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Research Article

China's potential economic growth rate and forecast 2024-2030: Based on endogenous technological progress model

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ABSTRACT

This paper makes an in-depth analysis of China's economic growth model, focusing on the effect of endogenous technological progress on the production function. Adopted endogenous technological progress on the production function. It is found that in the process of expansion, the stock scale of physical capital and human capital fails to give full play to its due scale effect or spillover effect. In addition, the report extends the endogenous growth model and explores China's real production function and total factor productivity (TFP). This paper also assesses financial efficiency, economic growth rates and their potential growth rates, and forecasts potential economic growth for 2024-2030. On the whole, China's economic growth faces many challenges, but there is also huge potential for development. By optimizing resource allocation and enhancing scientific and technological innovation capabilities, it is expected to further improve the efficiency and quality of economic growth. Looking ahead, China's economic development will continue to maintain a sound momentum of stability and contribute more impetus to global economic growth.

1. INTRODUCTION

The first quarter of 2024 is coming to an end. Since the emergence of the economic turning point in 2023, the growth center of China's economic growth rate has shifted down significantly, indicating that the analytical framework that solely relies on inertial extrapolation and trend reversal is no longer sufficient to accurately capture and predict the long-term economic development dynamics. According to the current economic development trajectory, 2023 can be regarded as another important inflection point after the "L-shaped" economic judgment of 2016. It is expected that after 2024, China's economy will show a zigzag development trend with fluctuations centered on 4.5%. In the early years of the implementation of the 14th Five-Year Plan, the overall performance of China's economic growth was not satisfactory due to the interwoven influence of multiple external factors. The market holds different views on the future economic growth prospects, highlighting the urgency and importance of accurately measuring future potential economic growth in the current economic environment.

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China's economy has undergone rapid growth and transformation over the past few decades, and technological advances and improvements in financial efficiency have been cited as key factors driving this process. The purpose of this paper is to review the main research results, development trends and existing problems on the relationship between China's economic operation status, technological progress and financial efficiency, and to forecast the future research direction

Technological progress is one of the important factors to promote economic growth (Solow, 1962; Galor & Tsiddon, 1997). Numerous studies have explored the contribution of technological progress to China's economic growth. Zhang, et al. (2020), found that the contribution rate of technological progress to China's economic growth increased significantly, especially the development of high-tech industries. In addition, Kelly et al. (2021), pointed out that the effect of dry learning in the process of capital deepening and the accumulation of human capital played a key role in improving production efficiency. However, Szymkowiak et al. (2021), also pointed out that although the government has adopted a series of policy measures to increase the capital stock, the capital has not been fully transformed into the driving force of economic growth due to inefficient resource allocation.

Financial efficiency is another key factor affecting economic growth (Louis et al., 2021). In recent years, there are more and more researches on the relationship between financial efficiency and economic growth. Guillaumont et al. (2006), analyzed the development of China's financial market and found that the improvement of financial efficiency could significantly promote economic growth. However, Chortareas et al. (2013), pointed out that the financial chaos existing in financial system, such as the over-strong role of shadow banking and the irregular use of funds by financial institutions, led to the reduction of financial efficiency. Edmans et al. (2016), further emphasized that optimizing financial structure and improving financial efficiency are the key to promoting the sustained and healthy growth of China's economy.

There is a close correlation between technological progress and financial efficiency (Lau & Brada, 1990). On the one hand, technological progress has promoted the innovation and development of the financial industry and improved financial efficiency. On the other hand, the improvement of financial efficiency also provides more financial support for technological progress (Zhang et al., 2006). However, there are still few researches on the correlation between technological progress and financial efficiency. Future studies can further explore the interaction mechanism between the two and how to promote technological progress and economic growth by optimizing financial structure and improving financial efficiency.

Although some achievements have been made on the relationship between technological progress, financial efficiency and economic growth, there are still some problems. First of all, the specific mechanism and influence path of technological progress and financial efficiency still need to be further studied. Second, with the change of the global economic environment and the adjustment of China's economic structure, the relationship between technological progress and financial efficiency and economic growth may also change.

Therefore, future research needs to pay attention to these changes and make corresponding policy recommendations.

2. CHINA'S ECONOMIC GROWTH MODEL

Since China's reform and opening up and the resumption of college entrance examination, both physical capital accumulation and human capital accumulation have experienced the simultaneous development of "quantity and quality". By 2023, China's capital coefficient (physical capital /GDP) is 3.54, the average years of education of the stock labor force is 11.05 years, and the average years of education of the new labor force is 14 years, which is close to the level of developed countries.

2.1. ENDOGENOUS TECHNOLOGICAL PROGRESS PRODUCTION FUNCTION

The source of technological progress of endogenous economic growth theory comes from "learning by doing" in the process of capital deepening and "learning by education" brought by human capital accumulation. As for the setting of national production function, it is necessary to introduce endogenous technological progress into the production function. The model Settings based on the above paper are as follows:

$$Y_t = A\exp(\mu_1(K_t/K_0)^{\nu} + \mu_2(H_t/H_0)^{\lambda})H_t^{\alpha}K_t^{1-\alpha}$$

Y_t, H_t and K_t are the gross national output, human capital stock and physical capital stock during t respectively. K_0 is the capital stock of the base period, H_0 is the human capital stock of the base period, parameters ν and λ represent the scale effect of capital and human capital respectively.

3. DATA SOURCE AND VARIABLE SELECTION

The time range is 1997-2023, and the starting point is 1997 because 1997 is the new stage of China's market-oriented reform.

GDP: "Gross Domestic product" in the Statistical Yearbook of China over the years.

Human capital stock: With the education index method, the average educational level of all employed people can be used as a proxy variable of per capita human capital stock. In competitive market, human capital reward reflects the labor productivity of employees to some extent, and the wage reward of employees is positively related to the labor productivity of employees. About human capital stock measurement, this paper press type calculation of human capital stock: $H_t = L_t * \ln(h_t)$, among them, the h_t human capital stock per capita.

Physical capital stock: Due to the lack of property statistics in the statistical yearbook, physical capital stock data need to be calculated based on investment and depreciation data. The general method is the perpetual inventory method, $\mathrm{K}_t = \mathrm{I}_t + (1-\delta_t)\mathrm{K}_{t-1}$, where $\mathrm{I}_t$is the new fixed capital input each year. δ_t is the capital depreciation rate for the period t.

4. REGRESSION RESULTS

4.1. TYPICAL FACT OF CHINA'S ECONOMIC GROWTH 1: IN THE PROCESS OF EXPANSION, THE STOCK SCALE OF PHYSICAL CAPITAL AND HUMAN CAPITAL FAILS TO EXERT ITS PROPER SCALE EFFECT OR SPILLOVER EFFECT EFFECTIVELY

The regression results in table 1, show that the stock scale of physical capital and human capital in the process of expansion has not effectively played its due scale effect or spillover effect. This means that although the government has tried to stimulate economic growth by increasing the capital stock, this capital has not been fully transformed into a driving force for economic growth due to the lack of efficient resource allocation and reasonable utilization mechanisms. In the face of external shocks, the interaction effects of scale effects and ad-hoc impacts on physical capital and human capital (i.e. regulation effects) are particularly important when exploring the dynamic mechanism of China's economic development.

Table 1. Regression results

Variable	OLS
lnh	0.434
	(1.163)
lnk	1.151
	(1.671)
lnKlnKtK97	-0.400
	(1.658)
lnHlnHtH97	-0.412
	(1.234)
_cons	-7.463
	(26.480)
N	27
adj. R^2	0.998

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.2. EXTENDED ENDOGENOUS GROWTH MODEL

Through the careful observation of China's factor input production function from 1997 to 2023, combined with the in-depth analysis of the actual economic operation, a crucial typical fact is revealed. When the economy faces external shocks, the government tends to adopt a series of policy measures, such as increasing investment or adjusting the enrollment rate and training scale of higher education. The essence of these measures is to expand the stock size of physical capital or human capital and interact with external shocks, thus indirectly affecting the subsequent total factor productivity. However, while these efforts seem reasonable, the actual results have been less than satisfactory. Endogenous technological advances need to be introduced into this production function. The model Settings based on the above paper are as follows:

$$Y_t = A\exp(\gamma_1 adhocimpact_t + \mu_1 adhocimpact_t * \ln(K_t/K_0) + \mu_2 adhocimpact_t * \ln(H_t/H_0))H_t^{\alpha}K_t^{1-\alpha}$$

Where $adhocimpact_t$ is the interaction effects of scale effects and ad-hoc impacts on physical capital and human capital.

Table 2. Regression results

Variable	OLS
lnkh	0.729***
	(0.006)
impacts	-0.043***
	(0.012)
impactsk	-0.016
	(0.023)
impactsh	0.362
	(0.274)
_cons	-0.567***
	(0.010)
N	27
adj. R^2	0.999

*Standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01*

The regression results in table 2, show that the increase of investment scale and the increase of education scale expand at the same time after the impact, and there is a collinearity, which indicates that the accumulation of physical capital and the accumulation of educational capital are completely substitutes, and cannot play a complementary role.

The simultaneous expansion of investment scale and education scale after external shocks may indeed exhibit certain collinearity. This collinearity implies that physical capital accumulation and educational capital accumulation show substitution effect rather than complementary effect to some extent.

Specifically, when the economic system faces external shocks, such as policy adjustments and market demand changes, enterprises and individuals may increase investment in physical capital (such as production equipment, infrastructure, etc.) and educational capital (such as education input, human resources training, etc.) at the same time. This phenomenon of simultaneous expansion may be due to the fact that investors believe that both can improve production efficiency and economic performance to a certain extent, thus forming a competitive relationship in resource allocation.

4.3. The Actual Production Function of China's Economic Output

Considering the expansion of human capital scale and physical capital expansion, there is a complete substitution relationship in the current stage of China, which also causes the collinearity of the above analysis. A variable is retained to reestimate the extended endogenous production function. The estimated results are shown in table 3 below.

For the results of regression, all the coefficients are significant at the significance level of 1%. For the capital elasticity coefficient, the regression results of the two models are both 0.73, once again verifying the validity of China's production function based on endogenous technological progress.

Table 3. Regression results

Variable	Capital size effect	Scale effect of human capital
lnkh	0.725***	0.727***
	(0.006)	(0.005)
impacts	-0.034***	-0.039***
	(0.010)	(0.011)
impactsk	0.014**	
	(0.005)	
impactsh		0.178***
		(0.058)
_cons	-0.561***	-0.564***
	(0.009)	(0.009)
N	27	27
adj. R^2	0.999	0.999

*Standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01*

Based on the regression results in table 3:1997-2023 China input-output relational expression is as follows:

$$Y_t = \exp(-0.036 adhocimpact_t - 0.561 * (K_t/K_0)^{0.0157 * adhocimpact_t}) H_t^{0.27} K_t^{0.73}$$

4.4. China's Total factor Productivity (TFP)

By analyzing the distribution map of total factor productivity (TFP), this paper reveals the power source and changing trend of China's economic growth in recent years. As an important index to measure the quality of economic growth, the change trend of total factor productivity is of great significance to understand the internal mechanism of economic growth.

According to the distribution map of total factor productivity given in Fig. 1, China's TFP shows a fluctuating trend from 1997 to 2023. Specifically, after reaching a high level in 1997, there was a sustained decline in TFP between 1998 and 1999, which may be related to the economic restructuring at that time, slow technological progress, and the adverse impact of the external economic environment. Subsequently, from 2001 to 2007, thanks to the technology spillover effect brought about by China's accession to the WTO, TFP showed a steady upward trend, indicating that China's economic growth momentum was gradually increasing. However, the global economic crisis in 2008 had a great impact on China's economy, leading to fluctuations in TFP in the following years. It is worth noting that after 2015, although the global economic environment is still complex and volatile, China's TFP as a whole has shown a stable recovery trend. This shows that the quality of China's economic growth is gradually improving, and the contribution of technological progress, institutional reform and other factors to economic growth is increasing. In addition, the government's efforts in recent years to promote innovation-driven development, optimize the industrial structure, and improve the efficiency of factor allocation have also achieved positive results.

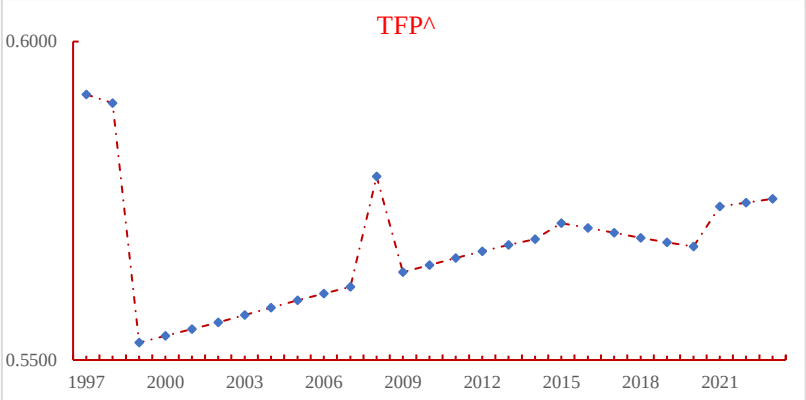

Fig. 1. China's Total factor Productivity (1997-2023)

However, it should be noted that the fluctuation of TFP is still large, which reflects that China's economic growth still faces many uncertainties and challenges. In the future, China should continue to deepen reform and opening up, strengthen innovation-driven, and optimize factor allocation to improve the stability of total factor productivity.

4.5. Financial Efficiency

The profit-maximizing marginal output of firms is higher than the average return on capital in the market in Fig. 2, and by 2022 the marginal output of capital is 21.1%, compared with the average return on capital of 9%, with a median difference of nearly 12%. This 12% of the flow is the depletion of the financial system, which is nested in layers. In terms of production effect, the financial industry belongs to the service industry, and there is no final product production effect, and the return on capital of 12% is obtained by the financial system, which is indeed a little too much. Excluding the capital iladequacy ratio and some unnecessary risk shocks, financial institutions took 3% to 5% of the risk bearing, which was appropriate enough, but now take an extra 7% to 9% of the yield, which is also the root cause of financial chaos. Advisory fees for bond issuance financing, various intermediary fees for corporate loans, etc., have increased the marginal output of enterprise production. It is imperative to reform the financial system to release the pressure on enterprises. In particular, the role of various shadow banks should be weakened, the use of funds by financial institutions should be regulated, the expansion of financial products and corporate financing channels should be accelerated, and the proportion of various corporate loans from banks should be reduced.

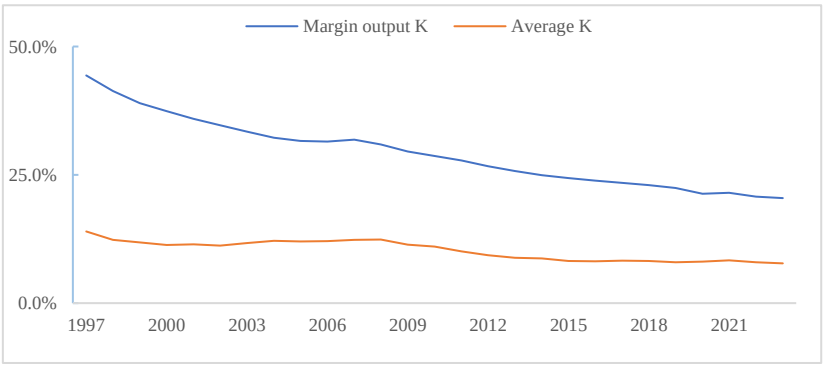

Fig. 2. China's Margin output

The change of financial efficiency reflects the quality of the financial system and its interaction with the real economy. Based on the measured data, financial efficiency showed a certain trend of fluctuation during the period from 1997 to 2023 in Fig. 3.

In terms of the overall trend, financial efficiency was relatively high between 1997 and 2003, but then gradually declined from 2004 until reaching a low point in 2008. The decline in this period may be related to changes in the global economic environment, the shock of the financial crisis, and structural problems in the domestic financial system. The occurrence of financial crisis leads to financial market turbulence and credit contraction, thus affecting financial efficiency.

Then, starting in 2009, financial efficiency gradually recovered, reaching a relative high point in 2015. The rebound in this period may be related to the advancement of financial reforms, the gradual opening up of financial markets, and the popularization of financial services. The adjustment at the policy level and the improvement of the market environment have created favorable conditions for the improvement of financial efficiency.

Since 2016, financial efficiency has again shown a trend of fluctuating decline. This may be affected by multiple factors such as the complex and changeable economic environment at home and abroad, the adjustment of financial regulatory policies and the intensification of competition in the financial market. Especially in recent years, global economic uncertainty has increased and financial market volatility has increased, which has had a certain impact on financial efficiency.

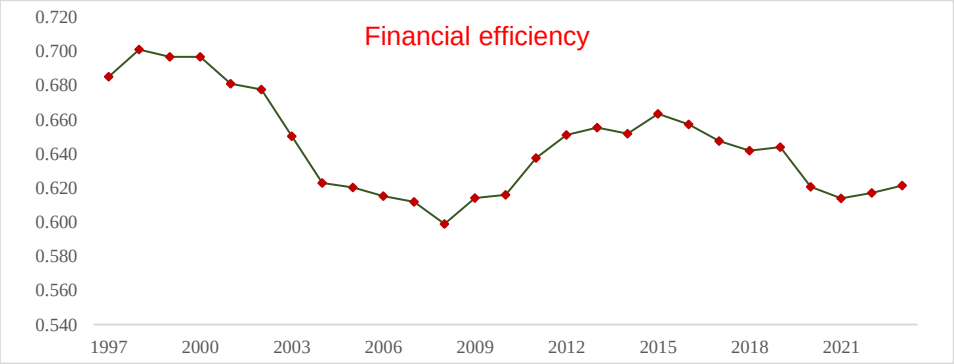

Fig. 3. Financial efficiency

It is worth noting that, despite fluctuations in financial efficiency, it has remained above a certain level as a whole. This shows that China's financial system has certain resilience and stability in responding to various challenges and risks. At the same time, it also reflects the continuous optimization and improvement of the financial system to provide more efficient and convenient financial services for the real economy.

4.6. Breakdown of Economic Growth Rate and Potential Growth Rate

The estimation of China's economic growth function shows that the three factors affecting GDP, physical capital stock, human capital stock and TFP, can further decompose the source of GDP increment, and the contribution degree of each factor can be obtained in Fig. 4. Due to the improvement of production organization and management level,

economic and political system reform, institutional changes and other changes are difficult to observe. Therefore, after deducting the contribution of capital input, labor input and TFP, the contribution of unobservable value to economic growth can be obtained.

The calculation results show that capital accumulation has been the main contributor to economic growth since 1997, and its contribution rate far exceeds that of labor input and TFP. The contribution of the human capital stock to the economy is positive, but the contribution has been low and began to show a negative effect in 2019. The contribution of total factor productivity to economic growth is bounded by 2008, and then it is negative for most years of economic growth.

As can be seen from the figure, China's potential GDP growth rate was basically at a high level from 1997 to 2011, and since 2012, the potential growth rate has gradually declined, while the actual GDP growth rate has basically fluctuated within the potential GDP growth rate. The gap between the actual growth rate and the potential growth rate can clearly reflect the cyclical fluctuations of China's economy. It is more consistent with our macro-economic experience. Since 2012, actual economic growth has slowed in line with potential growth, and the output gap has gradually narrowed. This may indicate that the characteristics of the real economic growth rate during this period are mainly caused by the decline in potential economic growth rate, so the decline in real economic growth rate is not cyclical, but a long-term trend

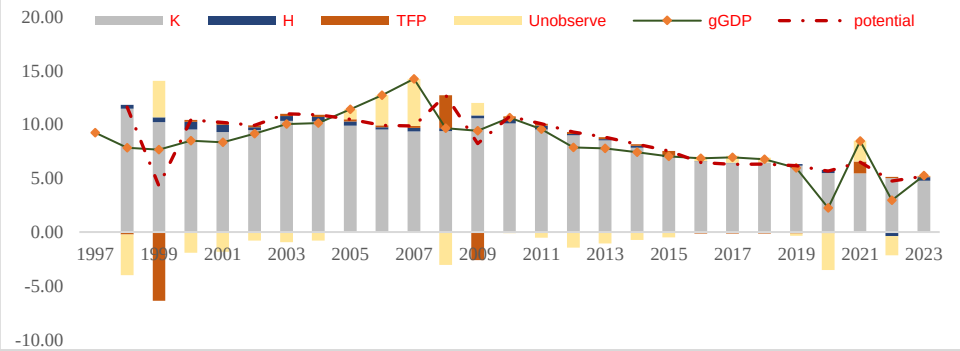

Fig. 4. Breakdown of economic growth rate and potential growth rate

4.7. Estimates of Potential Economic Growth in 2024-2030

Assuming that the international environment has not undergone major changes, domestic inflation fluctuates within the normal range, capital and labor are fully utilized, and potential output is calculated in Fig. 5.

In the period 1997-2023, China's GDP growth rate has shown a significant downward trend. In particular, from the peak of 14.23% in 2007, the growth rate gradually declined to 5.25% by 2023. This change reflects the transformation of China's economy from a high-speed growth stage to a medium-speed growth stage, and also reflects the combined impact of economic restructuring, industrial upgrading and changes in the global economic environment.

In the decade 2013-2023, the change in GDP growth rate is even more significant. From 7.77% in 2013, the growth rate has declined continuously, and the decline has accelerated

especially after 2015. Although there was a brief uptick in 2021 (reaching 8.45%), it then fell back quickly. The change in growth rate during this period was influenced by multiple factors at home and abroad, including global economic fluctuations, domestic industrial restructuring, trade frictions, and the impact of the COVID-19 pandemic.

Measuring the potential growth rate, the GDP growth rate forecast for 2024-2030 remains at a relatively low level and shows a trend of stable fluctuations. Specifically, the growth rate fluctuated between 4.5 and 4.8 per cent, with no significant rise or fall. The forecast reflects that China's economy has gradually entered a relatively stable stage of development after undergoing a period of adjustment and transformation.

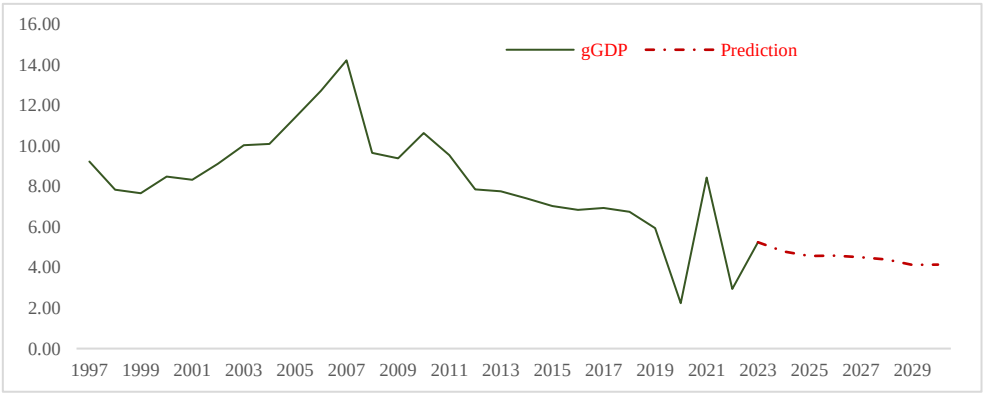

Fig. 5. Potential economic growth in 2024-2030

Compared to the 1997-2023 period, and especially the 2013-2023 period, the projected GDP growth rate for 2024-2030 shows the following characteristics:

1. Increased stability: Compared with the large fluctuations of previous years, the growth rate forecast for 2024-2030 is more stable, with no clear upward or downward trend.
2. Medium-speed growth becomes normal: China's economy has gradually adapted to the new normal of medium-speed growth, and the growth rate forecast for the next few years also reflects this trend.
3. The influence of internal and external factors is still significant: Although the forecast growth rate is relatively stable, the global economic situation, domestic policy adjustments, technological innovation and other factors may still have an important impact on the actual growth rate.

5. CHINA'S ECONOMIC FORECAST:

Based on the conclusion of this analysis: Share the forecast of China's economic future.

1. 2023 should be a new inflection point since the "L-shaped 2016" economic argument, and the economic growth rate after that should be a wave development of 4.5%.
2. In analyzing the current economy, we should abandon the traditional thinking of starting from the aggregate demand (troika) and trying to stimulate demand, and should understand that the root cause of the L-shaped long tail of the Chinese economy is that the potential growth rate has fallen.

3. The fundamental structural contradiction of China's economy is the capital efficiency problem caused by capital misallocation. It is necessary to reform the investment system to solve the problem of excessive investment and excessive entry caused by industrial stimulus policies.
4. Looking at the future Chinese economy from an international perspective, it is necessary to promote high-level opening-up, strengthen technical cooperation and technical exchanges, attract high-quality and high-tech enterprises to build factories and expand production in China, and fully absorb the inflow of technology rather than capital.
5. The government should share more of the burden of households, restrain the rise of precautionary savings ratio, increase the share of labor remuneration in national income, create domestic market and stimulate growth potential.

Author Contributions:

This research does not contain any studies with human participants performed by any of the authors. As a single author, all phases of this research were done by me.

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Conflicts of Interest:

I declare that I have no financial and personal relationships with other people or organizations that can inappropriately influence my work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of the manuscript entitled.

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