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Simulation of the Necessary Macro TFP Growth and its Feasible Dual Circulation Source Pathways to Achieve China Economic Vision Goal: A Dynamic CGE Study

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Abstract: An ambitious per capita GDP target has been envisioned by the Chinese government since 2020 to project its sustainable economic growth rate by 2035. Can China fully achieve its goal? This is a question worth investigating. By inserting relevant TABLO modules of the final goods trade, the intermediate goods trade, and factor-strengthening technology spillovers, along with technology absorption thresholds effects of the global value chain, this study builds a global dynamic recursive computational general equilibrium (CGE) model on basis of GTAP-RD. This approach allows considering the 'dual circulation' system strongly advocated and pointed out as the sole way to realize China's technological (total factor productivity (TFP)) progress by the Chinese government, which integrates both domestic internal and international external circulations (trade and foreign direct investment (FDI)). We simulate China's technological progress under eight scenarios, and use the latest GTAP Version 11 production and trade data (released in April 2023) for 141 countries and regions and results are aggregated into 10 countries groups with 9 activity sectors and 10 commodities. Main conclusions are as follows: (1) If China maintains its trade opening policy, the 2035 vision goal can be achieved, with external circulation being more important than internal circulation for technological spillovers. (2) The economic growth impacts of external and internal circulation operate relatively independently. However, FDI provides a relatively larger synergistic effect for all forms of external trade circulation than to the internal one. Regarding factor-strengthening effects, spillovers are more favorable to 'capital' than to labor factors. (3) We find that the Regional Comprehensive Economic Partnership Agreement is the most important strategic partner for China. (4) It appears that FDI is not an effective way to lift the productive services sector's total factor productivity (TFP), and more realistic for China is to open up the productive services market more widely, as its efficiency is a pivotal reflection of China's independent innovation capability. (5) China–US decoupling has an enormous global impact. In all the Scenarios we consider, the United States is always the country that loses the most, and Europe would be the group of countries that benefits when there is a large increase in TFP in the US.

Keywords: global value chain; total factor productivity; dual circulation; dynamic recursive general equilibrium; vision goal

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I. Introduction

The issue of China's economic growth is under the spotlight of global attention as its been an important sustainable and stable strength to the world. From the time it joined the World Trade Organization, China's account for the world GDP has rose from 4% to more than 18% of 2023, and average contribution to global economic growth has been close to 30% during this more than two decades period (WEO, 2024), making it a crucial engine for driving global economic continuity.

However, during the period from 2012 to 2015, China's average growth rate center started to decline to the range of 7-8%, from what China had in 2001 through 2011 with average growth reaching 10.46%. with an average of 7.53%. From 2016 to 2019, it further declined to the range of 6-7%, averaging 6.6%. This is the phenomenon we called as 'new normal.' Nowadays the growth center rate of China has been in an unprecedented state of uncertainty , impacted by the aftermath of the

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pandemic, global supply chain restructuring, and turbulence in China's real estate market. Actually in 2020-2023, the average growth was only 4.7%. So can China keep its sustainable growth trend? This is a question that China's government must answer to the world.

In October 2020, the Fifth Plenary Session of the 19th Central Committee of the Communist Party of China (CPC) officially announced the Suggestions of the CPC Central Committee on Formulating the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Vision Goals of China for 2035, which emphasized the goal of achieving the per capita level of medium-developed countries by 2035. It also pointed out that achieving this goal constitutes a strategic deployment of building a new high-quality development pattern that promotes domestic and international dual circulation. Furthermore, the Political Bureau of the CPC Central Committee conducted the eleventh collective study on the afternoon of January 31, 2024, pointing out that "advanced productive force, with a significant increase in total factor productivity (TFP) as its core indicator, is an intrinsic requirement and key focus for promoting new high-quality development"(XINHUA news, 2024) . Hence, "medium-developed per capita goal," "high-quality development" and "significant increase in TFP" are considered to be synonymous terms.

What is the specific standard for the per capita level of medium-developed countries in 2035? According to the World Bank, for the current 2025 fiscal year, the threshold standard for high-income economies is defined as a gross national income (GNI) per capita of USD 14,005. It was USD 13,845 for the 2024 fiscal year and USD 13,205 for the 2023 fiscal year. The above Figure 1 shows that the per capita GNI arithmetic average of the high-income group (86 countries) was USD 48,224 in 2023, USD 51,087 in 2022 (83 countries), and USD 47,887 in 2021 (81 countries). The median of this high-income group reached USD 32,000 in 2021, excluding countries with a population lower than 1 million (Gao Shanwen, 2022).

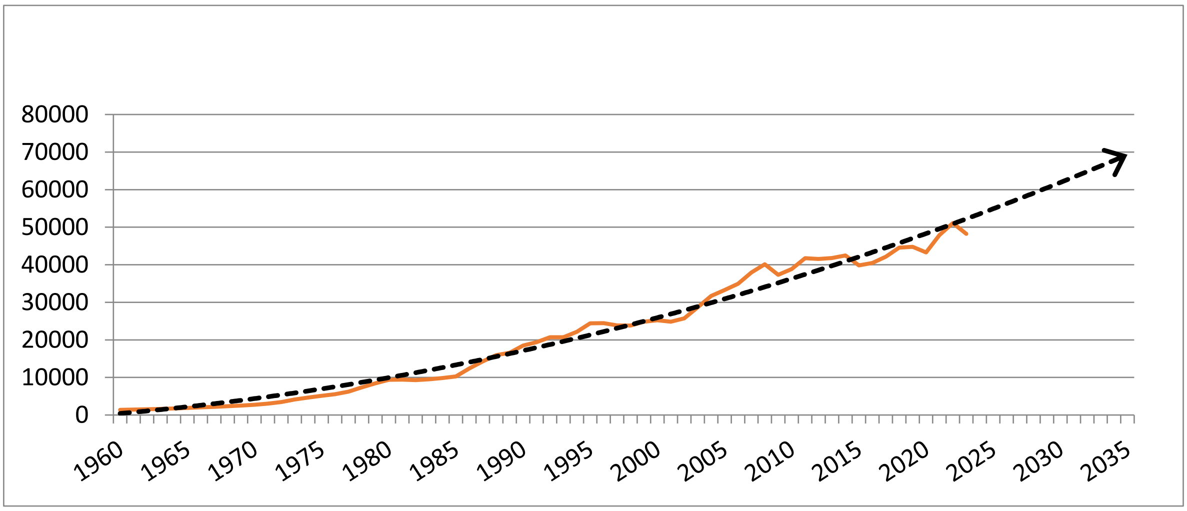

Figure 1. Trend of the average gross national income (GNI) per capita for the high-income group of countries (USD, current value). Source: World Bank. https://ourworldindata.org/grapher/world-bank-income-grou.ps

Although there is no direct conversion relationship between the arithmetic average of high-income countries, the median, and the China Communist Party(CCP)'s expected level for medium-developed countries, the former can serve as evidence for determining the range of the latter. According to Figure 1, the steady trend of the arithmetic average of that country group indicates that the value for 2035 would be at least USD 55,000, with the median conservatively estimated to be at least USD 40,000. On this basis, we could define the medium-developed country level for 2035 as a range of USD 30,000–45,000 per capita. According to the Center for International Economics Information (CEPII), France, Purchase Power Parity (PPP) conversion, if the 2011 US dollar/Renminbi value is taken as 1, then 2024 would be 1.43, and 2035 would be 1.79, with 1.79/1.43 = 1.25 serving as the basis for our conversion ratio between the 2023 US dollar and the 2035 US dollar, which is the accumulation inflation of the US dollar during this period as measured using renminbi. When converted using the CEPII PPP, the medium-developed country level for 2035 is equivalent to USD 24,000–36,000 in 2024. The actual value of China's per capita gross domestic product (GDP), calculated based on the average exchange rate in 2023, is USD 12,681 (RMB 89,400). Therefore, if we combine the US dollar/Renminbi setting of the CEPII PPP conversion ratio of 1.25 and work backward from the target of achieving the aforementioned per capita GDP range by 2035, China would need to achieve an average annual real growth of 5.48%–9.08% from 2024 to 2035, over a span of 12 years.

12681*（1+5.48%）12*1.25= 30068

This calculation is based on the assumption of a constant population. The premature arrival of negative population growth in China in 2022 might allow for the additional relaxation of the 5.48% target; however, this research still uses 5.48% as our economic growth goal, as we have retained a good deal of flexibility when setting the lower bound of the medium-developed country GNI per capita level interval.

Taking a holistic approach to the aforementioned goal, strategic deployment, and the key focus of the CPC, this study establishes a computational global dynamic recursive general equilibrium model to rationalize the 'vision goal' and its key concerns through 'dual circulations and total factor productivity (TFP)', namely, the international spillovers and independent domestic innovation of technological progress. We rationalize it in relation to various simulated Scenarios to test the feasibility of such growth targets in China.

The structure of the remainder of the article is as follows: Part II, Literature Review and Theoretical Analysis; Part III, Methodology; Part IV, Results; Part V, Analyses and Discussion; Part VI. Conclusions.

II. Literature Review and Theoretical Analysis

This section explains why we would make some innovative changes to the base model and why and how we should take some specific variables to shock in this paper. We will go over mainly some fundamental studies which may seem old and have been done long time ago, and already make themselves parts of common-accepted theoretical analyses, because structural changes of base model made in this study needs foundation of solid and systematical accumulations of theories. And also we would review some latest literature examinations published in this era as well, while baseline, aggregations and coefficients issues sometimes need to follow latest steps of researches. But one thing needs to be clarified is that since CGE projection is quite a case by case job, we did not find same theme paper to be reviewed in literature which means this study is complete original in the sense of simulation structure and purpose.

Overall, classical global technology ladder theories suggest three main patterns of technological advancement future for a country like China: the first involves internal circulation, while the second and third relate to external circulation.

A. Consumer-driven independent innovation approaching the technological frontier

For developing countries, despite its high costs, the model of independent innovation is a mode of technological progress that ensures national economic security during the process of technological catch-up. Thus, when a country has already approached the world technological frontier and cannot obtain more technological spillover through external circulation, the question arises as to where the internal motivation for independent innovation comes from.

The answer lies in the consumer market, where the process of meeting market demands also promotes the growth of the country's TFP. Traditionally, consumption has been considered a negative factor for TFP as it is regarded as the opposite variable to investment and capital formation. However, Foellmi and Zweimüller (2006) first constructed a model within the framework of endogenous growth theory that links consumers of different types with the pricing and innovation behaviors of monopolistic companies. Their research shows that, as income increases, the hierarchical climb in consumer preferences leads to an expansion of the corresponding market scale, directly providing momentum for product innovation. To some extent, this proves the adage that demand creates supply.

Foellmi et al. (2009) extended the aforementioned model to a more general field of process innovation, proving that, even without disruptive hierarchical increases in consumption, the upgrading of consumption among people below the median income level, driven by the advancement of income equalization, will promote innovation in product processes. A Consumption-led Growth model was built to explore the relationship between trade and current account openness and growth and answer a question of catching-up economy borrow like Argentina or Spain can grow like China or not (Brunnermeier, M. et. al., 2021). Their model exhibits a force by which the aggregate innovation rate λ is increasing with trade surpluses and decreasing with trade deficits. The highest tradable productivity growth can be achieved when the initial tradable productivity is low and the country runs a trade surplus. More interestingly, the country innovates faster when there is an asymmetry in the productivity levels across sectors. Xuewen Liu and Sichuang Xu (2023) also found when the market of new consumption varieties emerges, the rising demand drives the incentives of domestic innovation, resulting in technology progress and cost reduction.

Another question concerns the extent to which China's burgeoning middle class and its consumption will drive TFP growth. On the micro level, Beerli et al. (2020) used China's income distribution as an instrumental variable for the future market share, along with independent variables such as the price and quality of durable goods, to explain changes in R&D investment and labor productivity at the micro-enterprise level. The results show that a 1% change in the market share leads to a 4.4% increase in R&D, a 6.5% rise in micro labor productivity, and an increased probability of successful product innovation. On the macro level, Tian Youchun et al. (2021) calculated China's macro TFP based on industrial panel data, showing that, from 1991 to 2002, China's TFP growth mainly originated from the secondary industry, with an average annual growth of 10.17% in the TFP of the secondary industry alone. From 2005 to 2014, both the secondary and tertiary industries made contributions to TFP growth, with the average annual growth of the secondary industry's TFP dropping to 6.38%, and the tertiary industry catching up to an average annual growth of 5.49%, with a trend towards equal contributions in the future. The increased contribution of tertiary industry to TFP is mainly due to the growth of consumer-driven service industries. Therefore, it is possible that, in the future growth of China's macro TFP, 'internal circulation' will be a model led by consumer-driven service industries.

B. Technological progress through international investment: threshold effects and forward and reverse spillovers

Romer (1986) pointed out in his classical model that developing countries can learn and imitate advanced foreign technologies by utilizing international capital flows to narrow the technology gap, which is a practical choice. His model brings about a direct TFP growth effect due to increased capital accumulation. Subsequently, some research conclusions emphasize the accumulation of physical capital itself (Hymer, 1976; Thompson, 2008; Borensztein et al., 1998; Azman-Saini et al., 2010; Cooray et al., 2014; Slesman et al., 2015); others highlight the effect of human capital accumulation (Borensztein et al., 1998); and some provide positive conclusions about human capital accumulation in China (Eaton and Kortum, 1996; Xu, 2000; Caselli and Coleman, 2001).

In addition to the direct growth effects, foreign direct investment (FDI) also generates indirect TFP spillover effects from the industry to the overall economy. Romer (1986), Li and Liu (2005), Woo (2009), and Baltabaev (2014) all affirmed the macro TFP promotion effect of FDI. Görg and Greenaway (2004), Saggi (2002), Fosfuri et al. (2001), and Javorcik (2004) analyzed the specific pathways through which FDI promotes macro TFP growth, such as demonstration and imitation functions, the promotion of labor mobility, and forward and backward economic linkages.

The research has also considered whether there is any connection between the aforementioned increase in macro TFP from spillovers and the direct TFP effect of FDI. The answer to this question introduces another concept: the threshold effect of technology absorption. Abramovitz (1986) and Baumol et al. (1989) first proposed the issue of the host country's absorption capacity. Coe et al. (1997), Li et al. (2001), Liu et al. (2001), Wei and Liu (2001), Buckley et al. (2002), Hu and Jefferson (2002), Huang (2002), and Liu (2002), all conducted studies based on Chinese data; these studies concluded that the threshold effect does indeed exist in China. Studies conducted by Fosfuri et al. (2001) and

Meryer and Sinani (2009) show that FDI is associated with human capital and macro TFP, whereby human capital is a key threshold factor determining the host country's ability to digest and absorb technology. Kima et al. (2012) classified 122 countries and used data from 1989 to 2008 for an empirical analysis, finding that the greater the economic gap between the host country and the investing home country, that is, the greater the North–South effect, the more obvious the TFP promotion effect of FDI. Mastromarco and Simar (2018) showed that another gap between the host country and the investing home country, i.e., the size of the economy, is also a factor that affects the technology spillover effect.

The pattern of international capital flows also involves reverse spillover effects, meaning that outward direct investment (ODI) can also promote the improvement of labor productivity in the home country. Herzer (2010) used a cointegration panel to analyze data from 33 developing countries from 1980 to 2005 and concluded that ODI is beneficial to the macro TFP growth of developing home countries in the long run, revealing the following mechanism: horizontal or market-oriented ODI improves the related service exports of developing home countries, such as R&D, design, and marketing strategies. Pottelsberghe and Lichtenberg (2001) found that technology-seeking ODI from developing countries can enhance the long-term macro TFP of the home country through the spillover of the host country's R&D stock weighted by ODI. Vertical ODI, specific asset and technology-seeking ODI, and natural resource-seeking ODI can improve the macro TFP of the home country by reducing its production costs and promoting its intermediate goods exports (Herzer, 2008), bringing brands, marketing networks, and technology to the home country (Pottelsberghe and Lichtenberg, 2001), and enabling it to benefit from natural resources in terms of TFP dynamics (Dunning, 1998).

Latest researches concerning international investment’s direct and indirect roles in host country or reverse spillover in home country include:

C. Technological progress through international trade: threshold effects and forward and reverse spillovers

Romer (1986) pointed out that international trade is an important source of macro TFP growth for developing countries, namely, the so-called trade technology spillover (or embodied technology spillover) pathway. Since the 1990s, international trade has entered the era of global value chains (Baldwin, 2011). The United Nations Conference on Trade and Development recognized for the first time in the 2013 World Investment Report that global value chains have been formed; it pointed out that more than 60% of global trade, totaling more than USD 20 trillion, is trade in intermediate goods.

Meijl et al. (1999) divided trade technology spillovers into two pathways: one is technological progress, which is a Hicks-neutral pathway, obtained through final product trade; the other is technological progress obtained through the intermediate goods trade. Coe et al. (1997) used data from 77 developing countries and 22 developed countries from 1971 to 1990 to illustrate that the import of intermediate goods and machinery and equipment itself implies the digestion and absorption of the home country's R&D investment, design, and technical blueprints. This effect is not limited to this product or industry but also generally applies to technology transfer, process introduction, and the improvement of management skills through the use of imported goods and the host country's imitation of the new embodied technologies, which is ultimately reflected in the improvement of macro TFP.

Meijl et al. (1999) also pointed out that trade technology spillovers have a threshold effect, and the human capital of the importing country, as well as the R&D capacity, knowledge infrastructure, and the economic structure gap between trade partners, all affect the effectiveness of the spillover. Das (2009) demonstrated the existence of the threshold effect. Building on this, Coe et al. (2008) further clarified that the national system is the key variable determining whether other countries' R&D investment can be transformed into the host country's macro TFP through trade technology spillovers.

Bournakis et al. (2017) proved that, under the global value chain, both import and export trade are ways to achieve technology spillover; that is, the trade technology pathway also has the reverse effect of reverse technology spillover. Empirical studies conducted by Coe and Helpman (1993) and

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Coe et al. (1995) show that trade partners' technological progress is strongly dependent on each other's R&D investment, and the bidirectional effect also exists. Sjoholm (1996) verified that trade volume is a robust explanatory variable for both trade partners citing each other's patents. Many other studies (Navaretti and Tarr, 2000; Keller, 1997; Coe et al., 1997; Coe and Helpman, 1995; Das, 2002 and 2003; Eaton and Kortum, 1996) have also proven that industries and sectors that rely more heavily on relatively complex intermediate goods imports will derive more benefits from trade technology import spillovers.

Unlike investment-type technology spillovers, traded goods, as tangible items, can be used and interact with other factors of production aside from capital, thereby generating "factor-strengthening" characteristic spillover effects, which refer to "labor-strengthening" or "land-strengthening", concepts first proposed by Hicks (1932). Meijl et al. (1999) found that, when certain productivity growth occurs in the chemical and machinery sectors of Europe and North America, it affects agricultural production in other regions of the world through "labor-strengthening" and "land-strengthening" technology diffusion. The speed of technological progress in the importing country can even exceed that of the place where the technology originated; for example, when technological progress occurs in Europe, the impact on Japan is the greatest; meanwhile, technological progress in the United States has the greatest impact on Australia (Hans van Meijl and Frank van Tongeren, 1999).

III. Methodology

A. Model and Innovation

The model in this study is based on the dynamic recursive global computable general equilibrium (CGE) model Global Trade Analysis Project- Recursive Dynamic (GTAP-RD) (Aguiar et al., 2019), which, in turn, is built upon the seventh generation of the static Global Trade Analysis Project (GTAP v.7) (Corong et al., 2017) and is written in the TABLO language. When transitioning from static to dynamic, there are four possible axes for development: exogenous endowment, technological substitution, preference substitution, and policy substitution. This paper focuses on the twist strategy, pioneered by Dixon and Rimmer (2002) using the historical evolution of the capital/labor ratio, subject to a cost-neutral constraint on the cost function and TFP to target growth. Which means the following equation holds. ∀ represents the capital and labor ratio percent change.

$$\frac{K}{L} = (1 + \forall \frac{K_0}{L_0})$$

S.T.

$$C= \left[\propto^L \left(\frac{W}{\pi^l}\right)^{1-\sigma} + \propto^k \left(\frac{W}{\pi^k}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} = C_0 = [\propto^L W^{1-\sigma} + \propto^k R^{1-\sigma}]^{\frac{1}{1-\sigma}}$$

where C is the cost function (given the hypothesis that factor prices unchanged) and $\propto^L, \propto^k$ are technology improvement in terms of input factors in production function, with π^I, π^k the growth of labor and capital in efficiency units.

With extending to multi-sectors, Jorgenson et al. (2013) and Roson and van der Mensbrugghe (2017) suggest there are differences across activities that can be exploited, and normally standard starting point has been set to assume that TFP is 2 percent in manufacturing ( ).

Our innovations relate to our introduction of structural changes through trade-related technology spillovers and threshold effects, referring to Meijl and Tongeren (1998), Meijl et al. (1997), Bernstein and Mohnen (1994), and Coe et al. (1995) for the spillovers, and to the specific approach of Barro and Lee (1993) for the thresholds. Both the innovative add-on module and the thresholds are introduced using TABLO programming sub-units.

This study uses the GEMPECK RunDynam ( ) software and chooses the solution method of Gragg 2-4-6 step recursive extrapolation.

a. Threshold effect

First, the technology absorption capacity coefficient, as represented by the ratio of the average years of education between the importing and exporting countries, is introduced as a power value $S_{fr} = MIN(1, S_r/S_f)$, where S_r and S_f are the average years of education for the importing and exporting countries, respectively.

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Second, following the approach of Van et al. (1999), an economic structure similarity coefficient is introduced to analyze the structural differences between the importing and exporting countries, reflected by the proportion of the difference in the capital–labor ratio μ between the two countries and the maximum gap among all countries in the sample:

$$D_{fr} = e^{-|\frac{\mu_r - \mu_f}{D_{max}}|}$$

in which μ_r and μ_f are the capital–labor ratios for the importing and exporting countries, respectively.

Finally, following the method of Meijl et al. (1999), the threshold effect in this study is defined as the absolute value of the difference between the product of the above two coefficients and 1:

$$\Pi = |1 - S_{fr} * D_{fr}|.$$

b. Final goods trade technology spillover

Assuming that the main product of production activity a is c, and the exporting country of c is f, while the importing country is r, Equation (1) represents the proportion of all c exported from country f that is accounted for by country r. For all values of r, there is $\sum E_{cfr} = 1$. This import volume E is statistically based on the production sector with firms as the main body, not on imports for the purpose of residential consumption or government consumption.

$$DirectK_{afr} = \left[\frac{E_{cr}}{E_{cf}}\right]^{\pi} \quad (1)$$

c. Intermediate goods trade technology spillover

We assume that the main product of production activity a is c, and c is produced domestically in the importing destination country r, with a production volume of P_{ar}, but it uses imported intermediate goods d in quantity M_{dar}. In Equation (2), the denominator of the fraction represents the proportion of imported intermediate goods d used in the production of the same product in the exporting country f; β represents the proportion of imports from country f in the total imports of the production sector a in country r.

$$IndirectK_{afr} = \left[\frac{M_{dar}/P_{ar}}{M_{daf}/P_{af}} \times \beta\right]^{\pi} \quad (2)$$

d. Factor-strengthening technology spillover brought about by global value chains

Factor-strengthening technological progress is achieved through final goods trade technology spillovers and intermediate goods trade technology spillovers; that is, the importing country obtains technology through the technological progress of production activity a in the domestic production of product c in the importing source country f. In Equation (3), K represents the technological progress that has spilled over to various local factors at this time, including capital, unskilled labor, and skilled labor, which are denoted as K_C, $K_{Unskilled}$, $K_{Skilled}$, respectively. γ is the spillover ratio, with a value in the range of (0, 1).

$$K_l = \gamma * |Direct\ or. Indirect\ K_{afr}| \quad (3)$$

Figure 2 shows the nested hierarchy production structure, as well as a schematic diagram of the technological progress pathways based on the modified model structure described above.

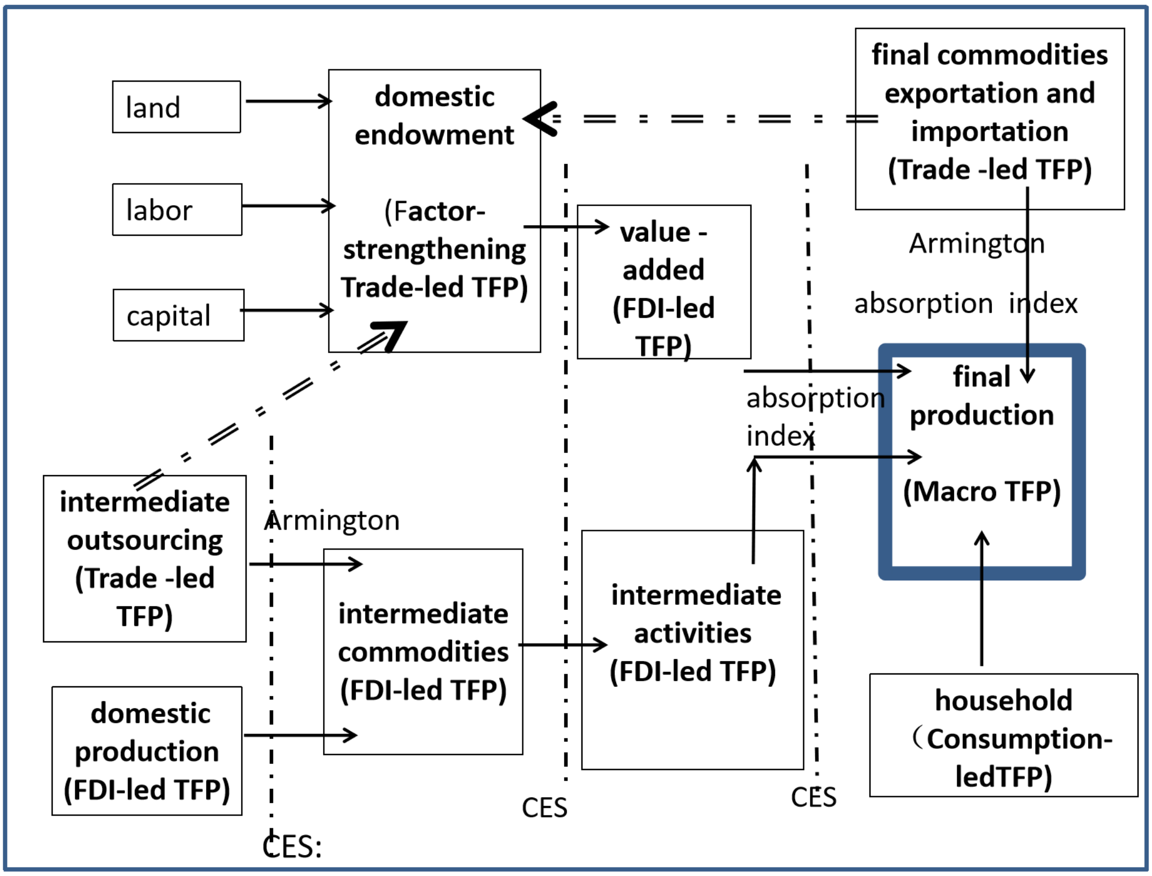

Figure 2. Potential pathways for the nested structure of model production and TFP enhancement.

B. Summary of Aggregations and Indexes.

Regarding data, we used the eleventh-edition GTAP database[1], which integrates input–output tables (I-O tables) from 141 countries and regions, including 65 production sectors, as well as actual detailed bilateral trade, logistics and transportation, and trade protection data characterizing economic links between regions; these data are in turn sourced from institutions such as the IMF, WB, OECD, UN Population Division, and IIASA as foundational data, and the necessary aggregations are carried out to make the model more applicable to this study's central problem.

a. Aggregation of countries (regions)

When dividing the 141 countries and regions in the 11th database into 10 regional groups (see Table 2), the main factors considered include whether they are part of the Regional Comprehensive Economic Partnership Agreement (RCEP), whether they are part of the One Belt and One Road Initiative (OBOR, consisting of 65 countries and regions), and whether they are part of the North American Free Trade Area . Both OBOR and RCEP are hotpot regions for China's outward ODI; the North American region other than the US, consisting of the Canada and Mexico, is categorized separately, mainly considering the potential supply chain layout for the United States' re-industrialization.

Table 1. Classification of 141 countries and regions worldwide into 10 regional groups.

Regional Groups	Specific Countries and Regions	Regional Groups	Specific Countries and Regions
Set 1: CHINA	CHINA	Set 4: US	US

[1] https://www.gtap.agecon.purdue.edu/databases/v11/

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Set 3: RCEPNOBOR (four countries that are members of RCEP but not part of OBOR)	Japan, South Korea, Australia, New Zealand	Set 5: NAMERICA (the North American region except for the US)	Canada, Mexico
Set 2: OBORYRCEP (nine countries that are both part of OBOR and members of RCEP)	Indonesia, Malaysia, Philippines, Thailand, Singapore, Brunei, Cambodia, Laos, Vietnam	Set 7: EU28NOBOR (ten countries that were part of the European Union but not part of OBOR before Brexit in the UK)	Germany, United Kingdom, France, Spain, Netherlands, Sweden, Belgium, Ireland, Denmark, Finland
Set 6: OBORYEU28 (eighteen countries overlapping between OBOR and the European Union)	Austria, Bulgaria, Cyprus, Croatia, Czech Republic, Estonia, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Romania, Slovakia, Slovenia	Set 8: RESTOBOR (twenty-seven countries in the Middle Eastern and West Asian part of OBOR)	Armenia, Albania, Azerbaijan, Bangladesh, Belarus, Egypt, Georgia, India, Kazakhstan, Oman, Nepal, Mongolia, Pakistan, Russia, Sri Lanka, Ukraine, Israel, Bahrain, Qatar, Iran, Kuwait, Saudi Arabia, Turkey, United Arab Emirates, Jordan, Kyrgyzstan, Tajikistan
Set 9: HK (China Hong Kong)	Hong Kong	Set 10: RESTWORLD (68 remaining countries and regions)	Other countries and regions of the world

Table 2. Groups of nine industries and ten commodities.

Industrial classification	Specific industries included	Industrial classification	Specific industries included
a_Agriculture (commodities produced include c_Crops and c_MeatLstk)	paddy rice; wheat; cereal grains NEC*; vegetables, fruit, nuts; oil seeds; sugar cane, sugar beet; plant-based fibers; crops NEC; bovine cattle,	a_HeavyMnfc (commodities produced include c_HeavyMnfc)	Petroleum, coal products ; chemicals ; basic pharmaceutical

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	sheep and goats, horses; animal products NEC; raw milk; wool, silk-worm cocoons; bovine meat products; meat products NEC; processed rice		products；rubber and plastic ； mineral products NEC ； ferrous metals ； metals NEC ； computer, electronic, and optical products；electrical equipment；machinery and equipment NEC
a_Extraction (commodities produced include c_Extraction)	Forestry ； fishing ； coal ； oil ； gas ； minerals NEC	a_Util_Cons (commodities produced include c _ Util _ Cons)	Electricity; gas manufacture, distribution；water；construction
a_ProcFood (commodities produced include c_ProcFood)	Vegetable oils and fats ； dairy products ； sugar；food products NEC ； beverages and tobacco products	a_TransComm (commodities produced include c_TransComm)	Trade ； accommodation, food and service activities ； transport NEC ； water transport； air transport ； warehousing and support activities ； communication
a_TextWapp (commodities produced include c_TextWapp)	Textiles; apparel	a_OthService (commodities produced include c_OthService)	Financial services NEC ； insurance； real estate ； business services NEC ；
a_LightMnfc	Leather products; wood products; paper products, publishing		

(commodities produced include c_LightMnfc)	; metal products ; motor vehicles and parts ; transport equipment NEC ; manufacturing NEC		recreational and other services ; public administration and defense ; education ; human health and social work activities ; dwellings

NEC*: NOT ELSEWHERE CLASSIFIED.

b. Aggregation of industries

This study consolidates the 65 industries in GTAP 11 into nine major industrial categories, with the products they produce aggregated into ten types (see Table 4).

Here, a_Agricultur (planting) and a_Extraction (mineral mining) constitute the primary industry; a_ProcFood (food and beverage processing), a_TextWapp (textile), a_LightMnfc (light industry), and a_HeavyMnfc (heavy industry) constitute the secondary industry; and a _ Util _ Cons (public service), a_TransComm (productive services), and a_OthService (consumer services) constitute the tertiary industry.

The contribution of the primary and resource product sectors to China's macro TFP has consistently been negative (Tian Youchun et al., 2021), and the absolute value is very small; so, this study does not consider this sector to be a source of China's economic growth.

c. Summary of technological threshold indexes and spillover coefficients

After the classification of countries was determined, the power value of the threshold effect for China to obtain technology spillover from the other nine regional groups can be calculated.

Table 3. The threshold effect value for China to obtain technologies from other countries.

	OBORYRCEP	RCEPNOBOR	US	NAMERICA	OBORYEU28	EU28NOBOR	RESTOBOR	HK	RESTWORLD
Education years ratio	1.03	1.56	1.65	1.37	1.47	1.53	1.21	1.52	0.62
Economic gap ratio (capital–labor ratio)	1.04	1.38	2.5	1.41	1.18	1.77	1.07	1	1.09
Technical overflow power value	0.01	0.13	0.34	0.03	0.24	0.14	0.14	0.52	0.43

Data source: years of education ratio from UNESCO Institute for Statistics （2020） , Barro and Lee （2018） , ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD （2019b） ; Capital data in the capital–labor ratio comes from the World Bank （2021） The Changing Wealth of Nations 2021 ; Labor data derived using data from International Labor Organization, ILOSTAT database and World Bank population estimates. Labor data retrieved in September 2018.

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As for the indirect spillovers, we need to explore China's input–output (I–O) table. First, it is necessary to identify the industries (those "a"s) where the imported intermediate commodities (those "c"s) account for more than 10% of an a's industrial output. For the "Aggregation of industries", we matched industries to their own commodities; now, using the I–O table, we further match industries and commodities using crossing industries, which is how indirect spillovers occur. Through further matching those matched-up imported intermediate commodities to their main regions of origin, again, only those whose exportation accounts for more than 5% of China's importation of the same product will be taken as intermediate trade technology source regions. Moreover, although the indirect coefficients for the groups of countries are also shown in Table 4, we in fact match each source industry in every source group with its own more specific after-powered indirect threshold index.

Table 4. Technological progresses spillover coefficients of final and intermediate goods trades, classified by regions of origin.

Regions	DirectK afr	IndirectK afr
2. OBORYRCEP	0.98	0.96
3.RCEPNOBOR	0.82	0.69
4.US	0.74	0.40
5.NAMERICA	0.68	0.87
6.OBORYEU28	0.63	0.25
7.EU28NOBOR	0.67	0.56
8.RESTOBOR	0.70	0.60
9.HK	0.78	0.01
10.RESTWORLD	0.75	0.31

Table 6. Main imported intermediate products and their source regions.

China's industries other than the primary sector	Imported intermediate commodities (intermediate commodities (those "c"s) that account for more than 10% of the industrial output)	Source regions by country group number (countries whose exportation accounts for more than 5% of China's importation of the same product)
a_Extraction	c_Extraction	c_Extraction is from 2/3/8
a_ProcFood	c_Crops; c_HeavyMnfc	c_Crops is from 2/3/4/5/10 c_HeavyMnfc is from 2/3/4/7/8/10
a_TextWapp	c_Crops ; c_MeatLstk ; c_Extraction	c_Crops is from 2/3/4/5/10 c_MeatLstk is from 3/4/5/7/10 c_Extraction is from 2/3/8
a_LightMnfc	c_Extraction	c_Extraction is from 2/3/8
a_HeavyMnfc	c_Extraction; c_HeavyMnfc	c_Extraction is from 2/3/8 c_HeavyMnfc is from 2/3/4/7/8/10
a_Util_Cons	c_Extraction	c_Extraction is from 2/3/8

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a_TransComm	c_LightMnfc ; c_HeavyMnfc	c_LightMnfc is from 3/4/6/7/10 c_HeavyMnfc is from 2/3/4/7/8/10
a_OthService	c_Extraction ; c_HeavyMnfc	c_Extraction is from 2/3/8 c_HeavyMnfc is from 2/3/4/7/8/10

With the aggregation of nations, the corresponding direct final trade technology spillover coefficients are calculated and are shown in Table 4.

C. Baseline Treatment

The newest GTAP database, version 11, adopts 2017 as the new base year, meaning that the world economic structure reflected in this study begins in 2017, and the scope of our estimation is from 2024 to 2035. Originally, GTAP-RD comes with two sets of predefined dynamic baseline data, Organization for Co-operation and Development (OECD) and The International Institute for Applied Systems Analysis (IIASA). Comparative studies show that the OECD is superior to the IIASA, since the IIASA does not list the TFP at all, while the OECD embeds a technology frontier growth rate based on the long-term growth trend of the economy (Johansson, 2013; Dellink et al., 2017). After examining all the OECD shared socioeconomic pathways (SSPs), which are Scenarios set for researchers to choose backgrounds, we chose the average OECD SSP3 as our simulation baseline, forecasting economic growth of 3.46% and a built-in macro TFP growth rate of 2% for China from 2023 to 2035. This 2% can be regarded as the "natural" macro TFP growth rate determined by the current urbanization, capital accumulation, and industrial structure in China, with a growth rate of 3.46 percent. There is a certain gap between the embedded rates and the required rates (5.48%–3.46%), which leaves room for this study to accelerate China's total factor productivity through the "internal" and "external" circulation pathways.

After determining the baseline as OECD SSP3, we updated the officially published actual GDP values for the studied countries from 2018 to 2023, put them into the database, and calibrated them according to the Walmsley dynamic recursive method (Walmsley, 2006) through shocks.

Before setting the Scenarios, we considered the following background to global economic growth.

a. China–US trade friction

The increase in tariffs resulting from the China–US trade friction since 2018 was not reduced following the first-phase trade agreement reached by the two countries in January 2020. Therefore, we updated the trade and related tariff data and applied a corresponding tariff shock for the year 2020. Referring to Minghao Li et al. (2020), and using the commodity classification detailed in Table 4, we determined the changes in tariffs as follows:

Table 7. Tariff changes before and after the US–China phase-one agreement.

Product classification	U.S. Tariffs on China		Chinese Tariffs on US	
	Pre-trade-war tariffs	Post-trade-war tariffs	Pre-trade-war tariffs	Post-trade-war tariffs
c_Crops	1.10%	23.75%	2.97%	28.37%
c_MeatLstk	0.64%	24.10%	8.21%	28.06%
c_Extraction	0.17%	24.80%	0.64%	14.98%
c_ProcFood	2.72%	24.00%	8.21%	24.87%
c_TextWapp	10.31%	9.94%	7.53%	13.03%
c_LightMnfc	4.33%	15.05%	9.58%	19.84%
c_HeavyMnfc	1.02%	20.87%	3.77%	15.13%

Data source: Minghao Li et al. (2020). Calculations carried out by the author.

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b. Consideration of the COVID-19 pandemic

As indicated by the theory of general equilibrium, CGE models focus on long-term impacts, and short-term disturbances, whether positive or negative, are eventually absorbed and compensated for by base effects in later stages. According to the IMF baseline forecast for the world, the economy is expected to continue growing at 3.2 percent during 2024 and 2025, at the same pace as in 2023. The forecast for global growth five years from now, for 2029, is 3.1 percent. In reality, the average growth rate of the world economy for the decade of 2010–2019 was 3.15%, and for the two decades of 2000–2019, it was 3.8%. This suggests that, if there were a structural change in the world economy, it may have happened around 2010. We are now only moving forward along the path that has been established since then. As we have adjusted our baseline data to reflect what actually happened in 2023, this study does not use any systematic shocks to describe the pandemic.

c. Base TFP Growth of Country Groups Except for China

We take the arithmetic mean of every country group's TFP growth from 2008 to 2021 from the CEPII as the basic TFP structure for world growth (except China). We found that this series also corresponds with U.S. Bureau of Labor Statistics data and Penn World Table version 10.0 data. In the CEPII database, during the same period, China's TFP growth shows a rate of 4.62%, which is absolutely too high.

According to the existing studies, the average growth rate of TFP in China's economy from 2003 to 2013 was approximately 3.2% (He Jingtong, He Lei, 2016), and, from 2005 to 2014, it was 4.38% (Tian Youchun et al., 2021). The expected average TFP growth rate during the "13th Five-Year Plan" period, 2016–2020, was 3.21% (Xiao Hongwei, Li Hui, 2014). Since 2008, the overcapacity issue has remained a prominent and urgent issue to be resolved. The Chinese government has implemented various supply-side structural adjustment policies since November 2015, which is also why the CCP now advocates the concept of TFP-driven new development patterns. Therefore, we abandon the numerical value of 4.62% and assign China a basic non-zero starting point of 0.01% in order to explore various possible TFP acquisition combinations through both internal and external circulations.

Table 8. Basic TFP structure for the world (except China) for growth.

2 OBORYRCEP	3 RCEPNOBOR	4 US	5 NAMERICA	6 OBORYEU28	7 EU28NOBOR	8 RESTOBOR	9 HK	10 RESTWORLD
1.93%	0.57%	0.52%	0.05%	0.66%	0.27%	1.18%	1.03%	1.05%

Source: CEPII. http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=11.

D. Shocks and Scenario Settings

a. Shock variables

The shock variables included in this study are listed in Table 5.

Table 9. List of shock variables.

Impact variables	Paraphrase
avareg (r)	Representative internal circulation. Simulates the local technological advances brought about by the consumption growth in the region.
aintall (a,r)	Represents the spillover type of local macro TFP growth (including forward and reverse) brought about by foreign capital in the external circulation.
aoall (a,r)	Represents the final goods trade productivity spillover effect (both forward and reverse). Country r and the trading partner country f are connected by the final goods trade technology spillover coefficient: $\mathrm{aoall}\,(\mathrm{a,r}) = DirectK_{afr} * a_f(\mathrm{a,f})$

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afall (c,a,r)	Represents the intermediate goods trade productivity spillover effect (including forward and reverse). Country r and trading partner f are connected by the intermediate trade technology overflow coefficient: afall (c, a, r) $= IndirectK_{afr} * a_f(\mathrm{c, a, f})$
afeall (e,a,r)	Technological advances representing factor enhancement from trade (transforming factor reinforcement (lab-biased))[2]afe (e, a, r) $= \gamma * a_f(\mathrm{c, a, f})$

b. Scenario settings and amplitude of shocks

Baseline Scenario: We ran the simulation without any TFP shocks to any country to see how much economic growth speed China would achieve from the baseline data; we found that the average of 2024–2035 would be 3.46%. All outcomes from the following Scenario will be compared with this value. All the Scenarios are designed to achieve the vision goal of 2035, which requires at least 5.48% economic growth on average.

Trend TFP Scenario: We ran the simulation without the basic TFP trends to other groups of groups but not China, to see what this basic global TFP structure could contribute to China's economic growth.

Scenario 1: Internal circulation: if household consumption (service-oriented consumption sector) leads to 8% average annual macro TFP growth.

Given that China's consumption growth point is now mainly service-oriented consumption, we focus on a shock to the consumption-oriented service sector (a_OthService) from 2024 to 2035. The amplitude of 8 was determined based on how much of an increase in this sector's TFP would satisfy our vision goal of 2035.

Scenario 2: Internal circulation: if household consumption leads to a more reasonable average annual macro TFP growth of 3%.

Scenario 3: External circulation: China acquires 0.4% technological progress in each secondary and tertiary industry via the path of direct final trade spillover effects.

Here, the spillover impact is determined solely by the trade in final products along the global value chain. With the trade friction between China and the United States and the recent emergence of other "anti-globalization" geopolitical factors, developed countries have begun to implement high-tech protection policies against China, among which the trade barriers for some products have become very high. In view of this, we assume that the technological spillover for China's secondary and tertiary industries is quite limited. According to the column "Percent of CEPII Base Accounts for Direct Source Industry TFP Increase" in Table 10, except for country groups 5 (NAMERICA) and 7 (EU28NOBOR), the world TFP growth structure will only support approximately 40% of "When the TFP of the Chinese industry grows by 1%, the TFP of the source industry increases." Thus, we determined that the corresponding total factor productivity growth rate of China's industries cannot be assumed to be as high as 1 but is at most 0.4. Considering the relatively low values of the direct spillover indexes for country groups 5 (0.68) and 7 (0.67), we can simply ignore these two groups.

Table 10. How much percent of CEPII base could account for direct source industry TFP increases.

Regions	TFP direct spillover; When the	Percent of CEPII base	TFP indirect spillover; When the	Percent of CEPII base accounts for

[2] In the IF statement of afe, on the premise that the e-element is an ENDWL, the original model emphasizes that the afelab (e, a,r); that is, when the dynamic baseline determination process is mainly inconsistent between the actual GDP and the calculated GDP of the model. This is used to absorb this residual difference, in order to further calibrate the variables of the model baseline (otherwise, 0), under the condition that the baseline calibration has been conducted. The emphasis is used to depict the productivity changes transmitted through the international trade in intermediate goods afelabact (a, r). Variables with other components are set to 0. The corresponding main TABLO language formulas are as follows: afe(e,a,r) = afecom(e) + afesec(a) + afereg(r) + afeall(e,a,r) + afecomreg(e,r) + IF[e in ENDWL, afelabreg(r) + afelabact(a,r) + afelab(e,a,r)] + IF[e in ENDWXC, afendwxcreg(r) + afendwxcact(a,r) + afendwxc(e,a,r)]

	TFP of Chinese industry grows by 1%, how much of the source industry increases	accounts for direct source industry TFP increase	TFP of Chinese industry grows by 1%, how much of the source industry increases	the indirect source industry TFP increase
2 .OBORYRCEP	1.02	188%	1.04	185%
3.RCEPNOBOR	1.22	47%	1.45	39%
4.US	1.35	39%	2.50	21%
5.NAMERICA	1.48	4%	1.15	5%
6.OBORYEU28	1.58	41%	4.00	16%
7.EU28NOBOR	1.48	18%	1.79	15%
8.RESTOBOR	1.43	82%	1.67	71%
9.HK	1.28	81%	100.00	1%
10.RESTWORLD	1.33	79%	3.23	33%

Scenario 4: External circulation: China acquires 0.1% technological progress in secondary and tertiary industries via the path of indirect intermediate trade spillover effects.

Again, in Table 10, we see even more dispersed data—this time for indirect spillovers. To be sufficiently conservative, we take 0.1 as the progress value.

Scenario 5: External Circulation: 1% annual growth in TFP in productive services due to U.S. FDI.

Before, the main source of technological spillover to China's manufacturing industry involved attracting foreign investment in general product manufacturing. This was related to the low technological barriers that developed countries imposed on China in these competitive markets after its accession to the World Trade Organization. However, since 2004, the share of FDI in China's manufacturing industry has declined rapidly, while the technological level of China's general products has reached (or approached) the world frontier level. The "14th Five-Year Plan for the Utilization of Foreign Investment" pointed out that, in 2021, the actual use of foreign investment in the service industry increased by 22.5%, with manufacturing only growing by 1.9%; the actual use of foreign investment in high-tech industries increased by 29.1%, with high-tech manufacturing growing by 15.2% and high-tech services growing by 33.4%. Thus, high-tech tertiary industries have become the focus of foreign investment growth.

Among the three kinds of services analyzed in this study, productive services (a_TransComm) consist of leasing and business services, transportation, warehousing and postal services, information transmission, computer services and software industries, scientific research and technical services, and geological exploration and finance. This means that productive services as a whole are inseparable from knowledge production and the dissemination of technology. Therefore, they are in turn regarded as representative of a country's high-tech tertiary industries and a country's independent innovation capabilities.

However, productive services do not play a significant role in China's input–output system. Overall, the share of intermediate inputs from productive services to other industries is still relatively low, reflecting China's shortage of independent innovation capabilities. Moreover, this "low" share is more prominent in light and heavy manufacturing.

Table 11. Contribution of productive services to China's input and output.

	a_Agricultur	a_Extraction	a_ProcFood	a_TextWapp	a_LightMnfc
c_TransComm Proportion of a certain industry	12.15%	12.21%	12.33%	8.94%	9.70%
	a_HeavyMnfc	a_Util_Cons	a_TransComm	a_OthService	
c_TransComm Proportion of a certain industry	8.20%	9.45%	27.40%	20.47%	

On this basis, we assume a 1% annual technological progress impact on productive services (a_TransComm) and artificially assume that the source of technology is the world technology frontier in the United States. Referring to the previously obtained threshold effect power value of 0.34 (Table 3, US column) and technology direct and indirect spillover values of 0.74 and 0.4 (Table 4, US row), respectively, the corresponding required positive shock occurring in the US can be assumed with a conservation value of 1.

Scenario 5 plus: External circulation: 5% annual TFP growth impact on productive services brought about by U.S. FDI.

Scenario 6: External circulation: combination of all the above external Scenarios of 3, 4, and 5.

Scenario 7: Combination of all the above internal and external Scenarios of 2, 3, 4, and 5.

According to the World Bank's "Top 10 Global Manufacturing Scale" list, China's manufacturing industry achieved an industry GDP of over USD 3.85 trillion in 2020, while the U.S. manufacturing industry slightly surpassed USD 2.34 trillion, accounting for approximately 60% of China's manufacturing scale and 11.2% of the US's total economy. In order to revitalize the U.S. manufacturing industry, starting from Obama, several U.S. presidents have successively signed multiple "manufacturing reshoring" acts, such as the "Manufacturing Enhancement Act," the "National Defense Production Act," and the National Network for Manufacturing Innovation (NNMI), continuously incentivizing the return of manufacturing to the US. The latest actions include the "Inflation Reduction Act" (IRA), officially passed by the U.S. Senate on August 7, 2022, which plans to provide billions of dollars in tax credits to the photovoltaic manufacturing industry. This may result in the return of several tens of gigawatts of solar panel production to the U.S. coast. On August 9,2022, President Biden officially signed the "Chip and Science Act," which claims that the global semiconductor manufacturing is currently mainly concentrated in East Asia, with the U.S. domestic share shrinking from nearly 40% in the early 1990s to around 12% now. Therefore, the USD 280 billion law includes USD 52.7 billion allocated from 2022 to 2026 for subsidizing the construction and updating of semiconductor labs to promote the reshoring of semiconductor manufacturing to the US. The chip act strongly hinders China from accessing related technologies and includes restrictions such as not allowing U.S. companies to invest in sub-28 nm process technology in China if they receive national subsidies during the assistance period.

In response to this, we considered and examined four Scenarios based on Scenario 7 describing the United States' re-manufacturing, representing decoupling between the US and China. We hypothesize that industrial sectors in the United States (light industry (a_LightMnfc) and heavy industry (a_HeavyMnfc)) have experienced technological progress of 2% in both the long term (persisting between 2022 and 2035) and the short term (from 2025 to 2028), and 5% in both the long and short terms. Additionally, to reflect the nature of the United States' global supply chain reversion,

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we apply shocks of 1% and 0.5% technological progress in the short and long terms, respectively, to simulate possible supply chain re-shoring effects to the North American country group, which means the U.S. manufacturing sector would most likely cooperate with that group to build up its own value chain.

Scenario 8: External circulation: factor-strengthening of the effects of global value chain technology.

As shown in formula (3), γ ranges from 0 to 1. We used the value of 0.5. Regardless of whether it is assessed in relation to final or intermediate goods trade, γ means that the spillovers of the global value chain on China can be absorbed and spread to factors in China. Here, factors refer to skilled labor, unskilled labor, and capital, excluding land and natural resources. Each type of technological spillover is divided into three cases. Since this Scenario cannot exist independently, it needs to be combined with Scenarios 3 and 4 in turn.

IV. Results

The forecast range of this study is from 2024 to 2035. The table below shows the average economic growth rate of China during this period, the year in which China's total GDP surpasses that of the United States, and the 2035 value of the CEPII PPP per capita GDP[3] under Scenarios 1 to 8 .

Under the baseline Scenario, the average economic growth rate from 2025 to 2035 would be 3.46%, and, in 2035, China's per capita GDP would reach USD 24,891. The Trendy TFP Scenario indicates that, if all other countries are experiencing technological progress while China is not, then China will have an average negative growth rate of -0.3%, meaning it is lagging behind the rest of the world.

In Scenario 1, a speed of 8% is needed for China to achieve the ideal level of economic growth by 2035 only through internal circulation. This is not very likely to happen.

In Scenario 2, a rather reasonable increase of 3% in terms of consumption will give China a 0.7% positive average growth rate.

Scenario 3 shows that the final goods trade technological spillover effect, supported by the world TFP trend structure, would give China the opportunity to approach the required speed, with an additional economic growth effect of 1.65%.

Scenario 4 has a negative effect on China's economic growth. Even though we constrained this speed to be only 0.1%, given the more dispersed data related to indirect spillovers, the harmful effect equals almost -1%, which is quite significant.

If the trade modes of final and intermediate goods are combined (Scenarios 3 + 4), we obtain positive growth of 0.92%, larger than the sum of Scenario 3 and Scenario 4 by 0.23%.

In Scenario 5, if foreign investment in productive service industries brings 1% technological progress annually, its effect on China's economic growth is negative, similar to the intermediate trade, at -0.17%.

In Scenario 5 plus, if we increase the technological progress brought about by foreign investment in productive service industries to 5%, the outcome shifts from negative to positive, although it remains quite small, at 0.17%. However, the assumption of an average annual technological progress of 5% is obviously too high.

In Scenario 6, by fully integrating foreign investment with foreign trade (combining the final goods and intermediate goods trades), the incremental economic growth rate from 2024 to 2035 is calculated to be 1.01%. This is the subtotal of external circulation.

If we combine Scenario 2 (reasonable internal) with Scenario 6 (reasonable external), we produce Scenario 7 and achieve a somewhat ideal TFP growth rate of 1.78%, with per capita GDP reaching 29,723 by 2035. This could be seen as almost the sum of the two Scenarios mechanically combined, making this Scenario the most reasonable pattern of China's TFP development.

For Scenario 8, the following Table 12 shows that, if land and natural resources are excluded from factor-enhanced technological advances, the remaining three economic input elements—capital,

[3] As before, the conversion here refers to the PPP calculation of CEPII, 1.25.

skilled labor, and unskilled labor—will be intensified through trade in final or intermediate goods by working with Scenario 3 or Scenario 4, since this intensification could not exist independently.

Table 12. Basic results of shocks.

	Average growth rate for 2024–2035	The effect of Scenario factors on the baseline mean velocity	Year in which China surpasses the United States	GDP per capita in 2035
Baseline Scenario	3.46%	n.a.	n.a.	24891
Trendy TFP Scenario	3.17%	-0.30%	n.a.	23415
Scenario 1: Consumption increased by 8%	5.48%	2.02%	2033	30544
Scenario 2: Consumption increased by 3%	4.17%	0.70%	n.a.	26284
Scenario 3: Technological progress of final products	5.11%	1.65%	2035	29306
Scenario 4: Technological progress of intermediate products	2.51%	-0.96%	n.a.	21679
Scenario 5: FDI 1%	3.29%	-0.17%	n.a.	23755
Scenario 5 plus: FDI 5%	3.63%	0.17%	n.a.	24706
Scenario 3 + 4: Technological advances in final and intermediate goods	4.39%	0.92%	n.a.	26964
Scenario 3 + 5	5.20%	1.74%	n.a.	29610
Scenario 4 + 5	2.63%	-0.83%	n.a.	21995
Scenario 6: 3+4+5	4.48%	1.01%	n.a.	27249
Scenario 7: Trade plus FDI 1% plus consumption 3%	5.24%	1.78%	2035	29723
Scenario 7+: Decoupling 2%, short term	5.19%	1.72%	n.a.	29552
Scenario 7+: Decoupling 2%, long term	5.38%	1.92%	n.a.	30217
Scenario 7+: Decoupling 5%, short term	4.38%	0.92%	n.a.	26949

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Scenario 7+: Decoupling 5%, long term	3.31%	-0.16%	n.a.	23775
Scenario 3+8C: Final goods plus capital	5.44%	1.97%	n.a.	30410
Scenario 3+8S: Final goods plus skilled labor	5.16%	1.69%	2035	29455
Scenario 3+8U: Final goods plus unskilled labor	5.28%	1.81%	2035	29860
Scenario 4+8C: Intermediate goods plus capital	2.82%	-0.64%	n.a.	22486
Scenario 4+8S: Intermediate goods plus skilled labor	2.55%	-0.91%	n.a.	21798
Scenario 4+8U: Intermediate goods plus unskilled labor	2.68%	-0.79%	n.a.	22110

Table 13. Factor-intensifying spillover.

	Scenarios 3 on capital factor	**Scenarios 3 on skilled labor factor**	**Scenarios 3 on unskilled labor factor**	**Scenarios 4 on capital factor**	**Scenarios 4 on skilled labor factor**	**Scenarios 4 on unskilled labor factor**
The extra effect of Scenario 8 on Scenario 3 or 4	**0.32%**	**0.04%**	**0.16%**	**0.32%**	**0.05%**	**0.17%**

To summarize, the above estimations show that China's per capita GDP is projected to reach USD 30,000 in 2035, in present value terms when Scenario 1, with its less-than-reasonable assumption of 8% internal circulation, the more reasonable Scenario 3, or other Scenarios dominated by Scenario 3 occur. Measured in USD, as for those Scenarios pertaining to reaching the 2035 per capita goal, China is projected to surpass the United States in 2035.

V. Analyses and Discussion

A. Analyses

a. Existence of global value chain and reasonable basic growth interval of China

It is clear that Scenario 3 has the best economic growth effect compared to other separate Scenarios. This indicates that, as long as China maintains openness to the world and participates in the global value chain of the international economy, it will secure this main contributing factor.

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As for the negative effect of Scenario 4, we attempted to extend the discussion by using one-tenth of the original shock. That is, we further constrained this intermediate increase speed to be only 0.01%, and we obtained the following result: a -0.38% impact on economic growth. This means that the negative impact of Scenario 4 cannot be eliminated under any circumstances by any means. So why China tolerates this kind of trade happening?

Actually this exactly demonstrates the existence of the global value chain, although reversely. When combined, the original economic growth increment created by the final goods element is only somewhat (not to the extent of all show-up of negative original Scenario 4) mitigated by the intermediate part, showing a complementary effect between the final and intermediate trades. It indicates that China's current intermediate goods trade and final goods trade with the world are not independent but are intrinsically integrated with each other. Pure Scenario 3 would not be accepted by the world since from that Scenario China will only gain with no pains. Otherwise, if China only engages in the international trade of intermediate goods, and all the final goods produced are consumed by China's domestic markets, China's economic growth rate could be hindered substantially by upstream components exterior dependence, which is the situation that would not be accepted by China either.

When we combine Scenario 3 with this diminished one-tenth of the original shock Scenario 4 , we find in Table 14 that the effect of Scenario factors on the baseline mean velocity becomes 1.55%, compared to its original value of 0.92% when going with original shock Scenario 4, and the economic growth effect becomes 5.02% (previously, 4.39%). This 5.02% can be regarded as the functioning upper limit of the superposition growth effect of the final and intermediate trades' TFP spillover, when FDI is out of consideration.

Table 14. Superposition of Scenario 3 and one tenth of Scenario 4.

	Average growth rate for 2024–2035	**Effect of Scenario factors on the baseline mean velocity**	**Year in which China surpasses the United States**	**GDP per capita in 2035**
Ideal Scenario 4: Technological progress of intermediate products	3.08%	-0.38%	n.a.	23181
Scenario 3: Technological progress of final products	5.11%	1.65%	2035	29306
Scenario 3 + ideal Scenario 4: Technological advances in final and intermediate goods	5.02%	1.55%	n.a.	28981

Furthermore,with consumption, we can achieve a very reasonable combination of economic growth rate rooted in TFP via dual pathways: Scenario 3 plus Scenario 4 forms the foundation, with an additional effect on the baseline of 0.92%, from where we hope to minimize the effect of Scenario 4 as much as possible, until it is reduced to one-tenth of its previous extent, denoting a speed of 1.55%. Then, we turn to consumption (internal circulation) for further TFP-driven growth, and an additional rate of 0.70% (Scenario 2):

3.46% baseline rate + (0.92%+0.70%, 1.55%+0.70%) = (5.08%, 5.71%)

We add the consumption-TFP-driven economic growth rate of 0.70% directly to the result of the possible external Scenario 3 plus Scenario 4 because internal circulation is somehow independent

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with no complementary effect on any other Scenario, which is the conclusion safe to draw from Table 12.

So, if "deglobalization" intensifies, denoting that China will have to shift towards domestic demand as the main driver of technological progress. However, consumption (internal circulation) may not have the potential to function so easily because as we can see from Table 12 of results that when consumption increased by 8% per year, China will get something equal to the upper interval limit we get here. But speed of 8% is almost impossible. Hence ,its practical and realistic for China to keep its opening-up trade policy and avoid collisions that could break those trade ties between China and the rest of the world.

b. As for FDI

When FDI is added to either final trade or intermediate trade, we can find positive effects, shown in Table 15. Comparatively, there is a slightly greater synergistic effect between foreign investment and intermediate goods trade. Again, if we combine FDI with all trade modes, we find an additional 0.09% increase as a supplement.

FDI itself has a limited effect of -0.17% when it grows by 1% per year and if we do more experiment by letting it grows by 5% per year, the result of sole FDI would be only 0.17%, indicating foreign capital FDI may not play as crucial a role in increasing China's TFP as it did when China fist opened-up.previously.

Table 15. Synergistic effect of FDI on trades.

The effect of Scenario 3 on the baseline mean velocity	**Scenarios 3 + 5**	**Synergistic effect of FDI**
1.65%	1.74%	0.09%
Effect of Scenario 4 on the baseline mean velocity	**Scenarios 4 + 5**	**Synergistic effect of FDI**
-0.96%	-0.83%	0.13%
Effect of Scenario 3+4 on the baseline mean velocity	**Scenarios 3+4 + 5**	**Synergistic effect of FDI**
0.92%	1.01%	0.09%

c. In terms of factor-strengthening effects

Table 13 illustrates that, among the three productive factors, the capital-augmenting effect is the most pronounced in the supplementary cases of both final product trade and intermediate product trade spillovers. This implies that, although foreign capital FDI may not play as crucial a role in increasing China's TFP as it did previously, domestic capital as a factor can still learn from international trade and develop the potential to provide additional growth effects. Furthermore, the effects of skilled labor are the least pronounced.

Regarding the technological progress obtained by unskilled labor, the intermediate goods trade can play a slightly more significant role than the final goods trade. Additionally, the supplementary effects manifested in unskilled labor are half of what is manifested in capital across both trade modes.

d. When talking about trade partners

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Regions	DirectK afr	IndirectK afr
2 OBORYRCEP	0.98	0.96
3.RCEPNOBOR	0.82	0.69
4.US	0.74	0.40
5.NAMERICA	0.68	0.87
6.OBORYEU28	0.63	0.25
7.EU28NOBOR	0.67	0.56
8.RESTOBOR	0.70	0.60
9.HK	0.78	0.01
10.	0.75	0.31

there are five sets of countries that serve as the main sources of technology spillover through the final goods trade. Three of these, namely, 3 (RCEPNOBOR), 4 (the US), and 9 (Hong Kong), are developed regions and include countries such as Japan, South Korea, Australia, and New Zealand from the RCEP and the US. Other main technological spillover source countries consist of 2 (OBORYRCEP) and 10 (RESTWORLD). Groups 5 (NAMERICA), 6 (OBORYEU28), and 7 (EU28NOBOR) are having significantly lower coefficients. This disparity indicates that, given the ongoing rise of attitudes in favor of "deglobalization", it is almost impossible to obtain technology spillover effects from EU groups, and the combination of groups 2 and 3 makes the RCEP the most important to China now. Alongside the RCEP countries, maintaining good relations with the US is perhaps the most realistic choice for China. Finally, It is not surprising to see the Hong Kong Special Administrative Region here because its trade structure is focused on re-export to mainland China.

Group 8 (RESTOBOR (27 countries in the Middle East and Western Asia direction of the OBOR)) has medium-high coefficients. Considering that group 6, OBORYEU28, is among the lowest, we can safely conclude that the development of the Belt and Road Initiative has not assumed the strategic position that the initiative was expected to have for China yet. This forward-thinking "going global" strategy is crucial for China's economic development in the next century in terms of potential.

e. China’s productive sectors

It is worth noting that, in the productive service inputs required by various industries, compared with other countries, China generally relies more on imports, as shown in the Table 16 below. The table presents the comparative status of China's productive services as inputs to certain industries compared to a specific country. A value greater than 1 indicates that China needs more imports than that specific country. The data show that, except for European countries, China's industries generally rely more on imports of productive services. As European countries are part of a large unified market, they are accounted for separately only in statistics. Therefore, it may seem that China is not as dependent on as European countries. However, in Europe, a large number of imports does not necessarily indicate an increase in uncertainty. Excluding Europe, a ratio greater than 1 indicates that China's productive service capacity is severely lacking compared to other countries, and it has to rely on imports, thereby increasing economic uncertainty.

The aforementioned descriptions of the effects of FDI indicate that improvements in this area cannot be contingent on foreign investment. Therefore, the realistic choice for China is to open the productive services market more widely to stimulate domestic competition, facilitate domestic market efficiency, and thus increase domestic productive sector contribution.

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Table 16. Comparison of the proportion of productive services contributing to other industries in China with that of other countries.

A group of countries compared with China	a_Agricultur	a_Extraction	a_ProcFood	a_TextWapp	a_LightMnfc	a_HeavyMnfc	a_Util_Cons	a_TransComm	a_OthService
OBORYRCEP	1.08	0.79	2.41	1.50	1.44	1.62	1.01	0.19	0.35
RCEPNOBOR	1.86	0.69	3.61	0.98	1.78	1.31	2.14	0.59	2.25
US	6.57	6.34	3.93	6.11	5.76	6.86	1.25	3.20	1.05
NAMERICA	1.63	1.33	3.06	3.40	2.53	2.41	1.44	1.07	1.84
OBORYEU28	0.82	0.49	0.82	0.68	0.62	0.77	0.56	0.41	0.66
EU28NOBOR	0.43	0.25	0.35	0.45	0.46	0.45	0.49	0.33	0.60
RESTOBOR	1.85	1.52	2.31	3.33	2.05	1.90	1.20	0.84	1.12
HK	0.43	0.95	0.73	1.03	1.00	0.98	0.48	1.07	1.14
RESTWORLD	1.63	1.15	1.63	2.01	1.75	1.94	0.96	0.69	1.21

f. Decoupling

Here, the term "decoupling" refers to the United States making technological advancements, primarily with other North American countries, indicating the re-manufacturing of the US by excluding China from its global value chain, without simulating some potential Scenarios where the United States will actively seek hard measures to contain China.

The chart below presents some significant results.

First, we can see that, in all cases, the United States would be the country to suffer the most, even though its domestic manufacturing sector is gaining a significant TFP increase. Moreover, regarding the extent of losses, in the comparison between time and degree, time is the better key element, meaning that long-term cases are always more severe.

Second, China will suffer a colossal loss only under the Scenarios of a relatively large TFP increase in the US no matter the lasting length of this change, but not in the event of a relatively mild TFP increase. Moreover, it is intriguing that, considering a mild TFP increase in the long term in the US, China will be one of the countries that benefit from this change.

Third, in every case, group 5 (NAMERICA) (the North American region except the US) is always the biggest winner. When a mild increase in TFP occurs in the US with a short interval, the countries that benefit include groups 2 (OBORYRCEP, the nine countries that are both part of OBOR and members of RCEP), 8 (RESTOBOR, the twenty-seven countries in the Middle Eastern and West Asian part of OBOR), and 9 (HK, or Hong Kong). With a long interval, the benefiting countries comprise not only the above four sets but also groups 1 (CHINA), 3 (RCEPNOBOR, the four countries that are members of RCEP but not part of OBOR), and 6 (OBORYEU28, the eighteen countries overlapping between OBOR and the European Union). When a large increase in TFP occurs in the US with a short interval, the benefiting countries include groups 7 (EU28NOBOR, the ten countries that were part of the European Union but not part of OBOR before Brexit in the UK) and 10 (RESTWORLD, the 68 remaining countries and regions). With a long interval, the benefiting countries also include group 9 (Hong Kong) in addition to the above two.

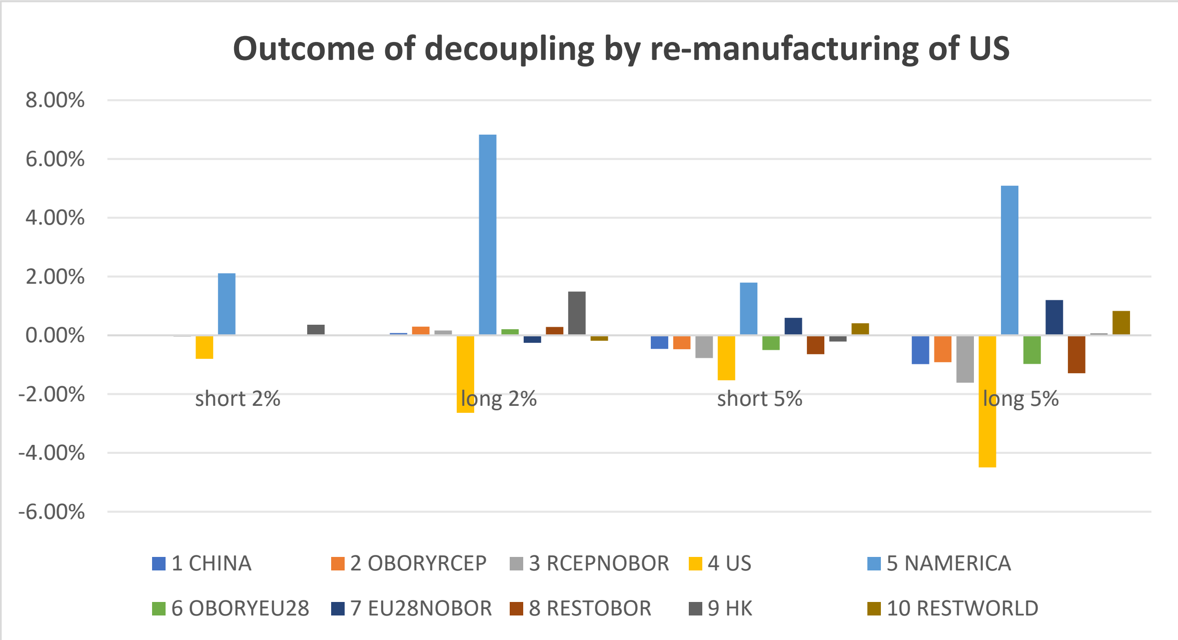

Figure 3. Comparison of the four results of simulating re-industrialization in the United States.

We can roughly depict a capacity–transition map story. When changes in TFP in the US are mild, in addition to the North American countries benefiting, the new global value chain will also require those OBOR countries that are connected to RCEP and Hong Kong (representative of China) to join and formulate the whole chain. When this change is sustained over a long period, China and the developed countries in RCEP, as well as other European OBOR countries, are also needed. Strong and continuous technological advancements make the labor cost advantage less significant in the overall production process and place more emphasis on the stages of transition. However, when changes in TFP are substantial, this implies that only developed European countries have the foundation to undertake such technological growth. For further cost-saving supply chains, the US and Europe could shift to other countries in the world outside of RCEP and OBOR to avoid geopolitical pressure from the US. In the long run, key factors influencing the United States' choice of a global production layout would depend more heavily on geopolitical considerations.

China will be one of the countries in the case of mild TFP occurring in a long term in the US. The reason for this phenomenon is that the spillover coefficient of group 5 (NAMERICA) countries to China is one of the lowest among the country groups, which means it is something of a bottleneck in terms of technological diffusion on a global scale. Therefore, when the TFP of Group 5 is improved by cooperating more closely and more stably with the US in the long term than ever before, China will benefit instead of losing out, keeping in mind that only a mild TFP increase is occurring in Group 5. In the short term, this kind of change will not benefit China because the TFP has not yet taken root and grown sufficiently in Group 5.

B. Main findings

a. Internal circulation works independently with external circulation. And since all external circulation will face the stability issue of the international geopolitical atmosphere, whereas internal circulation requires only domestic consumption and its total factor productivity growth, it is obviously more controllable and reliable, for the central government to stimulate with policies. This is why the CCP emphasizes that domestic circulation is the mainstay, this "mainstay" does not refer to the majority in quantity but rather to the foundation and cornerstone for stable and secure economic development. But, the most practical and realistic choice for China is to keep its opening-up trade policy and avoid collisions that could break those trade ties between China and the rest of the world, and gets the growth limits interval of (5.08%, 5.71%) easier.

b. FDI may not play as crucial a role in increasing China's TFP as it did when China fist opened-up previously. But domestic capital as a factor can still learn from international trade and develop the potential to provide additional growth effects. Intermediate goods trade can play a slightly more significant role than the final goods trade to unskilled labor factor.

c. RCEP is the most important trade partner to China now in terms of technological spillovers. Except RCEP, maintaining good relations with the US is perhaps the most realistic choice for China as it is almost impossible to obtain technology spillover effects from EU groups. Belt and Road Initiative has not assumed the strategic position that was expected to have for China yet, and a lot of words can be done in this area.

d. China's productive service capacity is severely lacking compared to other countries, and it has to rely on imports, thereby increasing economic uncertainty. Realistic choice for China is to open the productive services market more widely to stimulate domestic competition, facilitate domestic market efficiency, and thus increase domestic productive sector contribution.

e. When 'decoupling', the United States would be the country to suffer the most. China will suffer a colossal loss only under the Scenarios of a relatively large TFP increase in the US no matter the lasting length of this change, but not in the event of a relatively mild TFP increase. Moreover, China will be one of the countries that benefit from this change happening in the long term in the US. This benefit roots in the re-structuring of the world global value chain map since when changes in TFP in the US are mild, in addition to the North American countries benefiting, the new global value chain will also require those OBOR countries that are connected to RCEP and Hong Kong (representative of China) to join and formulate the whole chain. When this change is sustained over a long period, China and the developed countries in RCEP, as well as other European OBOR countries, are also needed.

C. Policy Implications

Based on the above findings, we propose the following policy recommendations:

As China shifts from high-speed growth to high-quality development and aims to establish a modern economic system, in which the mainstay is internal circulation, attention should be paid to cultivating high-tech consumer hot spots and exploring the technological innovation space. Meanwhile, consumption must be helped to upgrade reasonably, since the constant evolution of consumer desires is itself a driving force for technological development.

2. China's main channel for obtaining technological spillover from external circulation has shifted from foreign investment, when it first joined the World Trade Organization, to the trade of final goods. As such, when formulating trade encouragement policies, including free trade zone policies, emphasis should be placed on ensuring the transparency and sustained stability of these policies.

3. The "low" share of productive activities in China's input–output table is undoubtedly related to China's status of being a "manufacturing powerhouse" that is increasingly solidified within the global value chain. Other correlated factors include China's late start and weak foundation in R&D, the disconnect between the knowledge-intensive service industry and production sectors, and insufficient innovation capacity and low R&D efficiency in research institutions.

Therefore, establishing a collaborative innovation system between the knowledge-intensive service industry and production sectors is crucial for enhancing the future technological progress rate of productive sectors. Moreover, the current dependence on imported relevant services does not necessarily indicate over-sufficient openness; on the contrary, it often indicates insufficient openness, resulting in the lack of internal competition and the clear characteristics of related monopolies. Therefore, while ensuring economic security, the pace at which the productive service industry is opened up should be accelerated appropriately.

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VI. Conclusions

The main conclusions of this study are as follows:

a. The vision goal of 2035 can be achieved as long as China maintains its trade opening policy. The final product technological spillover in the global value chain is the main channel through which China can achieve TFP increases, thus making external circulation more important than the internal kind for China, although 'internal' has been defined as the 'mainstay.'

b. The economic growth impacts of external and internal circulation operate relatively independently. FDI itself has a limited effect but does provide a synergistic effect for all forms of external trade circulation. And all external trades are more friendly to domestic 'capital' as one of the production factors.

c. As for international trade partners, we find that the RCEP is the most important strategic partnership for China. OBOR has the potential to explore in this side.

d. It appears that FDI is not an effective way to lift the productive services sector's TFP, and, since the productive services sector relies heavily on importation, a realistic option for China is to open up the productive services market more widely.

e. China–US decoupling has a highly significant global impact; in all the Scenarios we considered, the United States is always the country that loses the most, and Europe would be the group to benefit when a large increase in TFP occurs in the US. China will be one of the countries that benefit from long term TFP change happening in the US.

Limitations of this study and further research directions include:

1. New growth theory focuses on endogenous technological progress and emphasizes research related to human capital, R&D, increasing returns, labor division and specialization, open economies, and monopolization. However, the absence of R&D variables in the GTAP database limits the model to assumptions made through external percentage shock increases. From this perspective, technology seems to be exogenous to this model. However, the technological spillover portrayed by our model is consistent with the explanatory framework of endogenous growth. Therefore, further research can consider integrating more endogenous theoretical elements, such as (1) combining the D-S model, which can incorporate increasing returns to scale and monopolistic competition into general equilibrium models to add and set parameters and variables; (2) introducing the Melitz model involving micro-industry and firm efficiency.

2. Linear models offer more potential and intuitive presentations for simulating economic realities, but their linearity limits their ability to accurately represent nonlinear outcomes. Further research can optimize the model's simulation effects through parameter updates and non-parametric substitutions.

3. Dynamic recursive general equilibrium models analyze problems within the framework of general equilibrium. General equilibrium means that, under the influence of trend lines, economic growth will be slowly absorbed and dissipated by the economic system, as long as enough time has passed. This framework results in the model's negative handling of shocks during recursive analysis. This may not be consistent with non-equilibrium phenomena in economic reality. Given that neoclassical and new Keynesian macroeconomics have achieved unity in dynamic stochastic general equilibrium (DSGE) methods, further research can be conducted based on DSGE as needed, considering non-equilibrium phenomena and divergent shocks near the steady state.

4. The extrapolation algorithm used here assumes equilibrium in growth, following Kaldor's stylized facts. However, economic reality also encompasses Kuznets's insights, highlighting structural changes beyond the growth changes outlined by Kaldor's facts.

5. Further research is needed to clarify and explore the various factors behind the trade structure, international capital flows, and changes in national welfare discussed in the conclusions.

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