is the best example of an FDI-led growth economy. As of 2022, China has received US$189.13 billion in FDI inflows (PRC State Council, 2023). Recognising the importance of FDI in regional development, Tuan and Ng (2004) reviewed the FDI and the related economic growth in China at its provincial level. The authors constructed the data of cross-provincial ones from China's 29 provinces and performed a two-staged system of equations test with OLS estimates to get empirical results. The authors concluded that China's FDI inflows went to the sections with more incredible economic growth, specifically the coastal areas and the special economic zones (SEZs). The authors also argued that higher educational attainment has been one of the main factors that persuaded investors to invest in certain provinces. The study also demonstrated that the higher infrastructural developments in the central and western areas would encourage regional investments and attract more companies to help create more jobs. Educational attainment would be essential since most companies used high-end technology, and higher-skilled education would be crucial to run the machinery based on those technologies. The coastal provinces with skilled labour through higher education have been China's primary beneficiaries of inward FDI. The implication is that regional and central governments should make specific efforts to increase the output level of these FDIs. If more FDI comes into the regions, there will be higher educational enrolment, and the GDP of the province shall grow subsequently.

Taking on the importance of FDI further, Wei and Liefner (2012) scrutinise the impact of FDI based on the geographical locations of the Chinese provinces. The authors believe that the FDI inflow is mainly from profit-oriented MNCs. Location-related factors like land availability, closer port access, labour availability,

educational rate, and infrastructure determine the investor's decision to invest. Wei and Liefner (2012) acknowledge that the FDI is distributed unevenly. Though land availability and labour are more costly in the developed coastal cities of Shanghai and Shenzhen, around 80-85% of the total FDI in China flows into those regions. Companies are finding newer locations, but these locations never go beyond the Pearl River Delta, Yangtze Delta region and Beijing's industrial corridor with Tianjin. Investments are taking place in the inner areas of China, but the local adaptability, home-host relationships, infrastructure, and government policies need to improve. The regional dynamics related to investment and procedures are often made according to location-specific areas with a varying geography, settlements, local population needs and social welfare. But these policies might hamper profit-oriented investments in coastal China, which is more metropolitan and has higher living standards.

Since the regional disparities of China caught the attention of academia, Chen and Zheng (2008) argue that the regional programmes for development launched in 2003 and 2004 have substantially benefited the inner regions of China. China's interior and eastern provinces are in comparative terms with coastal areas, especially in land prices and availability. The labour is relatively cheaper in the inner regions. The authors term the internal areas of China as a vast potential investment land for foreign investors and private industries. However, the government cannot redistribute the incoming FDI since, more than the government commands, the market-driven forces of supply and demand decide the direction of the FDI. Xu *et al*. (2013) observe that implementing the government's regional policies takes a severe setback. This implementation is reduced daily due to a lack of skilled labour, educational enrolment, and investors' high confidence in coastal and SEZ areas. This has only raised income disparities in China. The income inequalities can be reduced only though developing the inner regions of China through institutional reforms, professional education, and proper implementation of investor policies (Zhou and Song, 2016).

After the country’s reform in 1979, there was a wave of privatisation, and many private sector enterprises emerged in telecom, electronics, aviation, and ports. Private

investment in China's industrial and service sectors grew significantly. The share of the private sector in China's industrial sphere is 42.8% as of 2022 (Huang and Veron, 2023). Taking the importance of domestic private enterprises in China, Li *et al*. (2012) studied private business entrepreneurship on China's economic growth. The authors compiled a cross-sectional dataset of 29 Chinese provinces and used the regression technique of the system generalised method of moments for empirical results. The author's study concluded that private enterprises played a significant positive role in the economic growth of Chinese provinces. Private industries are generally profit-oriented. The promotions and appointments in these sectors are purely based on merit and performance records. These industries try to maximise their output value by using the minimum input value, thereby increasing the productivity of labour employed. More output enables private sectors to compete in global industrial markets. Proper incentives given to private industries can motivate them to invest in the inner and eastern Chinese provinces. The capital-output ratio and trade within the Chinese provinces' domestic market provide an appeal for the investment portfolios in the region (Ma *et al*., 2017). Increased domestic trade value in domestic areas attracts private investors since these players already have a robust local market to sell off their output. Private investment in Chinese provinces shall help the economic growth of the region.

Taking an outlook from a different angle, Cai (2020) takes the demographic dividend as a driver of China's economic growth and its provinces. China gained a lot through its young population after the reforms. All the SOEs, private industries and foreign industries got young and skilled labour force cheap. China's population growth was so high that in 1980, the government imposed a One Child Policy on families. However, with an increasingly ageing population coupled with a substantial increase in FDI inflows, the government lifted the One Child Policy in 2016. As the working age population starts ageing, the performance of human labour tends to decrease, productivity seems to be slowing down with the declining TFP. The gross output of industries has been decreasing. Cai (2010) also predicted that China had

reached the Lewis point in the demographic dividend it enjoyed, and China's advantage in having a young population will end in 2013. The current average age of China as of 2020 was 37.4 and is predicted to reach 40 in 2025 and 50 in 2050, which is a dangerous sign for economic growth in Chinese provinces and rural areas (Textor, 2023). The government should provide incentives for increasing the population's birth rate so that the FDI keeps flowing in China and private and SOE investments increase. The population factor is a golden opportunity for China's eastern provinces since, due to the high cost of living in coastal areas, the population birth rate is slowly increasing in locations like Shanghai and Shenzhen. Investments can be diversified and raised in eastern provinces since these provinces enjoy a demographic divided into comparative terms domestically.

Based on the existing literature, it can be assessed that for measuring the economic progress of a province, the GDP at current prices can be accepted as a vital sign of economic growth. Apart from that, population, the value of SOEs, the value of private enterprises, the value of FDI, higher educational enrolment, and domestic trade value can affect the GDP of 31 Chinese provinces and the central provinces in specific. Notably, the above literature and academia have been measuring the value of GDP determinants using some empirical models on how GDP determinants affect GDP growth. In this paper, we try to fill in the gap in the literature by measuring the efficiency of the economic growth process of the Chinese provinces.

3. Methodology and Framework

The size of any economy is typically measured by the total production of goods and services in the economy, which is generally referred to the gross domestic product (GDP). In other words, GDP is total value added from goods and services produced within the economy. How does the concept of efficiency enter into economic growth process? Efficiency of economic growth reveals the quality of production potential, which is the peak level of performance that uses the least number of inputs to achieve the highest amount of output using the existing technology. Hence, the GDP

efficiency indicates whether the economy is able to achieve its production potential by utilizing its resources and production capacity such that the utility derived is its maximum.

The theory of the stochastic frontier production function popularised by Aigner *et al*. (1977), and Meeusen and Van Den Broeck (1977) facilitates measuring the GDP efficiency. Drawing on the theory of the stochastic frontier production function, the above-cited studies demonstrated how to measure the average production efficiency of a group of firms. However, what would be interesting is to measure the firm-specific production efficiency of a group of firms. Jondrow *et al*. (1982) and Kalirajan and Flinn (1983), each developed a method to measure the individual firm-specific production efficiency along with the average efficiency of a group of firms. The individual province-specific GDP efficiency is measured by dividing the actual GDP divided by the potential GDP of each province for each year. The weighted average is taken that gives the efficiency rate of the province of its GDP performance.

Drawing on the time-varying stochastic frontier production function model suggested by Battese and Coelli (1992), in which it is assumed that the technical efficiencies of firms would either monotonically increased or decreased or remained constant over time. Hence, the theoretical framework followed in this paper is as follows:

$$\ln GDP_{ct} = \ln f(Y_{ct}) + v_{ct} - u_{ct} \quad (1)$$

Where, 'ln' is the natural logarithm; GDP is the actual Gross Domestic Product of province c at the time period t; and f (Y_{ct}) is the function of Y_{ct} in natural logarithm, wherein Y_{ct} is the determining variable or independent variable of the province 'c' that affects the GDP_{ct}, in the t^{th} period.

v_t is the 'statistical error' term that has a normal distribution with an average mean of zero and constant variance, σ_v.

The non-negative error term 'u' indicates that the actual GDP has not reached the

potential GDP due to many province-specific constraining factors. It is distributed as a truncated normal distribution truncated at zero with a mean (μ) and constant variance σ_u.

Now introducing the varying technical efficiency over time concept (Battese and Coelli, 1992), it is defined that

$$u_{ct} = (\eta_{ct} u_c) = \{[\exp-\eta (t-T)]\} u_c, \text{ and } t = 1,2,..T. \quad (2)$$

This model implies that the non-negative firm effects, u_{ct}, decrease, remain constant or increase as t increases, if $\eta > 0$, $\eta = 0$ or $\eta < 0$, respectively.

When the province-specific non-negative error term 'u' is equal to zero, it implies that the actual GDP is equal to the potential GDP of the concerned province. Therefore, the GDP efficiency (θ) is defined as the ratio of the actual GDP to the estimated potential GDP and it varies between 0 and 1.

$$\theta = \frac{\ln f(Yct) + vt - ut}{\ln f(Yct) + vt} \quad (3)$$

Table 1 presents all the variables used in the model. Additionally, the stochastic frontier gravity model has some assumptions that need to be considered:

a) The provinces have not achieved the potential GDP growth, and the actual GDP is below the potential.

b) Some domestic factors are hindering the Chinese provinces from achieving the potential growth rate.

Table 1: Variable descriptions

Variables	Definition	Measurement Units	Expected Value
GDP	The total GDP of the Chinese province at the given period of time	Per million Yuan at Nominal Prices	Positive
Population	The total number of population of the Chinese province at the given year	Per 10,000 person	Positive

SOE value	The total gross output value of the SOE at a given year of period in Chinese provinces	Per million Yuan at nominal prices	Positive
private value	The total gross output value of private enterprises at a given period of year in Chinese provinces	Per million Yuan at nominal prices	Positive or Negative
FDI value	The total gross output value of FDI companies in Chinese provinces at a given period of year	Per million Yuan at nominal prices	Positive or negative
domestic trade value	The total value and stock of the domestic trade in Chinese provinces at a given period of year	Per million Yuan at nominal prices	Positive

Source: National Bureau of Statistics of PRC

Then, the empirical model is given as below:

$$\ln GDP_{it} = \Omega_0 + \Omega_1 \ln population_{it} + \Omega_2 \ln SOEvalue_{it} + \Omega_3 \ln privatevalue_{it} + \Omega_4 \ln FDIvalue_{it} + \Omega_5 \ln highereducationenrolment_{it} + \Omega_6 \ln domestictradevalue_{it} + v_t - u_t \quad (4)$$

4. Empirical results and discussions

Table 2 shows the results for the whole country. A statistically significant eta (η), which is built in the estimation software (STATA), with positive value means that the constraints that were hindering the actual GDP to reach the potential GDP declined over the period of analysis. If η is significant and negative, it implies that the constraints have been increasing over time. If the estimate of η is not statistically significant, it indicates that the GDP efficiency is stagnant and has neither increased or decreased over time.

Tabel 2 reveals that the estimates of γ, μ, and η are statistically significant at the

1% level. γ 's significance denotes that the stochastic frontier gravity model best suits the panel dataset used in this paper. It also indicates that the gap between the Chinese provinces' actual and potential GDP is quite large. μ's positive value confirms that the assumption of the truncated normal distribution for the province-specific random error ‘u’ is valid for this data set. η is positive, which means that during 2000-2020, the gap between the provinces' actual GDP and potential GDP has been narrowing, proving that China is paying substantial attention to the development of the eastern and central regions.

Table 2: Results of the estimation of the stochastic frontier growth model

Variable Name	Estimated Coefficients
Constant	14.0086***
	(1.147826)
Population	0.4050445***
	(0. 0481231)
SOE value	0. 1409822***
	(0. 0226459)
Private value	0.0528022***
	(0.0099891)
FDI value	0.0406848***
	(0.0123765)
Higher Education Enrolment	0.1807266***
	(0.0296402)
Domestic Trade Value	0.0775788***
	(0.0138949)
Gamma (γ)	0.6713298***
	(0.0688914)

Mu (μ)	3.236942***
	(0.8669325)
Eta (η)	0.0169996***
	(0.004119)
Total Number of Observations	651

Notes: (1) ***, **, * denote significance at 1%, 5%, and 10% respectively.
(2) The standard errors are reported in the parentheses.

The estimate of the population is significantly positively impacting the GDP. This proves that increasing China's population would increase GDP confirming the demographic dividend that China would enjoy. In this context, it is worth nothing that China's economic rivals like India and Vietnam are enjoying the demographic dividend having a very young average median age of 28.4 and 32.5 as of 2020 (O'Neill, 2021). Chinese policymakers should ensure that China doesn't become the upcoming Japan since the latter cannot cope with the vast ageing population. There might arise a possibility that some of the manufacturing industries might shift to India and Vietnam instead of diversifying in the eastern and western provinces of China.

State Owned Enterprises have a positive value on the province's GDP that is statistically significant. The SOEs have contributed to the Chinese provinces' employment and economic development since the founding of the PRC. These Chinese SOEs are merging with private, foreign, and smaller SMEs and increasing their output value. These are competing both at the provincial and national levels and globally too. The profits of these provincial SOEs are used for the development of the respective province as well as for reinvestment to make the SOE bigger just as the successful Eastern Development programme (Jia *et al*., 2020). China's SOEs are also one of the most critical job providers in many regions.

Private Industries are profit-centric. Since the SOEs in China get preferential treatment with subsidies and land availability, these private industries fight hard to survive and make profits in the market, which is done through the use of technology and innovation. But in this process, they fully utilise the labour that increases labour productivity and TFP. Such industries employ skilled labour, which raises the demand for educated youth that increases the government's attention to raising the standards of education, health and social welfare of the province. Since the demand for skilled employment is increased, the wages would increase, thereby increasing the standard of living. Private enterprises would make full use of labour, increasing the labour output and Efficiency (*Li et al*., 2012). In this process, the private enterprise's output value rises, increasing the respective province's GDP.

The values of the estimate of FDI are statistically significant. Delis and Kyrkilis (2017) have concluded, using the spatial distribution and ANOVA analysis that China's FDI is concentrated in Special Economic Zones (SEZs) and in coastal cities since these are closer to the ports facilitating international trade. The FDI is getting diversified properly in the Chinese regions. Since the FDI inflow into China, which is mainly concerned with the product assembly process, is vital for international business, it is crucial in the GDP development of the provinces.

Many private investments and SOEs are moving towards technology, innovation, and high-end quality products. Especially after China signed the 2001 WTO accession and the FTAs with ASEAN and entered into RCEP, China has liberalised its service sector like finance, banking and IT sector to an enormous extent; there are many public-private partnerships in technology and R&D sector as well (Jones and Bloomfield, 2020). These sectors need to be diversified in Chinese provinces. Particularly the, R&D and related enterprises require skilled, educated labour that can handle machines, data analysis, policy initiation and digitalised financial transactions. Higher educational enrolment includes vocational and undergraduate education in 31

Chinese provinces. When a province is recognised with its high-level performance of its education sector, more and more industries will look forward to investing in those provinces, thereby creating employment, which would contribute to the GDP of the respective province.

A solid domestic trade value of a province indicates the quality of living standards of the region. It also gives a green signal showing the high purchasing power of the province's population. Each sector and industry like to invest in an area with a robust domestic market. A strong domestic market is one of the virtues that China's economy has maintained. Due to this virtue, China survived the 2007 GFC and the COVID pandemic maintaining a strong economic growth rate (Gunay *et al*., 2021). The domestic trade value increases with the domestic market transactions. A strong domestic market value for any province increases the economic activities, which fuel the province's economic growth.

Most indicators identified as the determinants of increasing the GDP growth rate in 31 Chinese provinces have shown statistically significant empirical results. But the actual GDP value of the GDP has not reached the potential value. Table 3 shows the Efficiency of economic growth (θ) defined in equation (2) of 31 Chinese provinces as a ratio of the average actual GDP value to the average potential GDP value for the years 2000-2020.

Table 3: Results of the estimates of the provincial GDP growth efficiency

Province	Average Actual GDP in natural logarithm figures	Average Potential GDP in natural logarithm figures	Average Potential Efficiency
Beijing	27.77826936	31.37616857	0.885330193
Tianjin	27.29717451	31.05162	0.879090189
Hebei	28.16171083	31.94001048	0.881706374

Shanxi	27.28980573	31.35770429	0.87027435
Inner Mongolia	27.38090803	31.00183143	0.88320292
Liaoning	27.94464689	31.7888219	0.879071485
Jilin	27.24143802	31.26345857	0.871350748
Heilongjiang	27.50388681	31.39466667	0.876068763
Shanghai	28.02770808	31.54788667	0.888417927
Jiangsu	28.8866983	32.35933905	0.892685053
Zhejiang	28.4845166	31.93617524	0.8919201
Anhui	27.74414461	31.7707181	0.87326149
Fujian	27.93408781	31.50852476	0.886556512
Jiangxi	27.42498649	31.44981524	0.872023771
Shandong	28.80913907	32.4153519	0.888749848
Henan	28.30388677	32.16462143	0.879969529
Hubei	28.00616889	31.91619667	0.877490798
Hunan	27.95439393	31.78668667	0.879437175
Guangdong	28.98036685	32.4574019	0.892873895
Guangxi	27.48545183	31.42851619	0.874538641
Hainan	25.93552933	29.79372095	0.870503197
Chongqing	27.2641338	31.25119333	0.872418967
Sichuan	28.05360523	31.95412714	0.877933705
Guizhou	26.81802392	31.02926429	0.864281656
Yunnan	27.26549082	31.37028714	0.869150183
Tibet	24.63413284	28.41136667	0.867052019
Shaanxi	27.42131166	31.43026381	0.8724493
Gansu	26.59230097	30.89549667	0.860717704
Qinghai	25.44050166	29.48021238	0.862968737
Ningxia	25.5871334	29.75643857	0.859885612
Xinjiang	26.91046518	30.84451238	0.872455523

However, the country level analysis may not reflect the heterogeneous growth pattern that exists across the provinces effectively, which necessitates a regional analysis of growth dividing China into- Central, Eastern and Western provinces. The Eastern areas are near the coast and more developed. Figure 1 shows the provinces of China.

Figure 1: Eastern, Central and Western provinces in China (UNICEF, 2023)

Since China's regions are classified into three groupings, we extend the stochastic frontier growth modelling to the three groupings and their respective provinces. Table 4 provides the estimates of the stochastic frontier growth model for the three different regions of China specifically.

Table 4: Results of the estimation of the regional stochastic frontier growth Model

Variables	Western provinces	Central Provinces	Eastern provinces
Constant	18.52548***	5.533093***	10.8922***

	(4.608904)	(1.993919)	(2.215607)
Population	0.2389274***	1.001613***	0.5996908***
	(0.081489)	(0.1189365)	(0.0454041)
SOE value	0.1545911***	0.1447596***	0.1026654***
	(0.039387)	(0.0399625)	(0.0307911)
Private value	0.0791201***	0.0796698***	-0.0181089
	(0.0151762)	(0.0194681)	(0.0175124)
FDI value	0.0269136*	-0.0268432	0.1214816***
	(0.015353)	(0.0344388)	(0.0301014)
Higher-Education	0.2686862***	0.0575035	0.1237361***
Enrolment	(0.0510281)	(0.052491)	(0.0410842)
Domestic Trade Value	0.0441028*	0.0258089	0.1289474***
	(0.0235512)	(0.0215066)	(0.0224496)
Gamma (γ)	0.582879***	0.5070059***	0.2605186**
	(0.1206582)	(0.19105)	(0.1189736)
Mu (μ)	6.090058	1.502569***	3.125491
	(4.512076)	(0.3613668)	(2.200163)
Eta (η)	0.0093463	0.0376872***	0.0163474
	(0.0065883)	(0.0072861)	(0.0101312)
Observations	252	175	231

Notes: (1) ***, **, * denote significance at 1%, 5%, and 10% respectively.

(2) The standard errors are reported in parentheses.

The results of the in-built estimators of gamma are statistically significant for all the estimations for western, eastern, and central provinces (Table 4). A statistically significant gamma indicates that the constructed panel dataset best suits the stochastic

frontier gravity model analytical framework; and that the model is best suited for the constructed panel dataset. The μ and η are statistically not significant for western and eastern provinces. There is a need for a rigorous on field primary research for gathering more appropriate data on the constraints that are impairing the GDP of the western and eastern provinces from reaching its maximum potential level. However, the μ and η for the central provinces are significant that gives the evidence that during the period of 2000-2020, the gap between the actual GDP and the potential GDP closed significantly.

After differentiating the provinces into three different sections, the sub modelling gives different empirical results shown in Table 4 that further explain the GDP growth of the eastern, western, and central provinces. The western, central and eastern provinces show the average GDP growth efficiencies of 79.95%, 92.49% and 88.18% respectively. These growth efficiencies are in line with the actual economic developments taking place in China across the different regions. These efficiency rates are healthy but should be more properly maintained to achieve the fullest potential possible. These efficiency rates are evident of the fact that the resources needed for economic developments are getting diversified and used in a well-organised manner resulting in sustainable growth patterns. McDowall *et al*. (2017) argued that though China is a developing country, the nation is efficiently achieving the aim of becoming a circular economy and its performance is better than the European countries.

The Central Chinese Provinces have shown the highest rate of GDP efficiency out of all three regions. This shows that the 2004 Plan for "Rise of Central China" has been successfully implemented, and the central provinces have been adequately looked after by the central government, and there is a proper central-provincial-county level coordination in the implementation of the initiated policies (Yuan, 2019). The 13th five-year plan in 2016 also outlined the central government's policy to focus on the economic development of the Central Chinese provinces (NDRC, 2016). The

average efficiency of the Central Chinese provinces has been above 90% indicating that the implementation of the policies outlined in the 2004 plan and 2016 plan have been fully implemented successfully. Though the central provinces are in transition, their growth efficiency performance have become leading examples of the Chinese provincial economic growth efficiency model for other transition economies' within around the world.

It is important to note that the FDI value, higher education enrolment and domestic trade have not yielded significant results on the GDP growth for Central China. From the empirical results, it can be understood that most of the FDI industries have been invested in the eastern provinces and western provinces, the latter getting renewable energy investments due to availability of land and high altitudes. Zhu *et al*. (2019), in their study on financial inclusion of Chinese regions due to FDI, used the Hotelling model and concluded that there was negative spatial spill over effects on the Central provinces of China. The educational enrolment has unexpectedly shown statistically insignificant estimate. This might be an indication on the lack of skilled education institutes in the central provinces. Zhu *et al*. (2018) had carried out a study on the panel data of six central provinces economic growth determinants and had concluded that the contribution of the education was less than 5% to the economic growth and yielded insignificant effects on the educational quality level in the central provinces. Due to better opportunities in eastern China and concentration of a significant FDI industrial growth in the coastal regions, a lot of educated youth might be migrating to eastern China SEZs for acquiring better career opportunities (Xia *et al*., 2022).

Hence, there is a direct causal relationship between FDI, and education combined on the economic growth at the provincial level. More than the FDI, there are domestic private industrial investments in Central China due to the incentives provided by the central and provincial government in the 2004 policy and 13th five-year plan. The domestic trade of Central China needs to improve through an

appropriate establishment of efficient provincial supply chain that would help the market forces of demand and supply to function more effectively. Liu *et al*. (2020) advocated that the enhanced supply chain responsibilities through interactions, diversifications and incorporations would impact positively in the community development, especially rural areas of the Central provinces of China.

5. Conclusions and Policy implications

This study has conducted a productivity survey of China's 31 provinces by measuring the GDP growth efficiencies of the provinces. The empirical results have indicated that the Chinese government has been improving economic development across all regions of China. The study also concludes that the gap between the potential GDP growth and the actual GDP growth has been narrowing over time at the national level, which means that the efficiency in GDP growth increased yearly from 2000-2018. However, the performance of the GDP growth efficiency at the regional level shows a different picture. Supported by empirical evidence, this paper also gives policy recommendations for improving the GDP growth and efficiency of economic growth for all 31 provinces of China.

On the national front, the future growth aspects of China should be concentrated on improving the growth efficiency of the 31 provinces. Economic development should be diversified across all provinces, GDP growth should be made more efficient. As the empirical model suggests, none of the Chinese provinces have achieved 100% growth efficiency. The growth efficiency figures estimated by the model are heterogeneous and vary across the provinces by regions. Though the eastern provinces are the most developed provinces with SEZs and ports, it has more potential to grow its GDP growth efficiency than the central provinces. The eastern provinces exhibited 85%-88% efficiency, while the central provinces showed 90%-92% efficiency. By increasing and improving skilled education institutes and intensifying supply chain opportunities through FDI, the central provinces achieving 100% growth efficiency

may not be ruled out.

The western provinces have the highest potential to grow its GDP growth efficiency and policies discussed in recommendations should be made effectively implemented to achieve the growth potential. It is important to observe that the Central provinces, which are in transition, had effectively closed the gap between their actual GDP and potential GDP over time. This is evident from the positive and significant μ and η. However, the growth efficiency performances of the eastern provinces, which are the developed region, and the western provinces, which have been under-developed, were stagnant as μ and η were not significant during the period of analysis. This warrants further analysis, which is beyond the scope of this paper due to the lack of proper data.

Besides using GDP to represent the economic growth process, the possibility of other limitations of this study may not be overlooked. For example, in the dynamic, diversified world, the modes of economic governance and policies to increase efficiency-led growth have been rapidly changing from increasing incentives to improving competition. Hence, the growth patterns have been shifting throughout history and, without doubts, will shift in the future. Thus, more unique avenues and expansion of the horizon for impending research and study on provincial, national, and international macroeconomics would emerge that would make current methodologies of the growth analysis outdated.

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