



Faculty of Economics and Business

Rethinking FDI and Growth in China: The Role of Technology Spillovers

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Rethinking FDI and Growth in China: The Role of Technology Spillovers

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

China has consistently attracted the highest foreign direct investment (FDI) inflows among developing nations for three decades. However, transitioning to a high-income economy requires a shift from relying on FDI for poverty alleviation to leveraging it for wealth creation. This study investigates the impacts of technology spillover on China's economic growth, focusing on its direct, indirect, and spatial effects. Based on Neoclassical and Exogenous growth theories, technology spillover and FDI are the key variables, with trade openness, government expenditure, and total population as control variables, and economic growth as the dependent variable. This study employs a panel dataset from 30 Chinese provinces spanning 2000-2022, sourced from the China Statistical Yearbook. Methodologically, the Cross-Section Dependence test, Augmented Mean Group (AMG) model, and Spatial model are used. Findings confirm cross-sectional dependence, validating the AMG model. Direct effects reveal that research and development (R&D) and real government expenditure significantly drive economic growth, while real FDI and trade openness are both insignificant and negatively correlated. Indirect effects highlight R&D's significant role in the relationship between FDI and economic growth. Spatial analysis reveals positive and significant coefficients for R&D, FDI, and government expenditure, emphasizing that neighbouring provinces exert a considerable influence on their growth. The implications of these findings are: first, fostering R&D investment is critical to magnifying the benefits of FDI and enhancing economic growth. Second, policies should focus on strengthening inter-provincial cooperation to maximize spatial spillover effects. Finally, aligning trade openness with sustainable growth strategies is important.

Keywords: Foreign direct investment, technology spillover, economic growth, China

Menilai Semula FDI dan Pertumbuhan di China: Peranan Limpahan Teknologi

ABSTRAK

Secara tekalnya, China muncul sebagai penerima utama pelaburan langsung asing (FDI) di kalangan negara membangun selama tiga dekad. Walau bagaimanapun, untuk mencapai peralihan kepada ekonomi berpendapatan tinggi, perubahan asas dalam peranan FDI diperlukan daripada hanya mengurangkan kemiskinan kepada memupuk penciptaan kekayaan yang berterusan dan pembangunan ekonomi berkualiti tinggi. Kajian ini secara kritikal menyiasat kesan limpahan teknologi terhadap pertumbuhan ekonomi China, dengan fokus pada kesan langsung, tidak langsung, dan 'spatial'. Berasaskan teori pertumbuhan Neoklasik dan 'Exogenous', kajian ini menggunakan limpahan teknologi dan FDI sebagai pemboleh ubah utama. Manakala, keterbukaan perdagangan, perbelanjaan kerajaan, dan jumlah penduduk sebagai pemboleh ubah kawalan, dan pertumbuhan ekonomi sebagai pemboleh ubah bersandar. Kajian ini menggunakan set data panel yang merangkumi 30 wilayah di China sepanjang tempoh 2000–2022, yang diperoleh daripada 'China Statistical Yearbook'. Untuk mencapai objektif kajian, ujian 'Cross-Section Dependence', model 'Augmented Mean Group' (AMG), dan model 'Spatial' digunakan. Kehadiran kebergantungan silang antara wilayah disahkan, sekali gus menegaskan keperluan untuk menggunakan model AMG. Hasil kajian mendapati: Pertama, kesan langsung penyelidikan dan pembangunan (R&D) serta perbelanjaan kerajaan adalah positif dan signifikan. Sebaliknya, FDI sebenar dan keterbukaan perdagangan menunjukkan impak yang tidak signifikan dengan pekali negatif, yang mencadangkan cabaran dalam mengoptimumkan pemboleh ubah ini untuk pertumbuhan. Kedua, hasil kajian menunjukkan kesan tidak langsung menekankan peranan penting R&D sebagai perantara, mengukuhkan hubungan antara FDI dan pertumbuhan ekonomi. Ketiga,

analisis 'spatial' mengenal pasti kesan limpahan positif yang signifikan, seperti yang dibuktikan oleh hubungan antara wilayah yang kukuh bagi R&D, FDI, dan perbelanjaan kerajaan. Penemuan ini menekankan bahawa aktiviti ekonomi dan dasar di satu wilayah secara signifikan mempengaruhi dinamik pertumbuhan wilayah jiran. Kajian ini menyediakan implikasi dasar seperti berikut: pertama, pelaburan yang signifikan dalam R&D adalah penting untuk memaksimumkan manfaat teknologi daripada FDI dan memastikan kemajuan ekonomi. Kedua, kepentingan kesan limpahan spatial menekankan keperluan untuk meningkatkan kerjasama antara wilayah. Ketiga, penyelarasan semula dasar keterbukaan perdagangan adalah penting.

Kata kunci: *FDI, limpahan teknologi, pertumbuhan ekonomi, China*

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LIST OF ABBREVIATIONS

AMG	Augmented Mean Group
BRICS	Brazil, Russia, India, China, South Africa, Egypt, Ethiopia, Iran and United Arab Emirates
CCEMG	Common Correlated Effects Mean Group Estimator
COVID-19	Coronavirus Disease 2019
FDI	Foreign Direct Investment
FIEs	Foreign-invested Enterprises
FTZ	Free Trade Zone
GBPC	Global Business Policy Council
GCRG	The Global Crisis Response Group on Food, Energy and Finance
LM	Lagrange Multiplier
M&A	Mergers and Acquisitions
MNEs	Multinational Enterprises
MOFCOM	Ministry of Commerce of the People's Republic of China
OECD	Organisation for Economic Cooperation and Development
RCEP	Regional Comprehensive Economic Partnership
R&D	Research and Development
SDM	Spatial Dubin Model
SLM	Spatial Lag Model
TGS	Tesla Giga Shanghai
UNCAD	United Nations Conference on Trade and Development
WFOE	Wholly Foreign-Owned Enterprises

CHAPTER 1

INTRODUCTION

1.1 Introduction

Foreign direct investment (FDI) has become the primary investment method, the means by which multinational enterprises (MNEs) conduct trade, technology transfer and bring about some degree of technology spillover since the mid-1990s, against the backdrop of the accelerated process of global economic integration (Behera, 2023; Yasin et al., 2024). MNEs will continue to dominate global cross-border investment and value chain design in terms of foreign investment (Linsi & Gristwood, 2024). Historically, developed economies like the United States, Japan, and the European Union have received the majority of the world's FDI influx, and these nations continue to be key hubs for luring FDI.

Simultaneously, with the growth of developing economies, the share of developing economies in the global FDI inflow has continued to exceed 50% since the Coronavirus Disease 2019 (COVID-19) Pandemic in 2020, and their position in the global economy has become more important. To a certain extent, technology spillovers have promoted local economic growth and technological progress. Global FDI reached US\$243 billion in 1990 and US\$1.3 trillion in 2022, according to figures from the United Nations Conference on Trade and Development (UNCAD), with an average annual growth rate of 40.2% from 1996 to 2000. Over the same time period, the GDP increased at an annual pace of just 1.3% in current prices. Global FDI has gradually decreased, as a result of the effects of the global financial crisis in 2008 and the global COVID-19 pandemic in 2020 (Figure 1.1). Under the multiple crises, such as deglobalisation (Pillich, 2024), geopolitical tensions

(Mohr et al., 2024) and energy prices and debt pressures, FDI rebounded strongly in 2021 and fell by 12% year-on-year (YoY) in 2022 after the latest bottoming out, showing downward pressure and challenges.

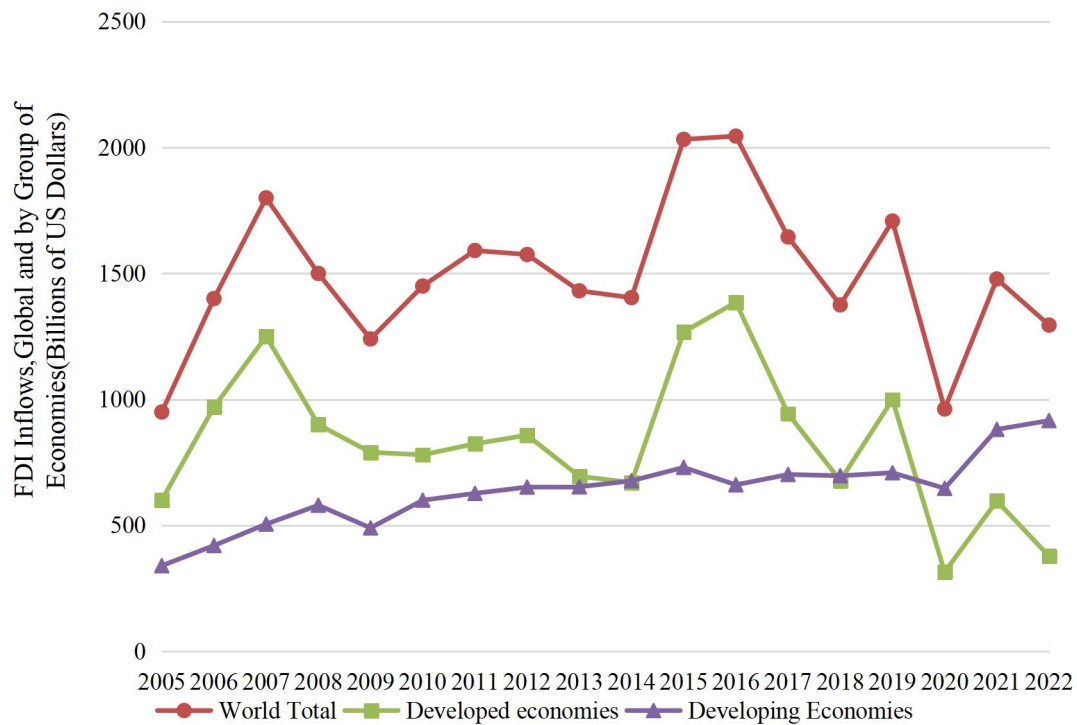


Figure 1.1: FDI inflows, global and by economic grouping (2005–2022)

Source: United Nations Conference on Trade and Development (UNCTAD, 2023)

In the World Investment Report 2022, UNCTAD called for sustainable economic recovery in developing countries and balanced development of the world economy. The World Investment Report 2023 called for a significant increase in investment in the energy transition in developing countries. A series of United Nations reports highlighted the important role of FDI in developing countries in stimulating global economic development. As reported in the reports, FDI in developing countries increased by 4% year on year in 2022, while FDI in developed countries fell by 37%, mainly because of the financing deals of multinational enterprises (MNEs) in developed economies, which enabled developing

countries to account for 70% of global FDI for the first time. However, this is not something for developing countries to be proud of. Relatively speaking, the economy and science and technology of developed countries complement each other and are more developed. On the other hand, developing countries are lagging economically and technologically (Shah et al., 2024). The ability of developing nations to carry out technological research, development, and innovation does not solely depend on their own capabilities. Instead, luring MNEs investment is an advantage to the countries to fully exploit the positive effects of technology spillover to support their economic growth, technological innovation, and knowledge and management improvement (Chan et al., 2024). FDI is therefore essential for the developing world's economic growth (Epor et al., 2024).

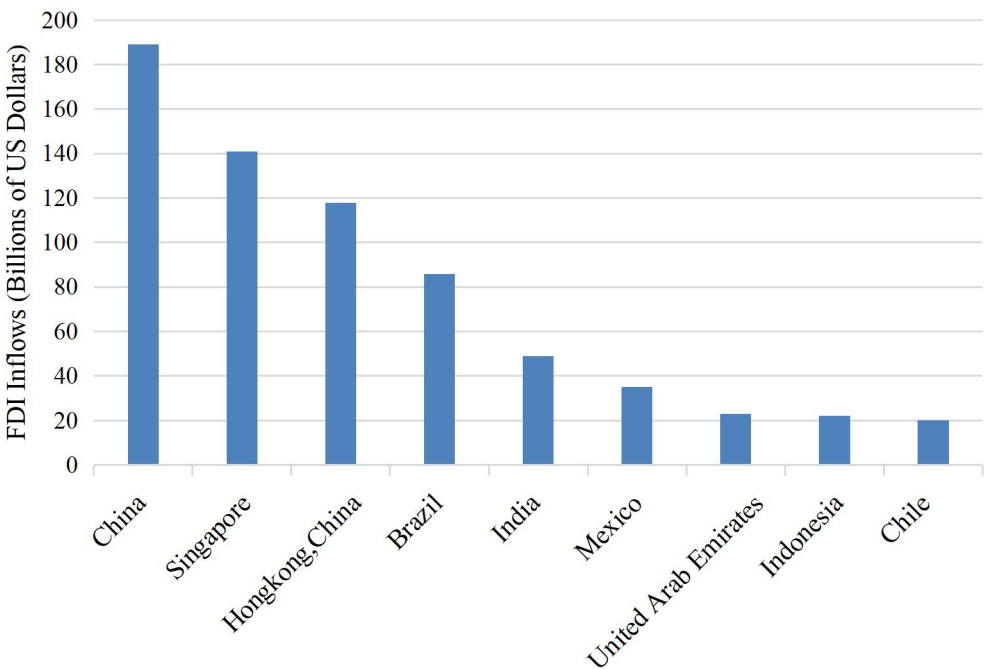


Figure 1.2: FDI inflows, top 9 host economies in developing economies in 2022
Source: United Nations Conference on Trade and Development (UNCTAD, 2023)

Based on Figure 1.2, China has attracted the most FDI amongst developing countries for 30 years in a row. Even in 2020, when global FDI dropped sharply due to the impact of the global COVID-19 pandemic, China's FDI bucked the trend and surpassed the United States to become the world's largest FDI recipient for the first time. China has comprehensive advantages in attracting foreign investment, such as a stable political environment, a huge market for raw materials and consumption, sound infrastructure, professional industrial workers, and a growing independent innovation and business environment.

China, the largest developing nation in the world, benefits from economic globalisation, FDI and technology spillover. Moreover, China contributes to the sustainable growth of the global economy due to its market size (Li et al., 2024; Yue et al., 2024; Morita & Nguyen, 2021; Feng & Li, 2021). The enormous achievements of China's economy since the implementation of the reform and opening up policy in 1979 and China's entry into the World Trade Organisation (WTO) in 2001 are attributed to the transfer of industrial capital caused by globalisation and the transfer of technology and knowledge embedded in the industrial capital. In just 30 years, China has advanced to become the world's factory. China's manufacturing sector's quick growth, its service sector's rapid development, its status as the largest trading nation in the world, and the establishment of its significant place in the value chain are all directly tied to FDI.

As shown in Figure 1.3, China began to introduce FDI and foreign-invested enterprises (FIEs) after the implementation of the reform and opening-up policy, which injected vitality into China's economic growth. Scholars such as Zhu and Zhao (2022), Sang (2021), and Zhang and Dai (2023) have all provided a detailed overview of the

history of China's utilisation of foreign investment. In 1979, faced with the two gaps of insufficient domestic savings and shortage of foreign exchange, China began to explore the construction of a planned commodity economy, and shifted from the exclusion to the encouragement of foreign investment. In 1992, China formally established the socialist market economic system and determined the policy of actively, reasonably and effectively utilising foreign investment, and the absorption of foreign investment entered into a period of rapid development, with the rapid growth of newly established FIEs and FDI inflow.

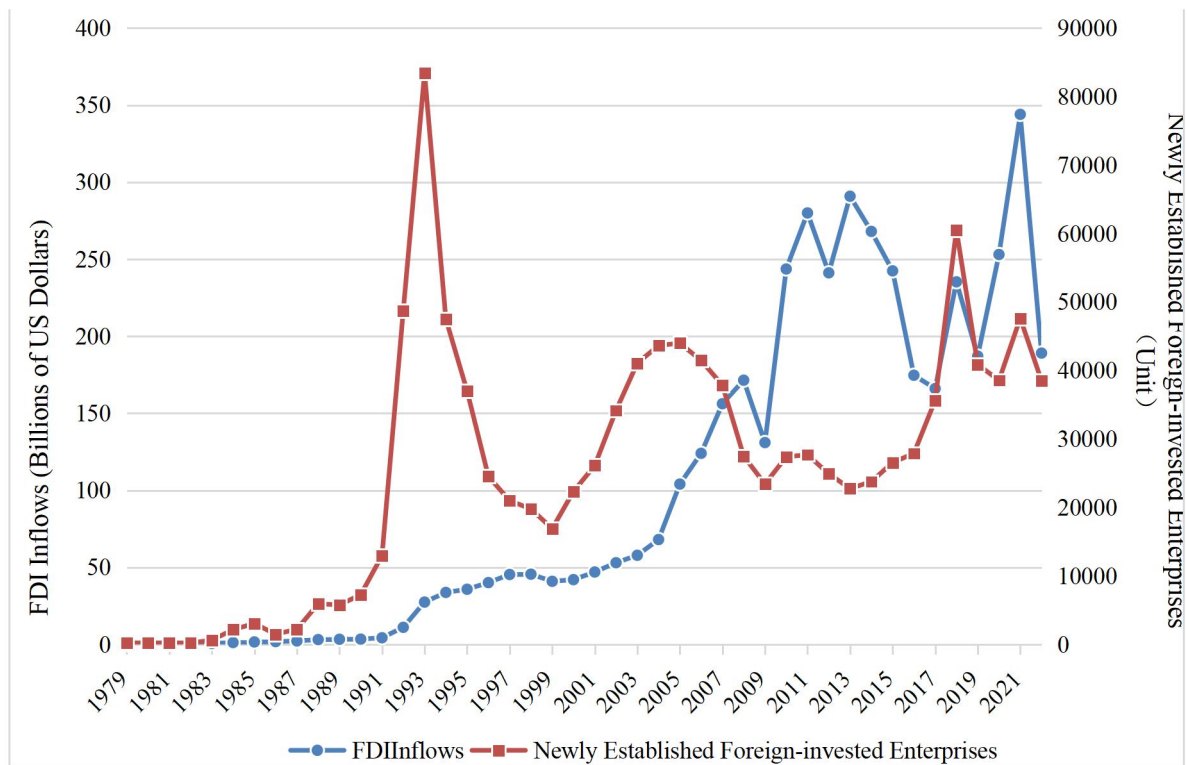


Figure 1.3: FDI inflows and newly established foreign-invested enterprises for China (1979–2022)

Source: MOFCOM FDI Statistics (2023)

After the Asian financial crisis in 1997, China's newly established FIEs and FDI inflow declined in phases and bottomed out in 1999 before rebounding. After China officially became a member of the WTO at the end of 2001, it ushered in the second key

opening up with WTO members on both sides, mutual and multi-level opening up, and then China's newly established FIEs and FDI inflows continued to grow. After being greatly affected by the global financial crisis in 2008, China's newly established FIEs and FDI inflow bottomed out rapidly in 2009 and then rebounded. In 2020, China's FIEs bottomed out again and then rebounded, while FDI inflow bottomed out and then rebounded in 2019, due to the COVID-19 significant negative impact. In a challenging global investment environment, China attracted a new high of US\$189.1 billion in FDI in 2022, 5% increase against the global decline trend, with a strong concentration in manufacturing and high-tech sectors, where technology spillovers continue to play a role in economic growth.

According to Sang (2019), China's reform and opening-up were carried out in accordance with its own economic and social conditions. They gradually increased the geographic area and industrial sectors of opening-up to the outside world, building the fundamental framework of all-around opening-up. China made a significant decision in the new age to create a new development paradigm known as "dual circulation" in order to satisfy the demands of high-quality economic development. The domestic great circulation serves as the major body of the new dual circulation development paradigm, which also features domestic and international dual circulations that support one another. Furthermore, a high level of opening-up to the outside world and continuing to attract FDI are the cornerstone and path for the sound development of external circulation.

According to Wang et al. (2019), FDI fostered worldwide talent development, brings cutting-edge technology and management expertise, and helped China integrate into the global value chain. China's manufacturing sector's rapid growth, the service sector's

quick expansion, the country's status as the world's largest trading partner, and the construction of its leadership role in the value chain are all directly tied to FDI. Liu and Han (2021) studied the micro data of Chinese enterprises in 2000–2007, they confirmed that FDI can enhance the stability of inserting into global value chain in both the foreign capital enterprise and the private enterprise. Also, through improving the quality of export products to build the transmission mechanism. However, the enterprise should improve its capability of independent innovation on the basis of introducing and absorbing foreign advanced technology. Therefore, in the dual circulation new development paradigm, China should continuously attract foreign investment and use technology spillover to promote domestic research and development and technological innovation.

The effect and role of FDI and technology spillover on the economic growth of the host countries in developing countries is still a hot topic for academics both at home and abroad due to the complex situation of economic deglobalisation (Pillich, 2024), the global COVID-19 pandemic threat, geopolitical tensions (Mohr et al., 2024), and the resurgence of trade protectionism. According to the Global Crisis Response Group on Food, Energy, and Finance (GCRG) of the United Nations, the global COVID-19 epidemic and the Russia-Ukraine conflict have had a detrimental influence on the world and have caused a food crisis, an energy crisis, and a financial system crisis. These three crises will lead to low confidence in overseas investment, increased uncertainty in global capital flows, and aggravate the trend of deglobalisation (Pillich, 2024) and the risk of capital flight and debt distress in developing countries.

China's economic growth is being put to a severe test in the complicated international political and economic environment, and there is mounting downward

pressure. In the short term, the global COVID-19 pandemic and geopolitical tensions have little direct impact on China's economy. China quickly adopted effective epidemic prevention measures, better controlled the domestic epidemic and adopted proactive fiscal and monetary policies, which led to a rapid recovery of the domestic economy, winning international trust and FDI return, and continued technology spillovers. Moreover, China's energy dependence on Russia is not too high. Long-term geopolitical tensions and the global COVID-19 pandemic will, however, have a stronger indirect effect on China's economy. The integrity of China's supply chain and industrial chain and the fluency of economic external circulation are constantly threatened. Also, the production cost is forced to increase, the comparative advantage of high quality and low prices is being lost, and the new advantage has not yet formed, which may affect the distribution of global FDI in China and the efficiency of technology spillover.

1.2 Background of the Study

Foreign direct investment (FDI) has emerged as a key driver of global economic integration, facilitating not only capital flow but also the diffusion of technology, knowledge, and managerial expertise across borders. The conceptual foundations of FDI are rooted in the seminal works of Hymer (1960) and Dunning (1977); on this note, FDI refers to cross-border capital investments where investors acquire controlling stakes in foreign enterprises and actively engage in their management, typically with the objective of long-term profit generation. FDI is widely acknowledged for generating technology spillover effects to domestic firms, enhancing their productivity and competitiveness (MacDougall, 1960; Romer, 1990); moreover, the influence of FDI often extends spatially across regions as theorized by Paelinck and Klaassen (1979) and later advanced by Anselin

(1988), spatial spillovers occur when the economic or technological benefits of FDI in one region also positively affect neighbouring areas through interregional linkages.

China, now one of the largest global recipients of FDI (Zhu & Zhao, 2022), has leveraged these investments to support its industrial development and integration into global value chains. However, as the nation transitions from rapid to moderate economic growth, it faces pressing structural challenges including the middle-income trap and middle-technology trap which threaten to stall further progress. In this context, unlocking the full potential of FDI spillovers becomes critical for ensuring sustainable and inclusive development. Despite substantial inflows of FDI, questions remain as to how effectively these spillovers are being transmitted, particularly across different regions in China. There is a need to understand not just whether FDI contributes to domestic productivity, but how these spillover effects both technological and spatial function under varying regional conditions. Moreover, empirical evidence is still fragmented regarding the factors that enhance or hinder these effects in the Chinese context. This study addresses this gap by examining the extent and nature of technology and spatial spillovers from FDI across Chinese regions. By doing so, it aims to provide insights into how FDI can be more effectively leveraged to foster balanced regional growth.

Figure 1.4 illustrates the scatter diagram depicting the relationship between FDI inflows and economic growth in China. It shows that FDI inflows were positively and significantly correlated with GDP from 1979 to 2022; FDI inflows increased alongside GDP, and vice versa. Based on the diagram, FDI inflows are treated as the independent variable and GDP as the dependent variable. The estimated trend line closely fits the actual data, indicating a strong degree of fit and a high explanatory power, thereby reflecting a

univariate linear relationship between the two variables. FDI is one of the key channels through which technology spillovers occur. Both the quantity and quality of FDI serve as the foundation and guarantee, respectively, for effective spillover, thereby exerting a profound impact on China's economic growth (Zhu & Zhao, 2022). Moreover, FDI acts as a vital mechanism for China's deeper integration into the global value chain and industrial system, while also serving as an essential conduit for the inflow of high-quality foreign resources to enhance domestic economic circulation (Wang et al., 2019).

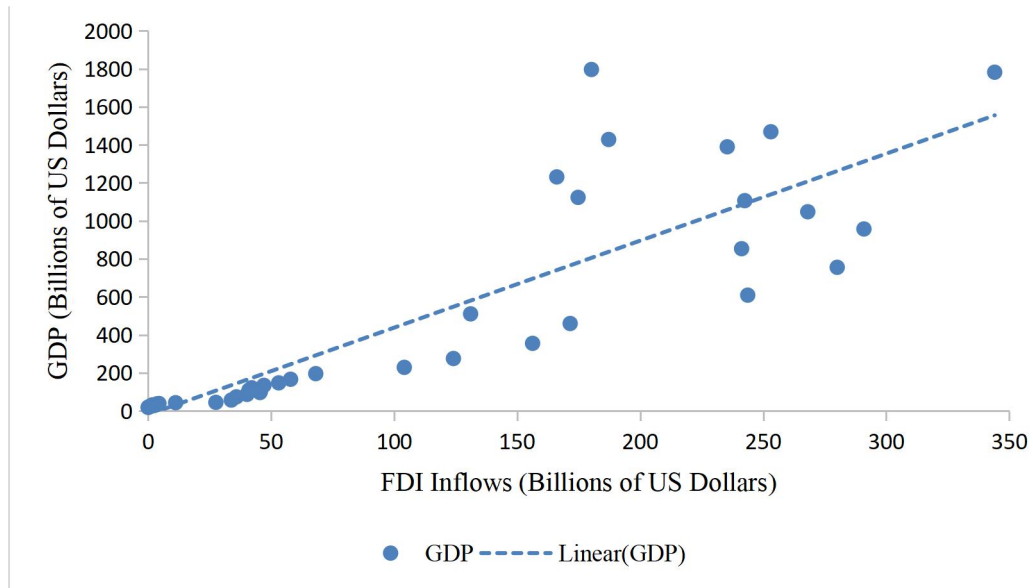


Figure 1.4: Scatter diagram between GDP growth and FDI inflows in China (1979–2022)
Source: World Bank (1980–2023)

However, the comparative cost advantage relying on cheap labour and abundant natural resources for a long time is losing (Zhang & Dai, 2023). The factor-driven model is shifting to an innovation-driven model, and the competitive advantage of high-quality economic development has not yet been formed. However, from the perspective of global value chain, MNEs began to deploy in Southeast Asia, such as Vietnam and Indonesia, where the cost advantage is lower (Hoang et al., 2022; Yasin et al., 2024). FDI can transfer

and spread advanced technology and management experience for the host country, but the core technology is still unique to the home country and MNEs (Kanval et al., 2024; Obeng-Amponsah & Owusu, 2023; Sunde, 2023; Behera, 2023). Meanwhile, FDI may bring a series of negative impacts, such as widening regional disparities, the lack of independent innovation of domestic enterprises, high external dependence and influence of government control (Epor et al., 2024; Yasin et al., 2024; Hoang et al., 2022). Against this backdrop, FDI remains a key policy tool for stimulating sustainable economic growth.

1.3 Problem Statement

Since the reform and opening-up in 1978, China has experienced remarkable economic growth, rapidly integrating into the global economy through export-led development and substantial foreign direct investment (FDI) inflows. As of 2022, China's GDP stood at USD 17.96 trillion, making it the world's second-largest economy (World Bank, 2023). Foreign firms have played a critical role in driving this transformation by introducing capital, advanced technologies, and managerial expertise. According to endogenous growth theory, sustained economic growth is primarily driven by technological progress, which may originate not only from internal R&D and human capital but also from external knowledge spillovers particularly via FDI (Romer, 1990).

Although China has the world's second-largest economy, it remains a developing country with a mid-level GDP per capita of USD12,720.22 in 2022, which is nearly equivalent to the global average of USD12,647.48 (World Bank, 2023). After transitioning from a lower-middle-income country in 2003 to an upper-middle-income country in 2011, China has remained in the middle-income category for over two decades. Simultaneously, China faces increasing technological bottlenecks; it lags in core technologies compared to

advanced economies while gradually losing its low-cost manufacturing advantage to developing competitors (Zhang & Dai, 2023). Together, these dual pressures have placed China at risk of falling into the middle-income and middle-technology traps (Wang, 2024; Zheng & He, 2024).

Hence, enhancing domestic innovation capacity and leveraging FDI for technology spillovers have become national priorities; China's shift from high-speed to high-quality growth demands more than capital accumulation. Thus, FDI must serve not only as a source of external investment but as a catalyst for productivity enhancement, industrial upgrading, and technological learning (Adilla, 2024). Yet, the effectiveness of FDI as a channel for technology diffusion varies significantly across regions.

While the Eastern region has attracted the majority of FDI and enjoys more advanced technological infrastructure, the Central and Western regions remain dependent on policy-driven support and industrial restructuring (Li & Hu, 2024). This geographical disparity in FDI absorption capacity and innovation ecosystems has led to uneven spillover effects across the country. In response, the Chinese government launched the dual circulation development paradigm in 2020, aiming to rebalance economic growth by strengthening domestic economic activity (internal circulation) while maintaining openness to foreign capital, trade, and innovation (external circulation). This model emphasizes domestic innovation, import substitution, and high-value-added industries, suggesting a shift in how FDI contributes to growth.

Despite growing scholarly interest, important gaps remain in past empirical studies. First, many studies recognize FDI's positive role in growth but fail to systematically differentiate between its direct, indirect (technological), and spatial spillover effects

(Blomström & Kokko, 1998; Liu, 2008). Traditional models such as Cobb-Douglas production functions and firm-level fixed effects often suggest FDI's effects with other capital inputs, thereby overlooking the mechanisms through which FDI enhances productivity (Zhao et al., 2024; Yang et al., 2024). Second, although some studies assess FDI's role in innovation (Han & Feng, 2023), few incorporate spatial econometrics to evaluate how FDI benefits diffuse across provinces (Anselin, 1988; Zhou & Lall, 2020). Under dual circulation, China's domestic innovation push alters how and where FDI impacts productivity growth. However, the empirical evidence remains limited. For example, although Han and Feng (2023) use spatial panel models to confirm FDI's direct and innovation effects in high-tech sectors, they do not examine the broader indirect effects or how these effects vary by region or sector. Thus, the main gap lies in the lack of models that integrate the direct, indirect, and spatial spillover effects of FDI within the context of China's dual circulation paradigm. This study addresses these gaps by quantifying the direct and indirect effects of FDI on regional economic growth as well as investigating spatial dependencies to assess interregional diffusion and potential regional inequalities.

1.4 Research Questions

- i. How do foreign direct investment (FDI) and technology spillovers directly contribute to China's economic growth?
- ii. What are the indirect effects of foreign direct investment and technology spillover on China's economic growth?
- iii. How do foreign direct investment (FDI) and technology spillovers generate spatial spillover effects that influence economic growth across regions in China?

1.5 Objectives of the Study

1.5.1 General Objective of the Study

The general objective of this study is to investigate the direct effects, indirect effects and spatial effects of foreign direct investment and technology spillover on China's economic growth during the study period from 2000 to 2022.

1.5.2 Specific Objectives

This can be achieved through the following set of objectives:

- i. To quantify the direct effects of foreign direct investment (FDI) and technology spillovers on China's economic growth.
- ii. To estimate the indirect effects of FDI on China's economic growth via technology spillovers.
- iii. To estimate the spatial spillover effects of FDI and technology spillover on regional economic growth in China.

1.6 Hypotheses of the Study

Based on the the empirical literature on economic growth and foreign direct investment (FDI), directional hypotheses grounded in established economic theories is adopted as suggested by Angrist and Pischke (2009); and Wooldridge (2010). This study presents three empirically testable hypotheses:

H1: FDI has a significant positive direct effect on regional economic growth.

H2: The effect of FDI on growth is moderated by regional innovation capacity (proxied by R&D capital stock).

H3: FDI generates positive spatial spillover effects on neighbouring regions.

H1 posits that FDI has a significant positive direct effect on regional economic growth; H2 proposes that the effect of FDI on growth is moderated by regional innovation capacity, proxied by R&D capital stock; and H3 suggests that FDI generates positive spatial spillover effects on neighbouring regions.

1.7 Scope of the Study

This study aimed to analyse the direct, indirect and spatial effects of foreign direct investment and technology spillover on China's economic growth in the context of the dual circulation new development paradigm. This study's data were collected from the China Statistical Yearbook of the National Bureau of Statistics that cover 30 provinces, municipalities and autonomous regions in China. This study analyses and demonstrates the relationship between FDI, technology spillover and economic growth in China and different regions by using a combination of theories from international economics, econometrics and statistics. Specifically, this study adopts the method of empirical analysis, combining Western economic theories with China's economic management practices, and conducts a comprehensive and systematic econometric analysis of China's cross-sectional data (2022), panel data (2000-2022), and regional heterogeneity in the Eastern, Central, and Western regions. However, this study exists some data limitations, such as data from Hong Kong Special Administrative Region, Macao Special Administrative Region, and Taiwan Province and Tibet Autonomous Region of China were excluded due to data unavailability, incomparability and model robustness issues.

1.8 Significance of the Study

1.8.1 Academic Significance

This study contributes to academic knowledge in the fields of foreign direct investment (FDI), regional economic development, and technology spillovers. First, it enhances the theoretical understanding of FDI-induced technology spillovers by integrating direct, indirect, and spatial spillover effects into an empirical framework. Unlike previous studies that have focused on the national or firm level, this study adopts a regionally disaggregated approach to examine how FDI affects economic growth across provinces, thereby addressing the spatial spillovers across the regions in China.

Second, the study advances empirical modeling by applying spatial econometric techniques, which account for the spillover effects of FDI and innovation beyond regional boundaries. This methodology helps overcome limitations of conventional panel data models, which often ignore spatial autocorrelation and underestimate the full economic impact of FDI. Third, by situating the analysis within the framework of China's dual circulation strategy, the study fills a conceptual gap in the literature. It offers new insights into how domestic innovation capacity, regional absorptive capabilities, and structural reforms mediate the relationship between FDI and long-term development outcomes under a shifting global economic order.

1.8.2 Policy Significance

This study also carries significant implications for policymakers particularly in countries pursuing innovation-led and regionally balanced growth strategies. From a policy perspective, the findings offer evidence for improving the quality and effectiveness of FDI attraction strategies. By identifying the region where FDI generates the most substantial

spillovers, the study can help optimize regional investment policies, support innovation-driven industrial clusters, and promote equitable regional development. Policymakers can use the results to enhance institutional support for technology transfer, improve business environments, and align FDI incentives with national development goals.

This study also highlights how sectors can harness FDI to catalyze capital accumulation, technological advancement, and talent development. Strategic targeting of high-spillover-potential investments particularly in manufacturing, green industries, and digital infrastructure can facilitate integration of the innovation chain, industrial chain, capital chain, and talent chain, accelerating China's transition to high-value-added production. By learning from foreign firms, local firms can improve competitiveness and reduce the technology gap through absorption, adaptation, and re-innovation.

In the global context, countries such as Malaysia, Indonesia and Vietnam which are striving to escape the middle-income or middle-technology trap, can apply similar frameworks to assess how FDI interacts with domestic capabilities and regional disparities. For instance, Malaysia has adopted its *National Investment Aspirations* and *Industry4WRD* policy to move up the value chain through targeted FDI and digital transformation (MITI, 2019). Indonesia has introduced Special Economic Zones (SEZs) to attract high-tech FDI, yet regional inequality and limited absorptive capacity remain barriers (OECD, 2021). Vietnam has attracted significant FDI inflows in electronics and textiles, but struggles with technology transfer and domestic innovation spillovers (Nguyen & Tran, 2020). Hence, the emerging economics could design and adopt innovation-driven, and regionally balanced FDI strategies.

1.9 Organisation of the Study

In Chapter One, the study's context is introduced. In the background of China's economic transition from high-speed to medium-low speed model, this study investigates the impact of China's FDI and technology spillover on economic growth and the regional differences between the Eastern, Central and Western regions. This research has certain theoretical and practical value.

Chapter Two introduces the background of Chinese economy. It includes the historical stages of FDI introduction in China, the meaning of FDI, the meaning and characteristics of technological spillovers. Also, a qualitative analysis of the impact of FDI and technological spillovers on economic growth in China.

In Chapter Three, existing domestic and international literature are reviewed to determine the theory, perspectives, determinants, operating mechanisms and empirical tests of FDI and technology spillover on economic growth in China.

Chapter Four is the methodology. This chapter presents the overall research design, conducts variable selection and related data collection for China and the Eastern, Central and Western regions, as well as model estimation and selection of appropriate measurement tools.

Chapter Five shows the data analysis and results analysis. It adopts Stata software version 17 and Augmented Mean Group estimator to analyse the secondary data and illustrate the empirical results such as direct effect, indirect effect and spatial spillover effect in detail.

Chapter Six is the conclusion section. It summarises the main findings of the study, contributions to body of knowledge and stakeholder, policy implications, research limitations and future research directions.

CHAPTER 2

THE ECONOMIC BACKGROUND OF CHINA

2.1 Introduction

Chapter 2.1 is an introduction. Chapter 2.2 explains the development history, geographic distribution, industrial distribution, sectoral distribution and main sources of FDI in China. Chapter 2.3 shows the technological spillovers generated by FDI in China. In particular, wholly foreign-owned enterprises become the main body of R&D, but foreign-invested enterprises' innovation advantage is weakening. However, FIEs remain the important channels of the export of high-tech new products and regional differences. Chapter 2.4 introduces GDP in China. GDP growth and GDP per capita in China are both rising, but there are big differences between Eastern, Central and Western Regions. Chapter 2.5 provides a remark of this chapter.

2.2 Foreign Direct Investment in China

2.2.1 The Development Process of China's Foreign Direct Investment

From the founding of the People's Republic of China to the first 30 years before reform and opening-up, China barely utilised foreign investment and suffered a slow economy growth. Since the reform and opening-up in 1978, China has opened its door to attract foreign investment. The scale and scope of foreign investment have continuously expanded, which has not only accumulated valuable construction funds, but also promoted the improvement of technological level and international competitiveness. Throughout the 40-year history of reform and opening-up, China's FDI absorption can be approximately divided into six stages (Sang, 2021): initial stage, slow development stage, rapid growth

stage, adjustment and upgrading stage, mature and stable stage and high-quality development stage, and different stages show different characteristics.

2.2.1.1 Initial Stage (1979–1985)

Under the guidance of the thinking of gradual reform guidance, China began to abandon the planned economy concept of "no domestic debt, no foreign debt" and explore the construction of a planned commodity economy. Faced with the double gap of insufficient domestic savings and foreign exchange shortage, China has turned from rejecting foreign investment to encouraging foreign investment. The way to attract foreign investment is mainly government foreign direct borrowing, while FDI is supplemented. In July 1979, the Law on Chinese-Foreign Equity Joint Ventures was promulgated and put into effect, providing the first legal basis for foreign-funded enterprises to operate in China.

In order to promote the opening-up with preferential policies, China formulated and promulgated the first direct foreign-related enterprise income tax law, the Income Tax Law of Sino-Foreign Joint Ventures, in 1980, and promulgated the Foreign Enterprise Income Tax Law in 1981, giving foreign enterprises preferential tax treatment over domestic enterprises. In 1984, China first put forward the policy of "exchanging market for technology" to introduce foreign capital, and "three-capital" (joint venture, cooperation, sole proprietorship) enterprises have gradually become the main form of utilising foreign capital. In 1985, in order to protect the legitimate rights and interests of the parties involved in foreign-related economic contracts and promote the development of economic relations with foreign countries, China formally promulgated the Foreign-Related Economic Contract Law.

In July 1979, China decided to establish special economic zones in Shenzhen, Zhuhai, Shantou and Xiamen as experimental fields for attracting foreign investment. In 1984, 14 cities including Dalian, Qinhuangdao, Tianjin, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Fuzhou, Guangzhou, Zhanjiang and Beihai were approved as the first Coastal Open cities in China. Then, in 1985, the Yangtze River Delta, Pearl River Delta and Xiamen, Zhangzhou and Spring triangle in Minnan were opened as coastal economic opening zones. The market and cities have a good economic base, industrial base, technical level and management level. Since the implementation of opening-up strategy to the outside world to take advantage of other countries capital, knowledge, and market. This eventually strengthens technological introduction and technical transformation of existing enterprises, thus promote the economic transformation, the domestic economy to the internal and external combination type and leads to the development of the mainland economy.

In this stage, China has to some extent realised the expansion of exports and the accumulation of funds for future technological upgrading, with a total of 6,797 new foreign direct investment enterprises established. Amongst the amount of foreign capital used, foreign loans led by the government amounted to US \$16.88 billion. While FDI was only US\$6.07 billion, accounting for 26.4% of the actual used foreign capital. The average annual growth rate was 33.2%. At this stage, the basic characteristics of China's FDI utilisation are as follows: the FDI scale is small, only US\$870 million per year. The regional distribution is unbalanced, mainly concentrated in Guangdong and Fujian provinces and coastal open cities, few capital flows to inland areas. The source of investment is concentrated in Hong Kong and Macao of China, and the investment from

western developed countries is scarce and mainly from the United States. The investment sector is concentrated in services such as labour-intensive processing and hotels.

2.2.1.2 Slow Development Stage (1986–1991)

In the exploration of attracting foreign investment through reform and opening-up, China has continuously expanded the scope of opening-up, improved relevant laws, regulations and policies, and strengthened infrastructure construction. In order to protect the legitimate rights and interests of foreign-funded enterprises, China promulgated the Law on Foreign-Funded Enterprises in 1986. In order to expand economic cooperation and technological exchanges with foreign countries and in accordance with the principle of equality and mutual benefit, China formally promulgated and put into effect the Law on Chinese-Foreign Cooperative Ventures in 1988. In the same year, in order to promote economic and technological exchanges and common prosperity between the mainland and Taiwan, the Provisions on Encouraging Investment by Taiwan Compatriots were promulgated and put into effect. China has proposed an economic development strategy for its coastal areas to boost exports and earn foreign exchange. At the same time, China has increased investment in infrastructure in such areas such as transportation, communications and energy, and constantly improved the environment for foreign investment.

In March 1988, China further expanded the scope of the open economic zones in the Yangtze River Delta, Pearl River Delta and Minnan Delta, and designated some cities and counties in the Liaodong Peninsula, Shandong Peninsula, Bohai Rim region and counties under the jurisdiction of the open coastal cities as the open economic zones. In April 1990, China announced the development and opening up of the Pudong New Area of Shanghai.

In this period, a total of 35,706 new FDI enterprises were established; Indirect investment through government-led foreign loan is still the main form of utilising foreign capital, and the proportion of government-led foreign loan decreases in the amount of foreign capital actually used, US\$18.933 billion, accounting for only 32.5% of the actually utilised foreign capital, with an average annual growth rate of 15.8%. At this stage, the basic characteristics of China's FDI utilization are as follows: FDI scale has a certain growth, with an annual average of US\$3.16 billion; Regional distribution expanded, in addition to coastal cities, some inland areas also began to introduce foreign capital; Hong Kong and Macao are still the main sources of investment. Meanwhile, Taiwan businessmen have started to invest in the mainland, while developed countries are still on standby. The investment field began to shift to productive projects and export enterprises, and the investment in tourism service projects decreased.

2.2.1.3 Rapid Growth Stage (1992–1995)

In 1992, China officially established that the goal of economic restructuring is to establish a socialist market economy. China has set a policy of positive, rational and effective utilisation of foreign investment, and the absorption of foreign investment has entered a period of rapid development and a stage of using technology for market exchange. The restrictions on the use of FDI have been greatly relaxed, and the pace of foreign capital entering China has been significantly accelerated. Since 1992, FDI has surpassed foreign loans to become the most important way of utilising foreign investment in China, and the scale of China's investment has ranked first, further improve the legal system of FDI.

First, in 1991, the Income Tax Law of the People's Republic of China on Enterprises with Foreign Investment and Foreign Enterprises was implemented, which unified the application of tax rates, tax preferences and tax jurisdiction to foreign-related enterprises. In 1992, in order to strengthen the administration of tax collection, the Standing Committee of the National People's Congress adopted the Law of the People's Republic of China on the Administration of Tax Collection to unify internal tax collection and foreign tax collection and promote economic and social development. In 1994, the standing committee of the eighth National People's Congress examined and approved of the National People's Congress standing committee on foreign investment enterprises and foreign enterprises for value added tax, consumption tax, business tax and other tax the decision of the provisional regulations. A new industrial and commercial tax system reform, the domestic foreign capital enterprise unified applicable to impose value added tax, consumption tax and business tax.

In 1995, the Ministry of Foreign Trade and Economic Cooperation promulgated the Implementation Rules of the Law of the People's Republic of China on Chinese-Foreign Cooperative Ventures, which improved the previous laws and regulations. With the continuous deepening of reform and opening up of China, the tax and fee system for foreign capital enterprises to favour domestic enterprises is increasingly inconsistent with the requirements of fair competition of market economy. China's foreign capital legislation has entered a new transitional period. In 1995, the National People's Congress adopted the Outline of the Ninth Five-Year Plan for National Economic and Social Development and the Long-term Goals for 2010, which explicitly states that policies for domestic and foreign-funded enterprises should be gradually unified and national treatment implemented.

Second, China is further expanding the areas and regions open to the outside world. Since 1992, commercial, financial, insurance, aviation, lawyer and accounting industries that were once off-limits to foreign investors have been allowed to carry out pilot projects. Moreover, land development, real estate, hotels and information consulting, which were once restricted to foreign investment, have been gradually opened. Simultaneously, further expand opening-up to the outside of the region, five cities along the Yangtze River (Chongqing), Yue Yang, Wuhan, Jiujiang, Wuhu City, four borders (Harbin, Changchun, Hohhot, Shijiazhuang) and 11 mainland provincial capitals (Taiyuan, Zhengzhou, Hefei, Nanchang, Changsha, Chengdu, Guiyang, Xi 'an, Lanzhou, Xining, Yinchuan), while maintaining the same policies as previous open coastal cities. So far, the new pattern of opening-up to the outside world has been preliminarily established.

Third, further strengthen industrial policy guidance. On June 20, 1995, the State Planning Commission, the State Economic Commission and the Ministry of Foreign Trade and Economic Cooperation jointly issued the new Interim Provisions on Guiding the Direction of Foreign Investment and the Catalogue for Guiding Foreign Investment Industries, reclassifying foreign investment projects into encouraged, restricted and prohibited categories and formulating corresponding supporting measures and policies. This document adjusts the industrial orientation of foreign investment, encourages new agricultural technologies, advanced technologies, new technologies and equipment for the prevention and control of environmental pollution. Foreign investment projects that can give priority to productivity and resource advantages of the Central and Western regions and prohibit projects that cause pollution damage to the environment, damage to natural resources or harm to human health.

During this period, the number of new FIEs soared to 216,761. Indirect investment through government-led foreign borrowing is no longer the main form of utilising foreign capital. Amongst the actual amount of used foreign capital, FDI rapidly increased to US\$109.81 billion, accounting for 73.5% of the actual amount of used foreign capital, with an average annual increase of 60.2%. At this stage, the basic characteristics of China's use of FDI are as follows: the scale of FDI grows rapidly, reaching an annual average of US\$27.45 billion. The areas and regions that are open to the outside world have been further expanded, and the areas that are prohibited and restricted have been narrowed down and further expanded from coastal cities to cities along rivers, border areas and capital cities in the interior. The sources of investment are diversified. Multinational companies from developed regions such as the United States and the European Union have invested in China. The industrial structure of investment shows a trend of advanced development, and the intensity of the service industry is increased. Wholly foreign-owned enterprises have developed rapidly, forming a pattern of joint venture, cooperation and sole proprietorship amongst developing countries for 30 years.

2.2.1.4 Adjustment Stage (1996–2001)

Since 1996, the focus of FDI introduction in China has shifted from quantity expansion to quality, efficiency improvement and structure optimisation. In September 1997, the report to the 15th National Congress formally stated that the common development of economic entities under various forms of ownership with public ownership as the mainstay is a basic economic system in the primary stage of socialism in China. China has continued to adjust its FDI policies and keep pace with the times, as shown below:

First, China needs to further expand investment in the service sector. Foreign investors are allowed to invest in finance, insurance, commerce, foreign trade, transportation, medical care, telecommunications and various intermediary institutions.

Second, China will encourage FIEs to set up research and development institutions. Research and development centers established by foreign investors in China will be exempted from import production tax and import link tax, and the transfer of technology will be exempted from business tax.

Third, China needs to strengthen industrial policy orientation. In December 1997, the State Planning Commission, the State Economic Commission and the Ministry of Foreign Trade and Economic Cooperation jointly issued the revised Catalogue for the Guidance of Foreign Industries, reclassifying the industries in which FDI is encouraged, restricted and prohibited. The revised catalogue contains 329 articles, of which 187 are encouraged, 26 are restricted A, 85 are restricted B, and 31 are prohibited. It also stipulates that as of January 1, 1998, China will be exempted from tariff and import value-added tax for equipment and technologies that need to be imported for foreign investment projects that are encouraged and supported.

Fourth, China will gradually implement national treatment for foreign-funded enterprises. Since April 1, 1996, all equipment and raw materials for self-use imported by newly established foreign-funded enterprises have been subjected to tariff and import link tax according to their statutory productivity. At the same time, special economic zones have abolished the preferential tariff area on investment goods imported by foreign-funded enterprises.

Fifth, China will encourage foreign investment to participate in the development of the Western region. Since March 2000, China has promulgated a series of preferential policies to encourage foreign investment in the Western region, mainly manifested as expanding the areas of foreign investment and implementing preferential tax policies.

During this period, a total of 130,761 new FDI enterprises were established. Since 2001, foreign loans have no longer been included in China Statistical Yearbook. Amongst the actual amount of used foreign capital, FDI has increased to US\$260.36 billion, accounting for 76.7% of the actual amount of used foreign capital, and the average annual growth rate has dropped to 2.1%. At this stage, the basic characteristics of China's FDI utilisation are as follows: the foreign capital availability rate increased rapidly to an annual average of US\$43.39 billion. The distribution of investment areas is likely to be reasonable, and some inland provinces and Western regions have become new investment hotspots. The sources of investment are mainly developed countries, such as Europe and the United States. More than 400 of the world's 500 largest multinational corporations have set up branches in China to improve the quality of FDI. The industrial distribution of foreign investment tends to be reasonable, and the technical content of foreign investment is obviously improved.

2.2.1.5 Mature and Stable Stage (2002–2016)

On December 11, 2001, China formally became a member of the WTO. This is China's second critical opening-up, from limited partial opening-up in certain areas to all-dimensional and multi-level opening-up, from policy-based opening up to foreseeable opening-up under the legal framework, from unilateral self-opening to bilateral and mutual opening-up with WTO members.

First of all, in order to cooperate with its accession to WTO, China has cleaned up, revised and abolished more than 2,000 laws, regulations and various red documents that are in conflict with WTO rules, so that relevant policies and regulations of FDI are compatible with WTO rules. Revoke foreign investment laws and regulations and the WTO “agreement on trade-related investment measures (TRIMs) conflict of laws, regulations and policies”, including cancellation of local content requirements, trade balance demands, import substitution, the import of foreign exchange restrictions, and domestic sales, et al. Also, responsibility fulfilled as a developing country to revoke the commitment over the next five years. Successively for the Chinese-foreign cooperative enterprise law of the National People's Congress (October 2000), “foreign enterprises” and “Chinese and foreign joint venture enterprise law major revisions (March 2001)”, and implementation of the new enterprise income tax law (March 2007), finally cancelled the foreign-related tax incentives, unified treatment of income tax of domestic and foreign enterprises.

Secondly, improve FDI industrial policies. The Catalogue for the Guidance of Foreign Investment Industries has been continuously formulated and revised, and industrial policies for absorbing foreign investment have been published in the form of regulations to improve policy transparency. China will introduce programs to encourage foreign investment. Thirdly, China will expand FDI market access in the service sector and increase market access opportunities in banking, insurance, securities, telecommunications, tourism, foreign trade and commerce.

In order to benchmark international investment rules, China for the first time in 2013 in the Shanghai Pilot Free Trade Zone to explore the implementation of the negative

list of foreign investment access system, marking the management of foreign investment access from the "positive list" to the "negative list" of the exploration began to put into practice. As a comparison to the positive list, the negative list system is more conducive to regulating government behaviour and providing a competitive market with high openness, high freedom and high transparency for market players. As the accumulation of capital in China continues to increase, China has changed from a foreign capital importer to a capital exporter since 2015. During this period, the number of newly established FIEs averaged 31,871 annually. Since 2015, the amount of used foreign capital only includes the amount of foreign investment. FDI has increased to US\$150,4127 billion in total, accounting for 97.9% of the amount of used foreign capital, and the average annual growth rate has increased to 9.3%.

The basic characteristics of FDI in this stage are as follows: except for the decline in 2008 due to the impact of the global financial crisis, the total FDI increased year by year at a high level. The service industry has become a new hotspot of FDI absorption and foreign investment in the service industry has become a new hotspot of investment. The number of large-scale projects invested by multinational corporations in China is increasing rapidly, and the average size of foreign invested projects is much larger than that of the previous four stages. While MNEs are expanding their investment in China, they are implementing localisation strategies. Many large MNEs have set up research and development institutions and procurement centers in China. Wholly foreign-owned enterprises outnumbered joint ventures and became the main form of FDI. Cross-border M&A has become an increasingly important means of foreign investment. The source of investment is still mainly multinational companies from developed countries such as Europe and the United States.

2.2.1.6 High-quality Development Stage (2017—present)

In October 2017, the 19th National Congress of China put forward the term "high-quality development" for the first time, indicating that China's economy has shifted from a stage of high-speed growth to a stage of high-quality development. The principal contradiction in Chinese society has been transformed into the contradiction between unbalanced and inadequate development and the people's ever-growing needs for a better life. Unbalanced and inadequate development is the direct manifestation of the low quality of development.

High-quality development lies in the vitality, innovation and competitiveness of the economy. In 2020, in order to cope with the risk of external chain breaks and the impact of the COVID-19 epidemic, China proposed for the first time to build a new development paradigm in which the domestic and international circulations reinforce each other, and the internal and external cycles work together to ensure economic security.

High-quality development refers to stable economic growth, balanced development between urban and rural areas in different regions, innovation-driven development, green development, and more equitable sharing of the fruits of economic development amongst all the people. The new development paradigm is to build domestic circulation as the mainstay with the domestic and international circulations reinforcing each other. Building a dual circulation new development paradigm is a major decision to improve the level of China's economic growth, which can better connect and use the two markets and two resources to achieve a sustainable development.

From the perspective of internal circulation, China should carry out market-oriented allocation of factors, optimise and upgrade the demand structure of the product

market, and strengthen the layout of the industrial chain. From the perspective of external circulation, China's super-large-scale market, relatively complete industrial system and perfect infrastructure construction are the advantages of attracting foreign investment.

In order to actively promote foreign investment and improve the rule of Law in Foreign Investment work, the Foreign Investment Law of the People's Republic of China came into effect on January 1, 2020. China have explicitly implemented the management system of pre-establishment national treatment plus a negative list for foreign investment, strengthened property rights protection for foreign-invested enterprises, facilitated the implementation of high-level investment liberalisation and facilitation policies.

Established and improved mechanisms for promoting foreign investment, and created a stable, transparent and predictable investment environment. This is the first comprehensive and systematic legislation on foreign investment in Chinese history, marking a new stage of institutional opening-up in China. On January 1, 2022, the Regional Comprehensive Economic Partnership (RCEP) came into force, bringing new opportunities for foreign investment in China.

According to data from China's Ministry of Commerce, from January to November 2022, the actual use of foreign capital in China's Eastern, Central and Western regions increased by 7.7%, 28.6% and 24.6% respectively, and the less developed Central and Western regions have released greater consumption space and market potential. From the perspective of investment sources, investment in countries along the Belt and Road Initiative and ASEAN grew rapidly, with real investment increasing by 29.4% and 29% year-on-year, respectively (including investment data through free ports).

China has made remarkable progress in opening-up new frontiers, with the actual use of foreign investment in the 21 pilot free trade zones accounting for 18.1% of the total foreign investment attracted. From the perspective of the optimisation of foreign investment structure, the high-tech industry attracted 28.3% more investment in 2022, and its share increased to 36.1%, realising the "double improvement" of the scale and quality of investment attracted.

In the 14th Five-Year Plan for the Utilisation of Foreign Investment, China proposed that it will make greater efforts to attract and utilize foreign investment, promote high-level opening-up, stabilize foreign trade, foreign investment and the economy, promote institutional opening-up, continuously reduce and implement the negative list of foreign investment access in the national and pilot free trade zones, ensure that “if not banned”, and revise and expand the Catalogue of Industries to Encourage Foreign Investment.

China will ensure that FIEs receive national treatment, attract more investment from multinational companies, and encourage more foreign investment in emerging sectors such as advanced manufacturing, modern services, new and high technologies, energy conservation, environmental protection, green and low-carbon, and digital economy, as well as in the Central and Western regions.

2.2.2 Geographical Distribution of Foreign Direct Investment in China

2.2.2.1 Foreign Direct Investment by Eastern, Central and Western Regions

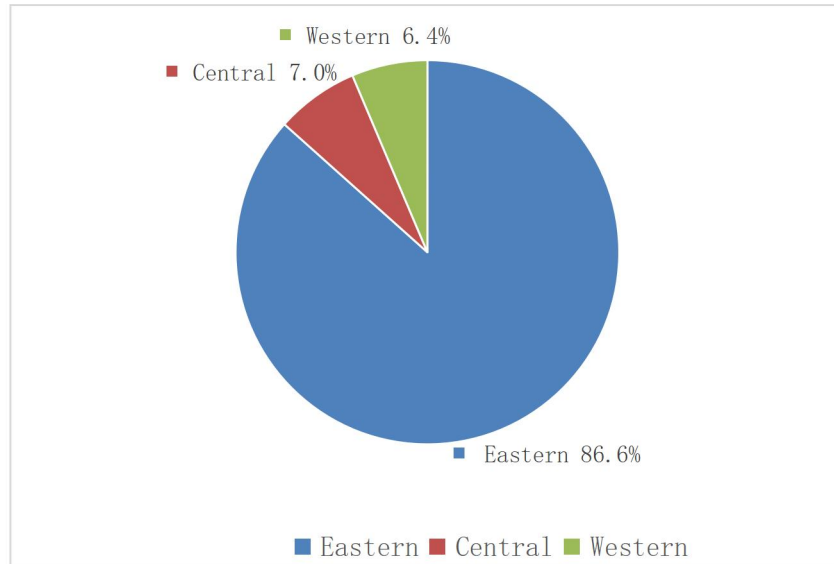


Figure 2.1: Newly established foreign-invested enterprises by China regions (2022)

Source: MOFCOM FDI Statistics (2023)

Note: 1. Eastern part: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan.
2. Central part: Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan.
3. Western part: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Xizang, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang.

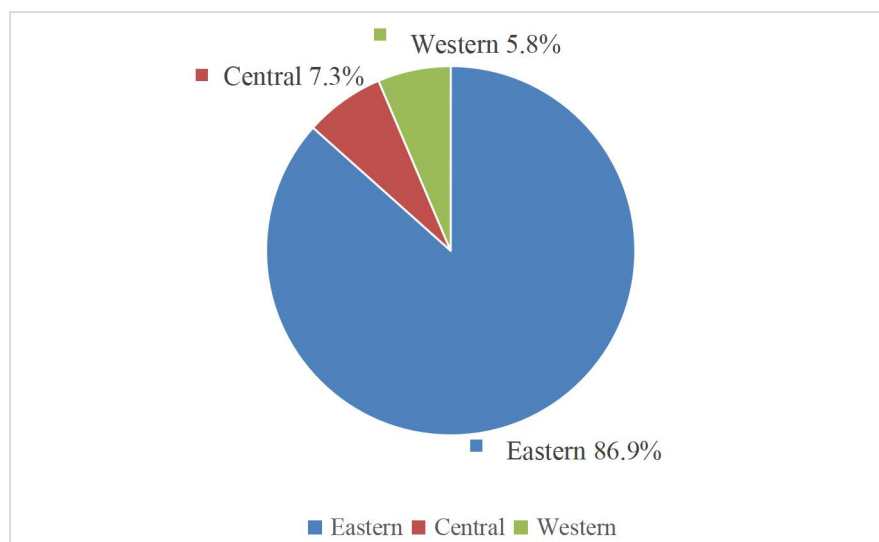


Figure 2.2: Realised foreign direct investment value by China regions (2022)

Source: MOFCOM FDI Statistics (2023)

In 2022, the number of newly established FIEs in China was 38,497, a year-on-year decrease of 19.2% from 2021. As shown in Figure 2.1, newly established foreign-invested enterprises (FIEs) in the Eastern, Central and Western regions were 33,341, 2,695 and 2,461, accounting for 86.6%, 7% and 6.4%, respectively. Amongst them, the number of newly established FIEs attracted by the Eastern region fell by 1.7% year-on-year as a share of the country, while the Central and the Western regions rose by 1.3% and 0.5%, respectively. In 2022, China's realised FDI amounted to US\$189.1 billion, an increase of 4.5% from 2021. As shown in Figure 2.2, the realised FDI values utilised in the Eastern, Central and Western regions were US\$164.39 billion, US\$13.78 billion and US\$10.96 billion, accounting for 86.9%, 7.3% and 5.8%, respectively. Amongst them, the amount of foreign investment attracted in the Eastern region rose by 7.7% year-on-year, while in the Central and Western regions, it rose by 23.5% and 13.7% year-on-year.

The Chinese Government has encouraged the inflow of foreign investment through a series of measures, but there are still some differences in the level of foreign investment brought in due to natural resources, geographic location, industrial structure and economic differences between the Eastern, Central and Western regions. The Eastern region, with its relatively well-developed infrastructure, good business environment and relatively mature market, and benefiting from its degree of internationalization and export-oriented economy, is usually a popular destination for foreign investment. Since the reform and opening of China, almost all the top 10 provinces in China in terms of bringing in foreign investment have come from the Eastern region, especially the coastal regions, such as Guangdong and Shanghai. The Central region has also made some progress in bringing in foreign investment, especially in manufacturing and infrastructure development, e.g., Hunan and Anhui. The Western region is relatively less developed, but is attractive to foreign

investment in areas, such as resource development and new energy, e.g., Shaanxi and Qinghai. Overall, although the FIEs and the realised FDI value of the Eastern region are dominant, the Central and Western regions are developing at a fast pace, and their latecomer advantages and potentials are gradually emerging.

2.2.2.2 Foreign Direct Investment by Province

Since the implementation of the reform and opening-up policy, China has been actively promoting opening-up and attracting foreign investment and has formulated a series of policies to encourage foreign investment, including simplifying the approval process and shortening the negative list. Meanwhile, the Chinese Government has been trying to optimise the business environment to attract more foreign investment. In 2022, the number of newly established FIEs in China was 38,497. As shown in Figure 2.3, the top ten provinces in China in terms of the number of newly-established FIEs were Guangdong (13,365), Shanghai (4,359), Jiangsu (3,303), Zhejiang (2,910), Fujian (2,733), Shandong (2,329), Beijing (1,408), Hainan (1,352), Sichuan (755), and Jiangxi (669), with a share of the national total amounting to 86.2%. Eight of these provinces belonged to the Eastern region, Sichuan in the Western region was in the ninth place, and Jiangxi in the Central region was in the tenth place. The clustering effect of FIEs in the Eastern region is more obvious, and the potential of the Central and Western regions is huge, with fierce competition among provinces to attract FIEs.

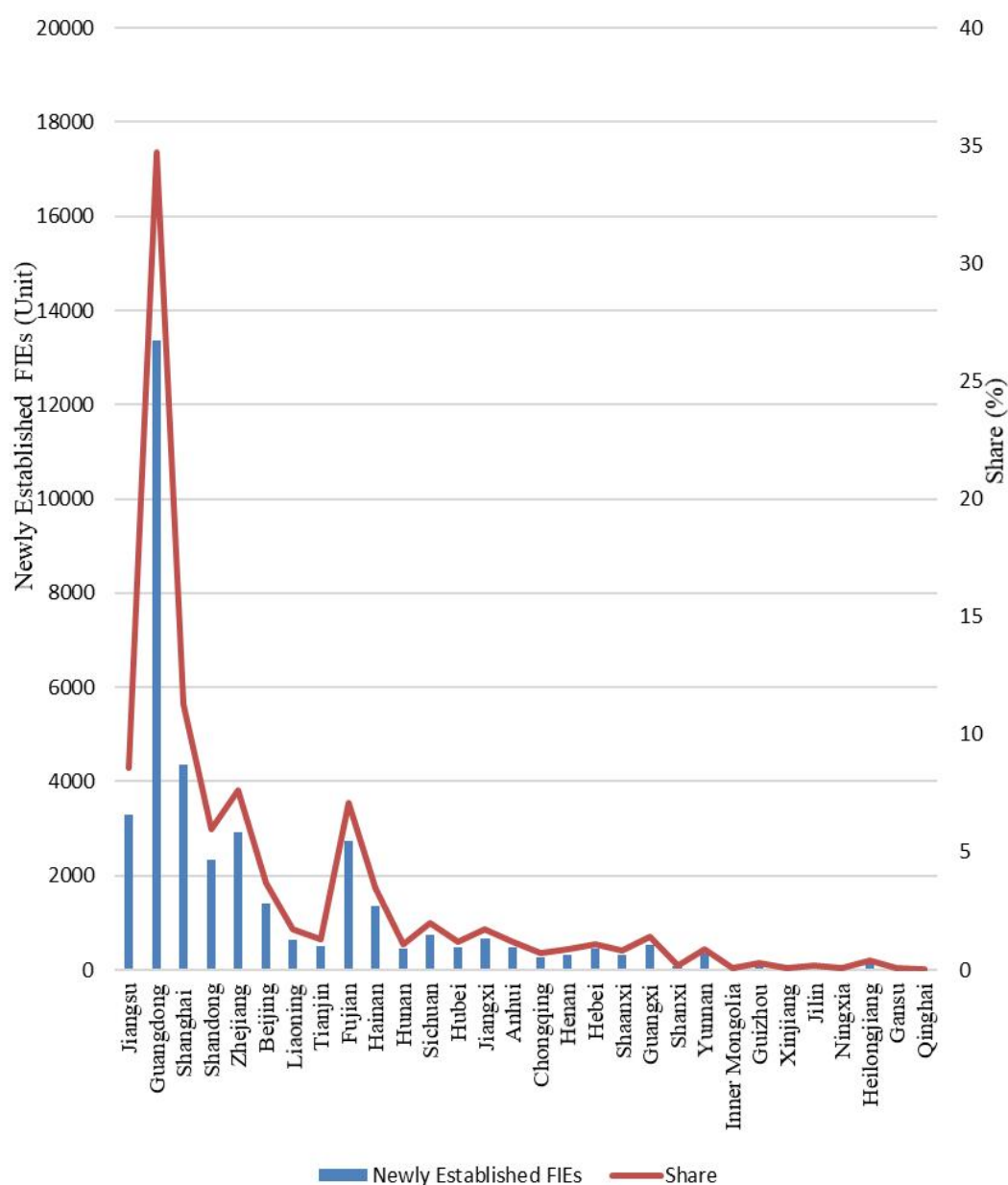


Figure 2.3: Newly established foreign-invested enterprises by provinces (2022)

Source: MOFCOM FDI Statistics (2023)

In 2022, China's realised FDI amounted to US\$189.1 billion, an increase of 4.5% from 2021, with the scale and quality improved. As shown in Figure 2.4, the top ten provinces all belong to the Eastern region, namely Jiangsu, Guangdong, Shanghai, Shandong, Zhejiang, Beijing, Liaoning, Tianjin, Fujian, and Hainan, accounting for 86% of

the country. Amongst them, Liaoning rose four places year-on-year and was amongst the top ten; while Sichuan fell two places year-on-year and was outside the top ten.

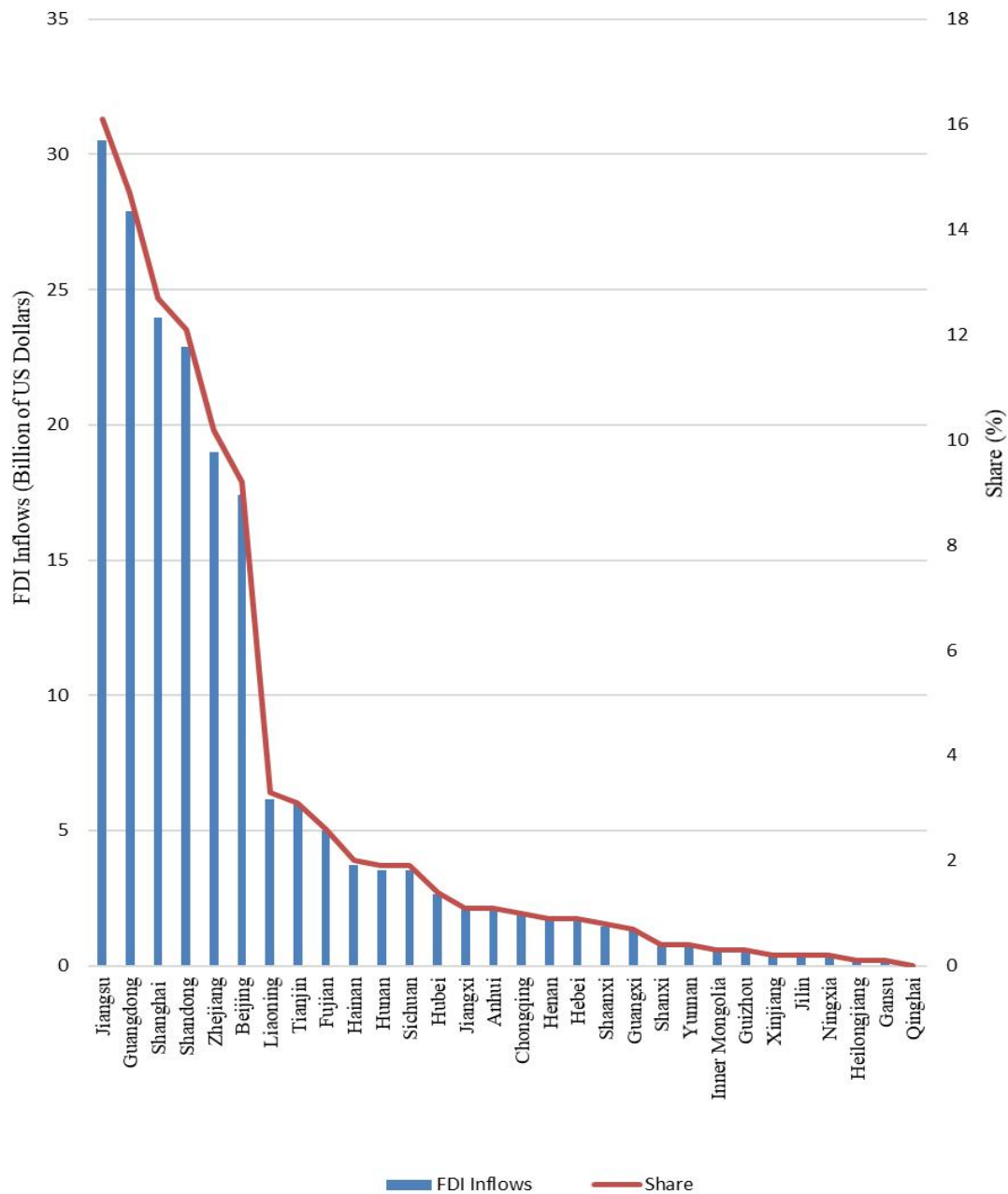


Figure 2.4: Foreign direct investment flows to China province (2022)
Source: MOFCOM FDI Statistics (2023)

2.2.3 Foreign Direct Investment by Industry in China

The Chinese government has adopted a series of policies to promote FDI in various industries to facilitate economic development and transformation. As shown in Figure 2.5, the number of newly established FIEs in the primary, secondary and tertiary industries in 2022 are 362, 4608 and 33527 units, accounting for 0.9%, 12% and 87.1% of the total respectively.

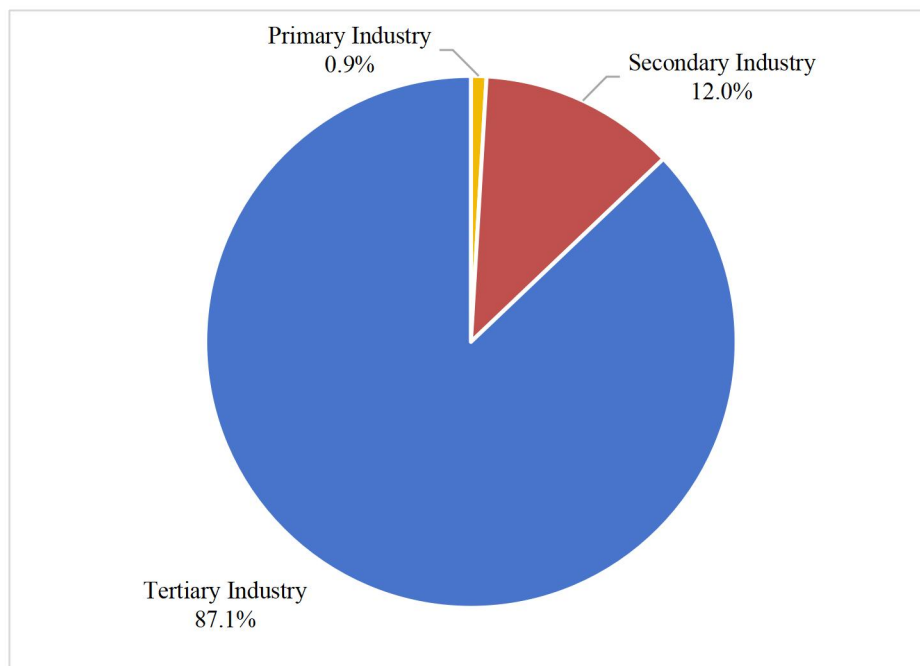


Figure 2.5: Newly established foreign-invested enterprises by China industry (2022)

Source: MOFCOM FDI Statistics (2023)

As shown in Figure 2.6, the realised FDI value in 2022 in the primary, secondary and tertiary industries is US\$0.47 billion, US\$57.07 billion and US\$131.59 billion, accounting for 0.3%, 30.2% and 69.6%, respectively. With the restructuring and upgrading of China's industries and the rise of the service industry, FDI is also flowing to the tertiary industry.

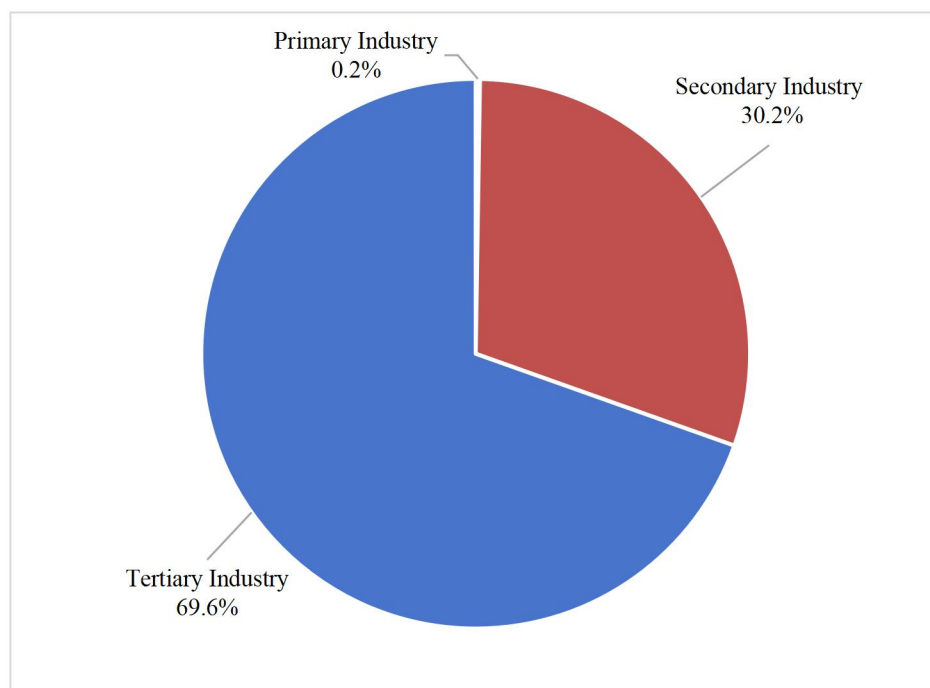


Figure 2.6: Realised foreign direct investment value by China industry (2022)

Source: MOFCOM FDI Statistics (2023)

2.2.4 Foreign Direct Investment by Sector in China

As shown in Figure 2.7, newly established FIEs mainly flowed to wholesale and retailing (10,894), leasing and business services (7,473), scientific research and technology services (7,280), manufacturing (3,570), information transmission software information technology services (3,059), as well as culture sports and entertainment (1,678) in 2022. Also, newly established FIEs in these six sectors accounted for 88.3%. As shown in Figure 2.8, realised FDI value was mainly invested in manufacturing, leasing and business services, scientific research and technology services, information transmission software and information technology services, wholesale and retailing, as well as real estate. Also, realised FDI value in these six sectors accounted for 87.6%. During the initial stage of reform and opening-up, foreign investment in China was mainly concentrated in labour-

intensive manufacturing industries, while the trend of foreign investment flowing to high-end manufacturing and modern service industries is now strengthening.

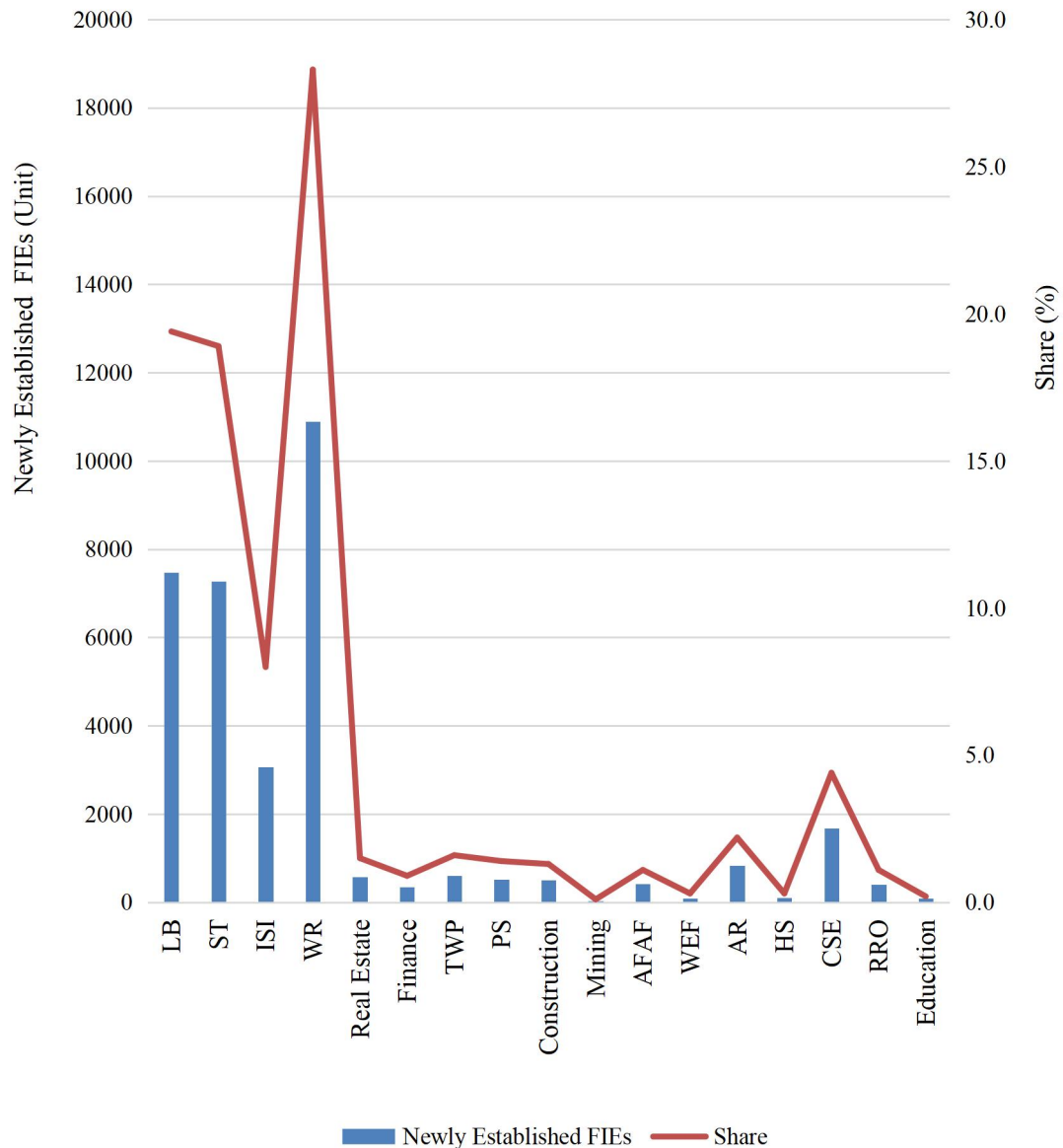


Figure 2.7: Newly established foreign-invested enterprises by China sector (2022)

Source: MOFCOM FDI Statistics (2023)

Note: AFAP represents Agriculture, Forestry, Animal Husbandry and Fishery; PS represents Production and Supply of Electricity, Heat, Gas and Water; WR represents Wholesale and Retailing; TWP represents Transportation, Warehousing and Post; AR represents Accommodation and Restaurants; ISI represents Information Transmission, Software and Information Technology Services; LB represents Leasing and Business Services; ST represents Scientific Research and Technology Services; WEF represents Water Conservancy, Environment and Public Facilities Management; RRO represents Resident Services, Repair and Other Services; HS represents Health and Social Work; CSE represents Culture, Sports and Entertainment.

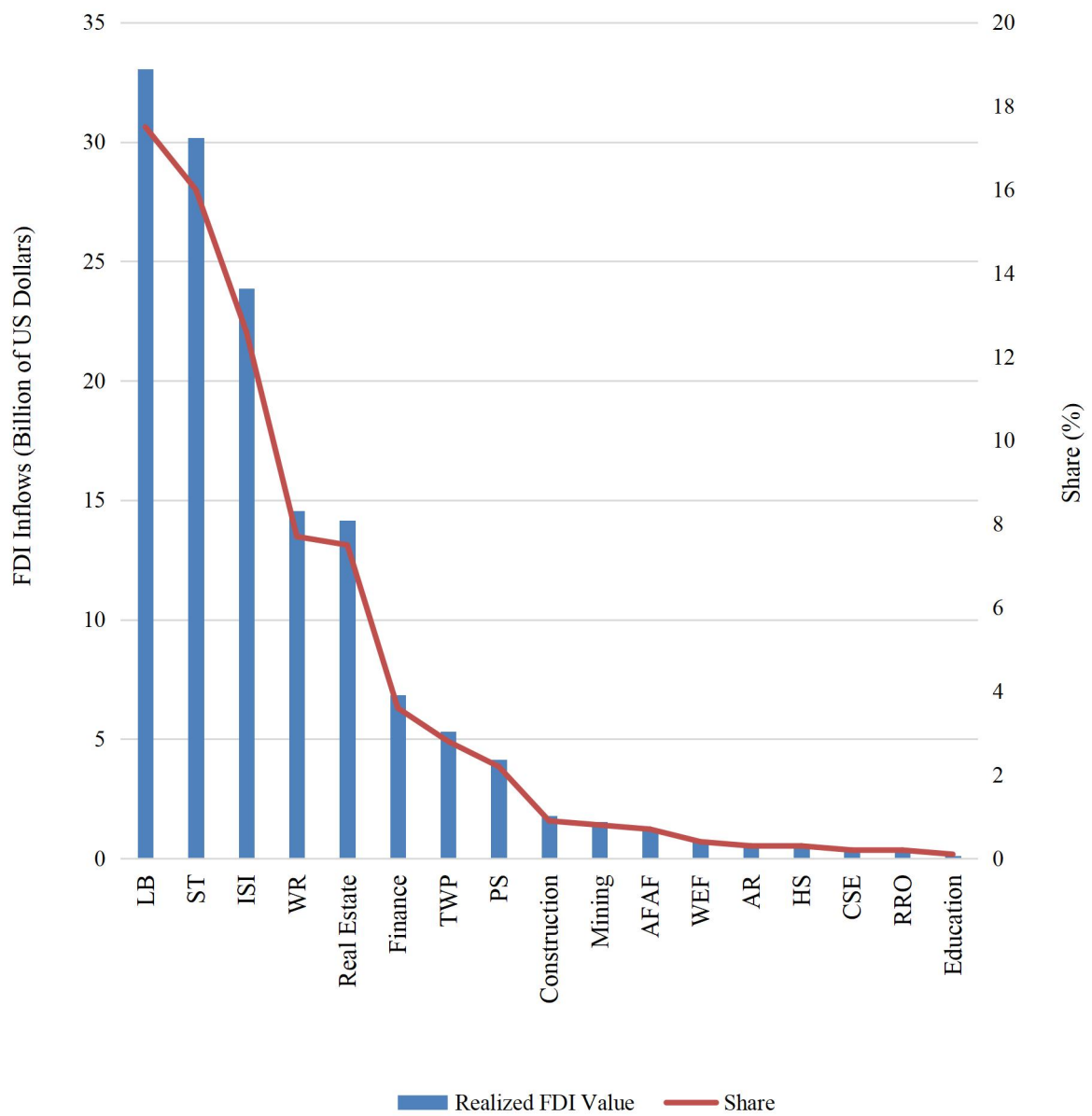


Figure 2.8: Realised foreign direct investment value by China sector (2022)

Source: MOFCOM FDI Statistics (2023)

2.2.5 Main Sources of Foreign Direct Investment in China

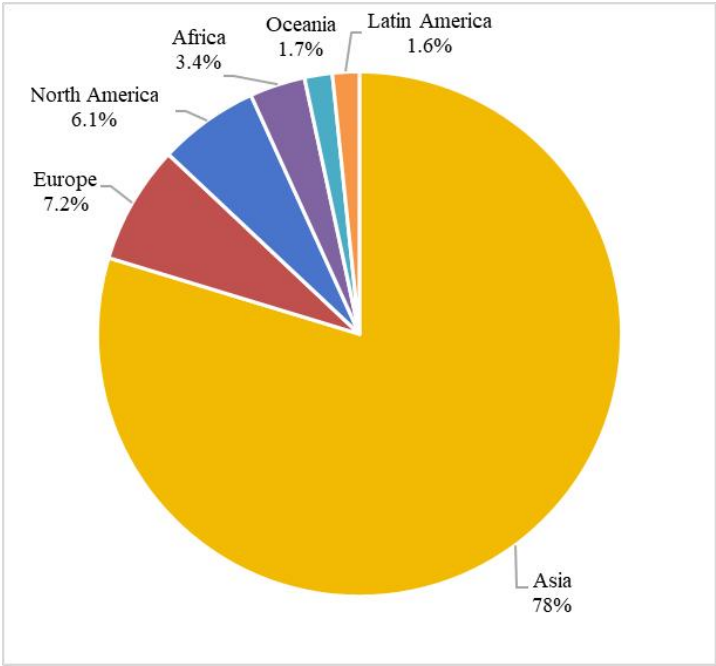


Figure 2.9: Newly established FIEs of FDI sources of China (2022)
Source: MOFCOM FDI Statistics (2023)

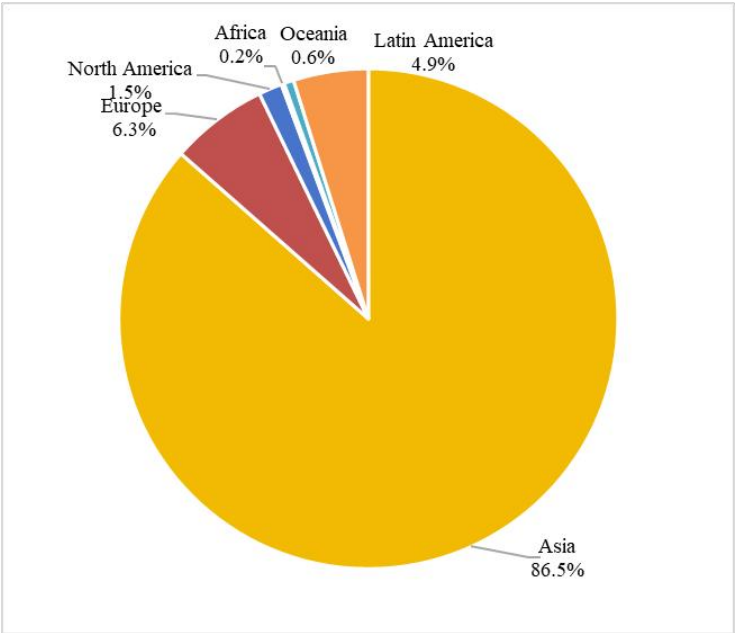


Figure 2.10: FDI inflows of sources of China (2022)
Source: MOFCOM FDI Statistics (2023)

From 1992 to 2022, China has been the largest developing country in terms of FDI for 31 consecutive years. Major sources of FDI in China continue to remain stable in 2022. As seen in Figure 2.9 and Figure 2.10, the major sources of FDI in mainland China in 2022 are Asia, Europe, North America and Latin America. The number of newly established FIEs in Asia is 30,027 units, accounting for 78% of the total, while FDI Inflows value of US\$163.57 billion, accounting for 86.5% of the total. Secondly, the number of newly established FIEs in Europe is 2,755 units, accounting for 7.2%, while FDI Inflows value of US\$11.98 billion, accounting for 6.3%. In addition, North America and Latin America also have a certain concentration of investment.

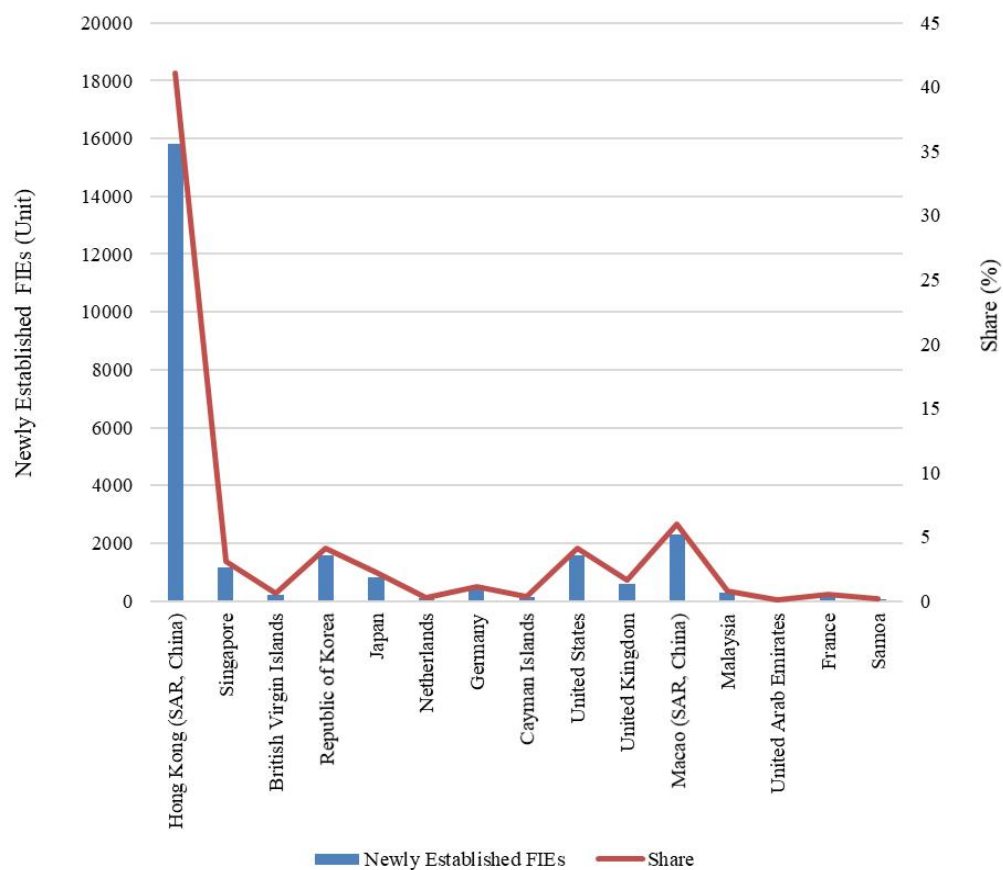


Figure 2.11: Newly established FIEs of top 15 FDI sources of China (2022)

Source: MOFCOM FDI Statistics (2023)

As shown in Figure 2.11 and Figure 2.12, classified by the nationality or place of registration of the investors (hereinafter referred to as “the same”), the top 15 investment sources set up a total of 25,413 foreign-invested enterprises in mainland China, accounting for 66% of the country's total. Also, realised FDI amounting to US\$183.8 billion, accounting for 97.2% of the country's total. In terms of investment sources, 6 of the top 15 investment sources belonged to Asia. Hong Kong and Macao from China continued to be the largest sources of overseas investment to mainland of China. Moreover, Asian countries such as Singapore, South Korea and Japan had been investing in China for a long time. In addition, Germany, the United States and the United Kingdom were also important sources of investment.

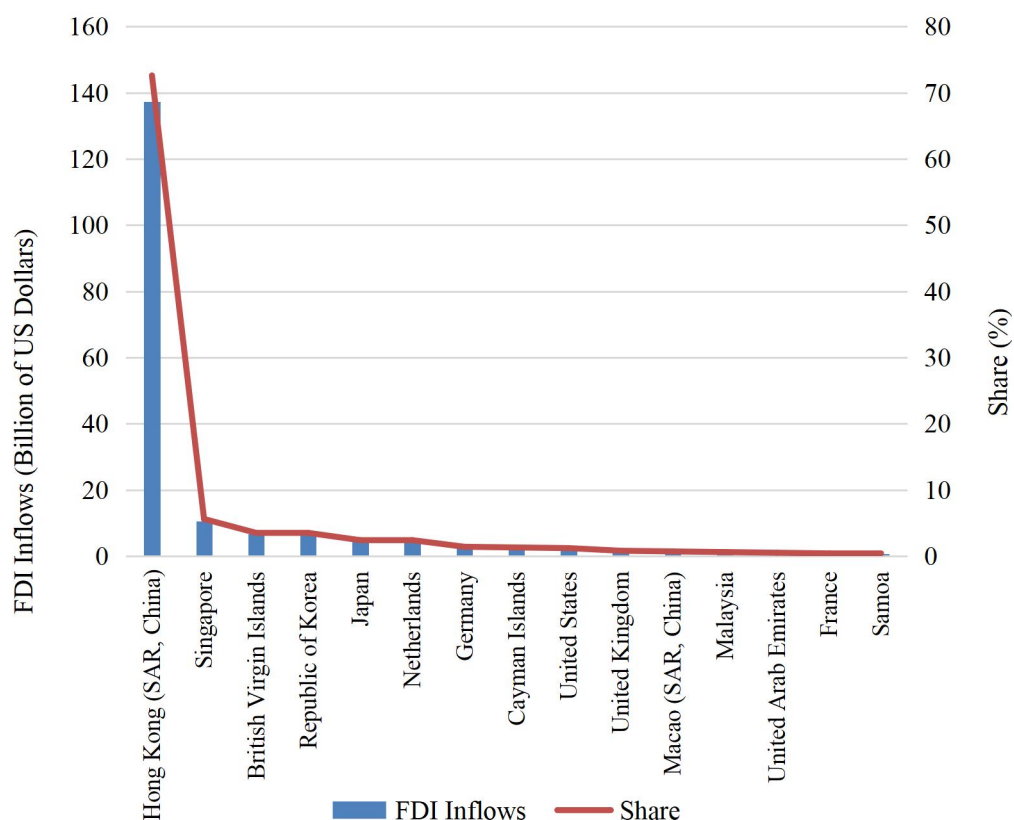


Figure 2.12: FDI inflows of top 15 sources of China (2022)

Source: MOFCOM FDI Statistics (2023)

Since the reform and opening-up, the evolution of foreign direct investment (FDI) in China has progressed through distinct phases from early-stage market access through technology exchange, to passive spillover effects, and more recently toward innovation-driven development. Although total FDI inflows have continued to rise, their regional distribution remains highly uneven. Provinces in the Eastern region consistently attract the majority of FDI, while the share received by the Central and Western regions has declined over time. This geographic concentration reflects persistent disparities in infrastructure, market size, and institutional quality. In terms of sectoral composition, FDI predominantly flows into the services sector, followed by the tertiary industry, although manufacturing still accounts for the bulk of realized FDI value. Asia remains the leading source of foreign investment. However, despite targeted policy incentives aimed at promoting industrial upgrading in inland provinces, the effectiveness of these interventions in enhancing technological competitiveness has been limited. Under the emerging dual circulation development paradigm, which emphasizes domestic innovation and regional rebalancing, there is a pressing need to reassess the role of FDI in driving economic growth and reducing regional inequality. Specifically, the question arises as to whether FDI can still serve as an effective mechanism for enhancing technological upgrading and productivity convergence across provinces in this new policy context.

2.3 Technology Spillover Effect in China

2.3.1 Wholly Foreign-Owned Enterprises become the Main Body of FIEs R&D

R&D brought by foreign invested enterprises (FIEs) has a great impact on China's economic growth, promoting technology spillover, enhancing innovation capacity, optimising industrial structure, and improving the international competitiveness of local enterprises (Imran & Rehman, 2024). FIEs usually have high R&D intensity, and their

activities spillover advanced technology and management experience to local enterprises through channels, such as demonstration, competition, affiliation, and personnel mobility, thus improving the innovation system of local enterprises (Islam et al., 2024).

Table 2.1: R&D institutions in high-tech industry (2018, 2020 and 2022)

Year	Status of Registration	R&D Institutions(unit) & Share (%)	Personnel (person) & Share (%)	Expenditure (CN\$10000) & Share (%)
2018	Total	16,052 100.0	1,011,294 100.0	36,984,023 100.0
	Domestic Enterprises	12,933 80.6	746,731 73.8	29,051,655 78.6
	Foreign Invested Enterprises	3,119 19.4	264,563 26.2	7,932,368 21.4
2020	Total	20,185 100.0	1,195,561 100.0	50,614,628 100.0
	Domestic Enterprises	17,076 84.6	914,657 76.5	40,747,840 80.5
	Foreign Invested Enterprises	3,109 15.4	280,904 23.5	9,866,789 19.5
2022	Total	25,084 100.0	1,341,431 100.0	57,919,288 100.0
	Domestic Enterprises	21,882 87.2	1,031,833 76.9	44,363,922 76.6
	Foreign Invested Enterprises	3,202 12.8	309,598 23.1	13,555,366 23.4

Source: China Statistical Yearbook on High Technology Industry (various years)

As shown in Table 2.1, the number of R&D institutions, personnel and expenditure in China had been rising in recent years, with the same phenomenon for FIEs, but the share was almost opposite. Specifically, from 2018 to 2022, the number of R&D institutions, personnel and expenditure of FIEs rose from 3,119 units, 264,563 persons and CN\$7,932,368 billion to 3,202 units, 309,598 persons and CN\$139,368 billion, respectively. However, the share of R&D institutions and personnel decreased from 19.4% and 26.2% to 12.8% and 23.1%, respectively. However, R&D expenditure decreased and then increased from 21.4% to 23.4%. Therefore, FIEs are still increasing their R&D efforts in China, but their share in China is decreasing.

The main ways of FDI absorption in China are Sino-foreign joint venture, Sino-foreign cooperation and wholly foreign-owned investment (Zhang & Dai, 2023). In addition, it also includes foreign-invested joint-stock companies, cooperative development, compensation trade, processing and assembly, et al. Amongst them, joint ventures, cooperative and wholly foreign-owned enterprises (WFOE) accounted for more than 85% of the total number of projects, contract amount and actual amount. Over time, the proportion of the three main modes of FDI in China has changed dramatically (Liu & Huang, 2024). From 1979 to 1985, it was mainly a Sino-foreign cooperative enterprise. From 1986 to 1996, it changed to mainly Sino-foreign joint-venture enterprises. In 1997, the number of WFOE exceeded that of joint-venture enterprises for the first time. Since 2000, the proportion of the actual amount of foreign capital used by WFOE began to exceed that of joint-venture enterprises and showed an upward trend year-by-year.

In recent years, China has comprehensively relaxed market access conditions and shifted from opening-up to institutional opening up, such as commodity and factor

mobility. The overall investment environment continues to improve (Liang et al., 2024). Multinational companies tend to acquire control of joint-venture enterprises, and the tendency of WFOEs is becoming more and more obvious. The global layout of R&D activities of multinational corporations, mainly WFOE, is continuing, and WFOE's R&D efforts in China are also increasing. Attracting foreign R&D activities is a necessary measure for the externalisation and marketisation of Chinese local enterprises' R&D activities, as well as an important measure to improve the quality of foreign investment (Islam et al., 2024). It is conducive to the development of China's high-end manufacturing and service industries, and to the promotion of China's independent R&D and innovation capacity through the technology spillover effect (Imran & Rehman, 2024).

As seen in Table 2.2, amongst FIEs above the designated size, the R&D efforts of wholly foreign-owned enterprises (WFOEs) were increasing, with a clear trend of surpassing that of Sino-foreign joint venture. From 2018 to 2022, the expenditure of R&D of WFOEs rose from CN ¥ 122,682.26 million to CN ¥ 163,276.59 million, and the proportion of FIEs rose and then fell to 44.5%. However, the expenditure of R&D of joint-venture enterprises decreased and the proportion dropped to 39.4%, which is lower than the proportion of WFOEs. On this note, the number of effective inventions of WFOE increased from 91,387 pieces to 128,720 pieces. Even though the share of FIEs first rose and then fell, the number and share were higher than that of joint-venture enterprises and had a tendency to expand. Therefore, WFOEs are the R&D mainstay of FIEs and play an increasingly important role in China's economic growth.

Table 2.2: Statistics on R&D expenditure and effective inventions (2018, 2020 and 2022)

Year	Status of FIEs Registration	R&D		Effective Inventions	
		Expenditure (10,000 yuan)	Share (%)	Number (piece)	Share (%)
2018	Total	26,827,792	100.0	186,344	100.0
	Joint-venture Enterprises	12,339,218	46.0	78,090	41.9
	Cooperative Enterprises	277,226	1.0	1,280	0.7
	Wholly Foreign-Owned Enterprises	12,268,226	45.7	91,387	49.0
2020	Total	29,986,065	100.0	214,396	100.0
	Joint-venture Enterprises	13,174,559	43.9	83,217	38.8
	Cooperative Enterprises	276,571	0.9	1,140	0.5
	Wholly Foreign-Owned Enterprises	14,293,358	47.7	109,168	50.9
2022	Total	36,721,952	100.0	275,084	100.0
	Joint-venture Enterprises	14,450,866	39.4	101,251	36.8
	Cooperative Enterprises	252,695	0.7	1,347	0.5
	Wholly Foreign-Owned Enterprises	16,327,659	44.5	128,720	46.8

Note: From 2011, the statistics coverage of the industrial enterprises above designated size in China has been changed from the industrial enterprises with the sales revenue above CN ¥ 5 million to the industrial enterprises with the sales revenue above CN ¥ 20 million. The same applies to the following tables.

Source: China Statistical Yearbook (various years)

Based on Table 2.2, R&D investment by foreign investors, especially wholly foreign-owned enterprises, has become an important measure for China to improve the quality of foreign investment utilisation, and realise the transformation from “world factory” to “world office” (Khan et al., 2024). In the face of the increasing trend of foreign R&D sole proprietorship, Chinese local enterprises should actively participate in

the international economic cycle and make full use of the spillover effect of technology to enhance the technological innovation capability of local institutions (Ali & Akhtar, 2024).

2.3.2 Weakening of the Innovation Advantage of Foreign-invested Enterprises

In 1912, Schumpeter, an American economist, first put forward the concept of "innovation" (Ebner, 2024; Rocca & Vallet, 2024; Gürgen, 2024; Kurz & Salvadori, 2024). Innovation specifically includes five cases, namely product innovation, process innovation or production technology innovation, market innovation, development of new resources and organisational management innovation (Zuhroh & Rini, 2024; Bataineh et al., 2024). Innovation can also be divided into two types: technological innovation and institutional innovation (Khan et al., 2024; Sethi et al., 2024; Menter, 2024). Amongst them, technological innovation is not a technological behaviour, but economic behaviour, the core is entrepreneurs, the output is new products and new processes, et al., the purpose is to obtain potential profits. Enterprise innovation generally begins with product innovation. In the early stage of development, the frequency of product innovation is higher than that of process innovation. When mass production, process innovation becomes dominant. In the process of technological innovation, product innovation and technological innovation has certain dependence and interaction, and technological innovation is the basis of industrial innovation.

Table 2.3 shows the number of Chinese industrial enterprises above designated size with innovation activities had been on the rise in recent years, and FIEs had played an important role. As seen in Table 2.3, the number of FIEs with product or process innovation activities had been increased from 2018 to 2022, from 21,940 units to 269,001units. However, the share gradually decreased, from 13.6% to 9.1%. Similarly, the number of FIEs with organizational or marketing innovation activities had increased from

2018 to 2022, from 136,211 units to 171,962 units. However, the share gradually decreased, from 11.7% to 8.4%. This showed that the innovation share of FIEs was gradually decreasing and also showed that the number of innovation activities and share of domestic invested enterprises in China were increasing.

Table 2.3: Foreign-invested industrial enterprises in China (2018, 2020 and 2022)

Year	Product or Process Innovation Activities		Organisational or Marketing Innovation Activities	
	Number (unit)	Share (%)	Number (unit)	Share (%)
2018	21,940	13.6	15,887	11.7
2020	23,429	11.3	15,885	9.9
2022	24,489	9.1	14,426	8.4

Source: China Statistical Yearbook (various years)

As seen in Table 2.4, Chinese share of enterprises with product or process innovation had gradually risen from 2018 to 2022 while the share of enterprises with organizational or marketing innovation rose and then fell, the performance of FIEs and domestic invested enterprises were just on the opposite sides. As noted, the share of FIEs with product or process innovation was rising and almost exceeding the level of domestic invested enterprises and the total level of the country. While the share of FIEs with organizational or marketing innovation rose and then fell and was lower than the level of domestic invested enterprises and the total level of the country.

Table 2.4: Innovation share of China industrial enterprises (2018, 2020 and 2022)

Year	Status of Registration	Innovation Share (%)			
		Product	Process	Organisational	Marketing
2018	Total	28.8	30.4	29.3	28.0
	Domestic Invested Enterprises	28.1	29.8	29.4	28.4
	Foreign Invested Enterprises	34.2	34.9	28.5	25.7
2020	Total	35.3	39.4	31.9	31.4
	Domestic Invested Enterprises	35.0	39.2	32.3	31.9
	Foreign Invested Enterprises	37.7	40.7	30.5	26.9
2022	Total	35.5	41.4	27.9	27.4
	Domestic Invested Enterprises	35.5	41.4	28.2	27.8
	Foreign Invested Enterprises	35.5	41.3	24.8	23.8

Source: China Statistical Yearbook (various years)

From the perspective of technological innovation, share of enterprises above designated size with product or process innovation in China increased from 28.8% and 30.4% to 35.5% and 41.4%, respectively. Amongst them, share of FIEs increased from 34.2% and 34.9% to 35.5% and 41.3%, respectively, which were higher than or close to the total national level and domestic invested enterprises. From the perspective of system innovation, share of FIEs above designated size with organizational or marketing innovation rose from 28.5% and 25.7% to 24.8% and 23.8%, respectively, all of which

were lower than the total national level and the share of domestic invested enterprises. Therefore, FIEs' innovation activities in China tend to weaken gradually, and there are signs that the advantages of product and process innovation activities are fading, while organisational and marketing innovation are rapidly weakening.

With China's economic level and technical level of ascension, technology innovation for China's economic development and industrial upgrading has a very important role (Imran & Rehman, 2024). FIEs especially large multinational companies in China should increase the technology innovation strength to maintain in China's huge market and profits (Islam et al., 2024). In the rapidly developing countries, especially China, rely not only on technological innovation, but more importantly on institutional innovation.

2.3.3 Foreign-invested Enterprises Are an Important Driving Force for the Development of China's High-Tech Industry

High-tech industry has adopted modern advanced technology compared to the conventional technology, which specialised in the production of high-tech products industry group. This industry has marked characteristics, such as the knowledge and technology intensive, less energy consumption of resources, high share of expenditure and personnel on R&D, higher industrial growth rate, and has a strong penetration technology to other industry (Zheng et al., 2024). The rapid development of high-tech industries in China has greatly increased labour productivity, optimised the industrial structure and enhanced the international competitiveness of enterprises, which has had a tremendous positive impact on social and economic development (Yan et al., 2024; Sojoodi & Baghbanpour, 2024). Foreign invested enterprises (FIEs) have been an important booster for the development of China's high-tech industry, especially development of high-tech

service industries (Zhao et al., 2024; Zhang et al., 2024). Liu and Guo (2019) believed that the important role of technology spillover effect on technological progress in developing countries has been confirmed by empirical studies in China.

Table 2.5: FDI in China high-tech industry (2018, 2020 and 2022)

Year	High-tech Industry	New FIEs		Realised FDI Value	
		Number (Unit)	Share (%)	Value (US\$100 million)	Share (%)
2018	Total	60,560	100.0	1,383.1	100.0
	High-tech Industry	14,035	23.2	321.0	23.2
	High-tech Manufacturing	1,478	2.4	137.9	10.0
	High-tech Services	12,557	20.7	183.1	13.2
2020	Total	38,578	100.0	1,493.4	100.0
	High-tech Industry	10,924	28.3	427.6	28.6
	High-tech Manufacturing	857	2.2	103.0	6.9
	High-tech Services	10,067	26.1	324.6	21.7
2022	Total	38,497	100.0	1,891.3	100.0
	High-tech Industry	10,885	28.3	683.5	36.1
	High-tech Manufacturing	866	2.2	182.1	9.6
	High-tech Services	10,019	26.0	501.4	26.5

Source: Statistical Bulletin of FDI in China (various years)

As listed in Table 2.5, FIEs continue to increase their investment in China's high-tech industry, the actual use of foreign capital in China's high-tech industry continues to maintain a high growth, and the ability to attract investment in the service industry is greatly enhanced. First, the number of newly established enterprises is decreasing trend,

which had 60,560 units in 2018 then decreased to 38,497 units. Furthermore, the proportion of newly established FIEs in high-tech industries in the annual number of newly established enterprises, the realised FDI value and its proportion were on the rise, rising from 23.2%, US \$32.10 billion and 23.2% in 2018 to 28.3%, US \$42.76 billion and 36.1% in 2020. In addition, FDI in high-tech industries is mainly concentrated in high-tech services, and its upward trend is obvious. The proportion of number of FIEs, the realised FDI value and its proportion increased from 20.7%, US\$18.31 billion and 13.2% in 2018 to 26.1%, US\$32.46 billion and 21.7% in 2020. On the other hand, the relevant indicators of high-tech industries showed a downward trend.

China continues to optimise the structure of foreign investment and improve the quality of foreign investment, which is in line with the development direction of the overall economic transformation and upgrading and will boost high-quality economic development (Cho, 2024). The extensive expansion of the manufacturing sector in the past has come to an end, the transformation and upgrading of the manufacturing sector has accelerated, and the service sector has become more capable of attracting investment, many of which serve medium and high-end manufacturing industries (Gong & Zhang, 2024). The development of producer services has promoted the integration of manufacturing and service industries (Li et al., 2024).

2.3.4 Foreign-invested Enterprises Are Important Channels of the Export of High-tech New Products

Driven by profits, the export of foreign-invested enterprises (FIEs) keeps growing, which also promote the rapid growth of China's import and export (Li & Li, 2024). It is an indispensable force for China's economic growth. First, FIEs, especially large multinational corporations, have absolute advantages in technology and management, pay

attention to the research and development of new products and technology upgrading, and invest heavily, their products are more in line with the needs of the international market (Rauf & Bao, 2024). In addition, most of the FIEs are export-oriented enterprises, and have the advantage of sales channels. In other words, FIEs are both familiar with the domestic market and closely linked to the international market, reducing barriers to entry in the international market and expanding exports to explore foreign markets with many reputable international brands.

Since its accession to the World Trade Organisation (WTO) in 2001, China's foreign trade has been growing rapidly, and FIEs have played a great role in driving the growth of China's foreign trade (Liang et al., 2024; Liu et al., 2024). The import and export value of FIEs accounted for as much as 58.9% and 59.7% of the country's total value in 2006, while the value of export value was as high as 58.3% in 2005, which was the highest in the history of the country.

From Table 2.6, China's imports and exports had been on an upward trend in recent years, and amongst them, the imports and exports value completed by FIEs had been on a downward and then upward trend. However, its share had been on a rapid downward trend, and the imports and exports valued by FIEs had also shown such a pattern. Specifically, from 2018 to 2022, imports as well as exports by FIEs first decreased and then increased from US\$1968.1 billion, US\$932.1 billion and US\$103.6 billion to US\$2,076.4 billion, US\$953.0 billion and US\$1,123.3 billion, respectively. However, the share of imports and exports by FIEs accounted for 42.6%, 43.6% and 41.7 of the national total then decreased to 33.1%, 35.1% and 31.5%, respectively, with the largest decrease in the share of exports.

Table 2.6: Value of Imports and Exports by FIEs in (US \$100 million)

Imports and Exports	Status of Registration	2018	2020	2022
Imports and Exports	Total	46,224	46,559	62,813
	FIEs	19,681	17,976	20,764
	Share (%)	42.6	38.6	33.1
Imports	Total	21,357	20,660	27,120
	FIEs	9,321	8,653	9,530
	Share (%)	43.6	41.9	35.1
Exports	Total	24,867	25,900	35,693
	FIEs	10,360	9,323	11,233
	Share (%)	41.7	36.0	31.5

Source: General Administration of Customs Statistics (various years)

As shown in Table 2.7, from 2018 to 2022, the sales revenue and exports of new products in China's high-tech industry showed an upward trend, respectively. The share of exports in the sales revenue of new products in China's high-tech industry first rose and then fell. Also, domestic invested enterprises had the same performance. However, the sales revenue of new products of high-tech industry of FIEs showed a trend of firstly decreasing and then slightly increasing but relatively decreasing. Exports showed an upward trend, and exports of FIEs accounted for the proportion of sales revenue of new products of China's high-tech industry firstly increased and then decreased.

Table 2.7: New Products Sales Revenue in High-tech Industry in China (2018, 2020 and 2022)

Year	Status of Registration	Sales Revenue of New Products		
		Sales Revenue (CN ¥ 10,000)	Exports (CN ¥ 10,000)	Share (%)
2018	Total	568,941,517	193,320,485	34.0
	Domestic Invested Enterprises	364,092,067	73,750,611	20.3
	Foreign Invested Enterprises	364,092,067	73,750,611	58.4
2020	Total	685,491,445	248,802,768	36.3
	Domestic Invested Enterprises	443,814,136	102,835,209	23.2
	Foreign Invested Enterprises	241,677,309	145,967,559	60.4
2022	Total	875,482,574	279,392,077	31.9
	Domestic Invested Enterprises	594,879,786	117,982,126	19.8
	Foreign Invested Enterprises	280,602,788	161,409,952	57.5

Source: China Statistical Yearbook on High Technology Industry (various years)

Specifically, from 2018 to 2022, the sales revenue and exports of new products of high-tech industry of FIEs decreased from CN ¥ 36,409,206.67 million to CN ¥ 280,602,788 million, respectively, and the exports increased rapidly from CN ¥ 7,375,061.11 million to CN ¥ 16,140,952 million, respectively. Exports of FIEs accounted for 57.5% of the sales revenue of China's new products in high-tech industries, after rising from 58.4%. This share far exceeds that of domestic enterprises invested by about 20%. The different performance of FIEs compared to China total enterprises and domestic invested enterprises suggests that even during the COVID-19 pandemic, FIEs

were still the main channel for the exports of new products, with a strong degree of outward orientation and export competitiveness.

New products that adopt new technology principles significantly improve the performance of the original products performance or expand the use of functions (Charoenrat & Amornkitvikai, 2024). Trade is a barometer of a country's economic development. FIEs, especially transnational corporations, have advanced technological advantages and mature sales channels, which make the new products of China's high-tech industry successfully exported to the international market (Deng et al., 2024). Moreover, the propensity of FIEs to export is much higher than that of domestic invested enterprises, generating a huge export effect, technology spillover effect and a certain degree of inhibition effect on domestic enterprises (Liu et al., 2024). Therefore, FIEs are extremely important in China's international circulation and play a facilitating role in the domestic circulation.

2.3.5 Regional Differences in R&D of Foreign-invested Enterprises

As there are certain regional differences in resource endowment, economic development level, industrial structure, infrastructure and national policies among China's Eastern Region, Central Region and Western regions, there are also significant regional differences in R&D activity and innovation ecology (Allen et al., 2024; Chi et al., 2024). In addition, FDI is an important force for R&D in China and has significant regional differences (Edeh & Prévot, 2024).

Table 2.8: R&D institutions in high-tech industry by region (2018, 2020 and 2022)

Year	Region	R&D Institutions(unit) & Share (%)	Personnel (person) & Share (%)	Expenditure (CN\$10000) & Share (%)
2018	Total	16,052 (100)	1,011,294 (100)	36,984,023 (100)
	Eastern Region	12,695 (79.0)	819,777 (81.1)	31,682,764 (85.7)
	Central Region	2,416 (15.1)	121,777 (12.0)	3,121,338 (8.4)
	Western Region	941 (5.9)	69,740 (6.9)	2,179,922 (5.9)
2020	Total	20,185 (100)	1,195,561 (100)	50,614,628 (100)
	Eastern Region	15,562 (77.1)	942,226 (78.8)	43,220,981 (85.4)
	Central Region	3,345 (16.6)	175,939 (14.7)	5,021,790 (9.9)
	Western Region	1,278 (6.3)	77,396 (6.5)	2,371,858 (4.7)
2022	Total	25,084 (100)	1,341,431 (100)	57,919,288 (100)
	Eastern Region	18,488 73.7	1,018,587 (75.9)	45,340,362 (78.3)
	Central Region	4,953 19.7	217,390 (16.2)	8,198,065 (14.2)
	Western Region	1,643 6.5	105,454 (7.9)	4,380,861 (7.6)

Source: China Statistical Yearbook on High Technology Industry (various years)

As shown in Table 2.8, the most important place for units, personnel and expenditure of R&D institutions in high-tech industry is Eastern region, followed by

Central region and the least is Western region. For example, in 2022 R&D institutions in Eastern, Central and Western regions were 18,488 units, 4,953 units and 1,643 units, accounting for 73.7%, 19.7% and 6.5%, respectively of the national total. Moreover, all three indicators were increasing in all three regions from 2018 to 2022, but the share of the Eastern region was decreasing while the shares of the Central region and the Western region were increasing.

Specifically, in the Eastern, Central and Western regions, the changes in the shares of R&D activity were -5.3%, 4.6% and 0.6%, respectively. The changes in the shares of R&D personnel were -5.2%, 4.2% and 1.0%, respectively and the changes in the shares of R&D expenditures were -7.4%, 5.8% and 1.7%, respectively. As a comparison to R&D activity, the intensity of R&D personnel and expenditure in the Eastern region was higher than that in the Central and Western regions. Hence, while the Eastern region attracts most of the R&D activity, the Central and Western regions are beginning to show the potential of latecomers.

As shown in Table 2.9, R&D Institutions, Personnel and Expenditures in high-tech industry of FIEs had the highest share in Eastern region, which was much higher than the national average in Table 2.8. However, the share of Central and Western regions increased from 2018 to 2022. For example, the shares of R&D Institutions in the Eastern, Central and Western regions of China in 2022 were 73.7%, 19.7% and 6.5%, respectively. However, the shares of FIEs in the three regions were 87.9%, 8.6% and 3.5%, respectively. The Eastern region, with its concentration and large in scale of R&D activity, is a key region for FDI. Hence, FIEs mainly concentrate their R&D activity in the Eastern region

for higher investment returns but also increase their investments in the Central and Western regions.

Table 2.9: FIEs' R&D institutions in high-tech industry by region

Year	Foreign Invested Enterprises	R&D Institutions(unit) & Share (%)	Personnel (person) & Share (%)	Expenditure (CN\$10,000) & Share (%)
2018	Total	3,119 100.0	264,563 100.0	7,932,368 100.0
	Eastern Region	2,905 93.1	245,603 92.8	7,491,455 94.4
	Central Region	151 4.8	14,133 5.3	287,156 3.6
	Western Region	63 2.0	4,827 1.8	153,757 1.9
2020	Total	3,109 100.0	280,904 100.0	9,866,789 100.0
	Eastern Region	2,763 88.9	245,643 87.4	8,936,336 90.6
	Central Region	235 7.6	29,268 10.4	766,976 7.8
	Western Region	111 3.6	5,993 2.1	163,477 1.7
2022	Total	3,202 100.0	309,598 100.0	13,555,366 100.0
	Eastern Region	2,814 87.9	278,575 90.0	1,245,734 91.9
	Central Region	274 8.6	23,200 7.5	813,586 6.0
	Western Region	111 3.5	7,823 2.5	284,435 2.1

Source: China Statistical Yearbook on High Technology Industry (various years)

The Eastern region has a favourable geographical location, developed economy, more optimised industrial structure, perfect infrastructure, sufficient high-end talents, strong national policy support, and a better ecological environment for innovation, attracting most of the high-tech industries and high-intensity foreign R&D in the country (Li & Wu, 2024). The Central region's economy is underdeveloped and its industrial structure needed to be upgraded. Cheap labour and land have attracted FIEs mainly in the manufacturing sector, and R&D activity has risen rapidly, but high-end R&D is low (Chi et al., 2024). The Western region is economically underdeveloped, with weak infrastructure, a predominantly resource-based industrial structure, less attractive to foreign investment, and a low level of R&D investment. However, the Eastern region can fully utilise the spillover effect of FDI in R&D, complement the resources of Central and Western regions, develop synergistically, form an industrial chain, and promote the overall economic growth of the regions (Li & Hu, 2024).

Overall, the foreign firms have become the dominant force behind foreign-led R&D activities in China, contributing significantly to the advancement and export capacity of the country's high-tech industries. However, the innovation advantage traditionally held by the firms has shown signs of weakening in recent years, and the regional distribution of these innovation benefits remains highly uneven. As the subjective initiative of foreign-invested R&D declines and the efficiency of technology spillovers continues to diverge across regions, it becomes increasingly important to examine how China can promote balanced regional development.

2.4 Background of GDP in China

2.4.1 GDP Growth and GDP per Capita in China

From the world economic pattern, from 1979 to 2022, the world GDP gradually increased from US\$10.11 trillion to US\$101.2 trillion, while China's GDP share in the world increased from 1.76% to 17.67%. China's GDP growth was in line with the world average until 1979 (Deng et al., 2023). Since the reform and opening-up in 1979, China's economy has continued to expand and has gradually become the world's second largest economy and the world's largest country in terms of trade in goods from a poor and closed agricultural country (Han & Wu, 2024). China has chosen a gradual path of economic reform that suits its national conditions and has made important contributions to the sustained growth of developing countries and the world economy, as well as reshaping the pattern of world economic growth (Linglin & Ghosh, 2024).

Figure 2.13 shows that since China's reform and opening-up in 1978, China's GDP has been on an upward trend, but its growth rate has decreased from a high growth rate to a low growth rate. Specifically, China's GDP was US\$25.99 billion in 1984 and the annual growth rate was as high as 15.19%, while in 2022 it has dropped to 2.99%. During 1979 to 2016, China experienced the exploration of reform and opening-up, the 1997 Asian financial crisis, accession to the WTO, the 2008 global financial turmoil, the transformation of industrialisation and urbanisation, and the average annual growth rate of GDP was 9.62%. Then, during 2017 to 2022, China has experienced major challenges, such as the transformation of economic growth mode, COVID-19 pandemic, and global supply chain disruption, the average annual growth rate of GDP has dropped to 5.55%. During these 44 years, China's average annual growth rate was as high as 9.07%, much higher than the average growth rate of the global economy of 3% in the same period.

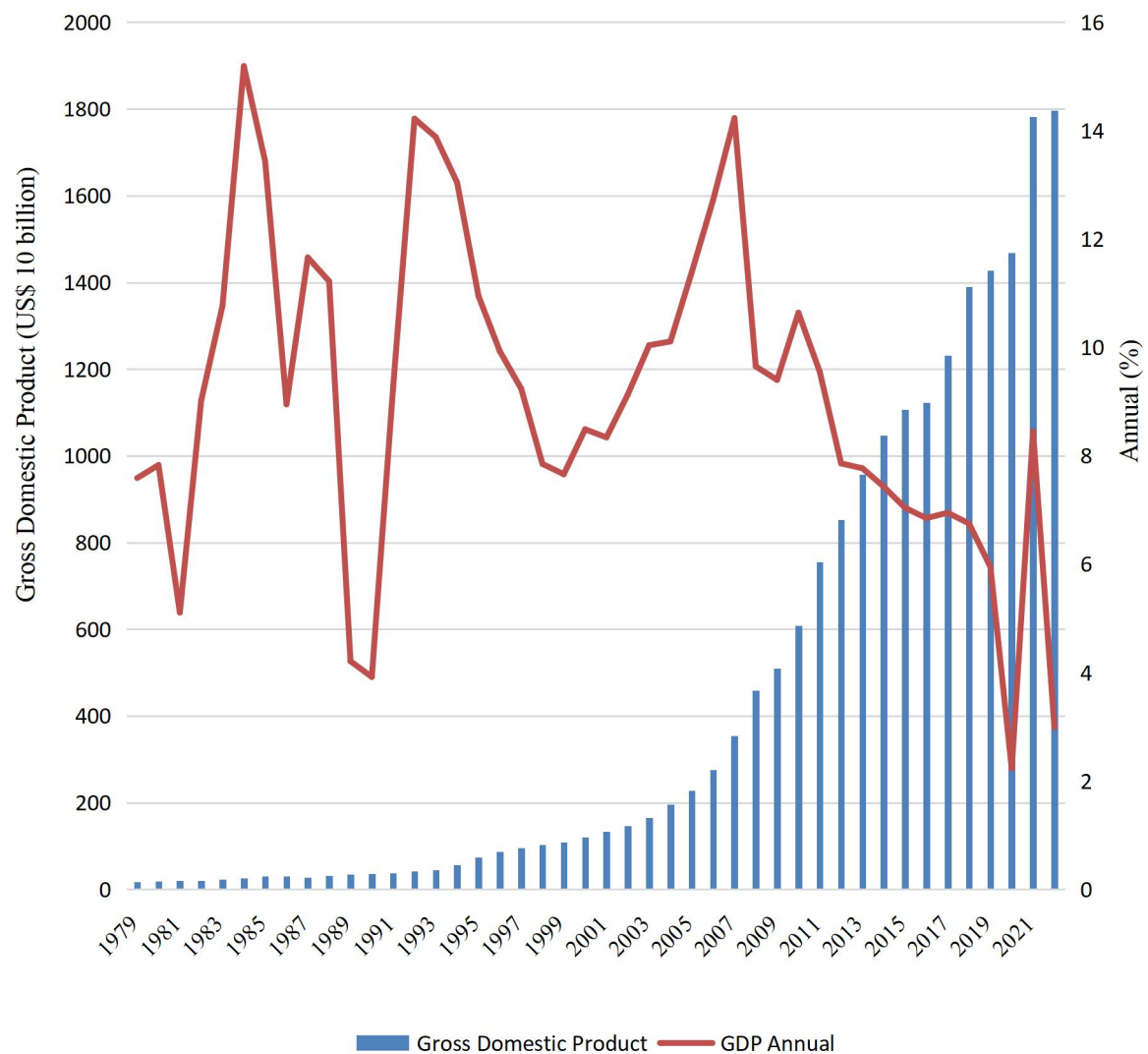


Figure 2.13: Gross domestic product of China (1979-2022)

Source: World Bank (2023)

As shown in Figure 2.14, China's GDP per capita showed an upward trend from 1979 to 2022, and its growth rate showed a trend of high growth rate followed by low growth rate, which is similar to the national GDP performance as shown in Figure 2.13. According to the World Bank (2023) data, China's GDP per capita was US\$183.98 in 1979, which was much lower than global's US\$2302.88, then rose to US\$12,720.22 in 2022, which was closer to global's US\$12,647.48. Therefore, although China has a huge economy, its GDP per capita is low due to factors such as poor economic foundation, large

population, unbalanced regional economic development and low labour productivity. However, with the economic transformation since the reform and opening up, the policy of attracting foreign investment and the improvement of R&D level, China's per capita GDP is gradually increasing.

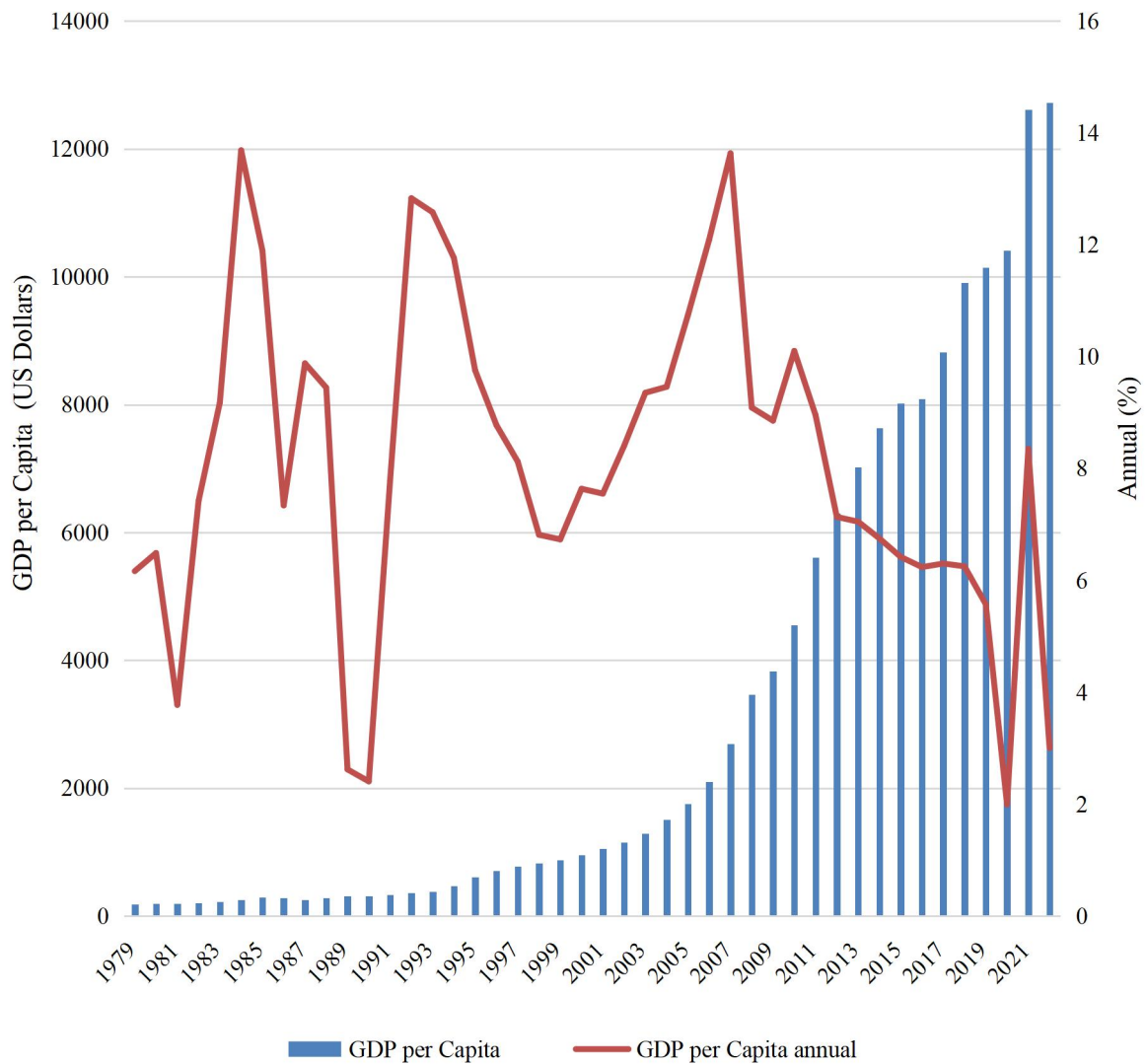


Figure 2.14: GDP per capita of China (1979–2022)

Source: World Bank (2023)

Although China has become the largest developing country in terms of FDI utilization, its GDP per capita remains modest relative to the scale of its overall economic

output. China's GDP per capita is currently only slightly above the world average, indicating a structural disconnect between aggregate economic size and individual income levels. While China experienced rapid economic expansion, averaging 9.7% annual GDP growth from 1979 to 2000, which further accelerated to 10.55% between 2001 and 2010; the growth rate has gradually declined. From 2011 to 2016, the average annual growth rate fell to 7.75% and has since decreased further to 5.55% from 2017 onward (Deng et al., 2023). This deceleration reflects China's ongoing transition from a high-speed to a high-quality development model (Gao et al., 2024; Guo et al., 2024). Since the reform and opening-up, China has adopted an expansionary growth model, heavily reliant on factor accumulation and investment-driven strategies, which sustained exceptionally high growth for several decades. A key milestone was reached in 2010 when China became the world's second-largest economy, symbolizing its ascent in the global economic hierarchy. However, as structural reforms and industrial upgrading have taken effect, growth has moderated in a controlled manner, achieving a soft landing that has laid the groundwork for a more sustainable, innovation-oriented, and inclusive growth trajectory.

High-quality development in China encompasses stable economic growth, balanced regional and urban–rural development, innovation-driven progress, green transformation, and a more equitable distribution of development outcomes across society (Wang et al., 2019). A nation's capacity for innovation is shaped by the strength of its R&D infrastructure, the quality of industrial clusters, and the depth of university–industry linkages (Furman et al., 2002). In 2020, the Chinese government introduced a new development paradigm known as dual circulation, in which the domestic economic cycle serves as the core, supported and enhanced by international circulation. Despite this strategic pivot, China continues to attract substantial levels of foreign direct investment

(FDI), and the role of foreign firms remains significant. By integrating domestic and international markets and resources, the dual circulation strategy seeks to enhance self-sufficiency, promote technological upgrading, and ensure long-term, inclusive, and environmentally sustainable growth.

2.4.2 Real GDP by Region and Province in China

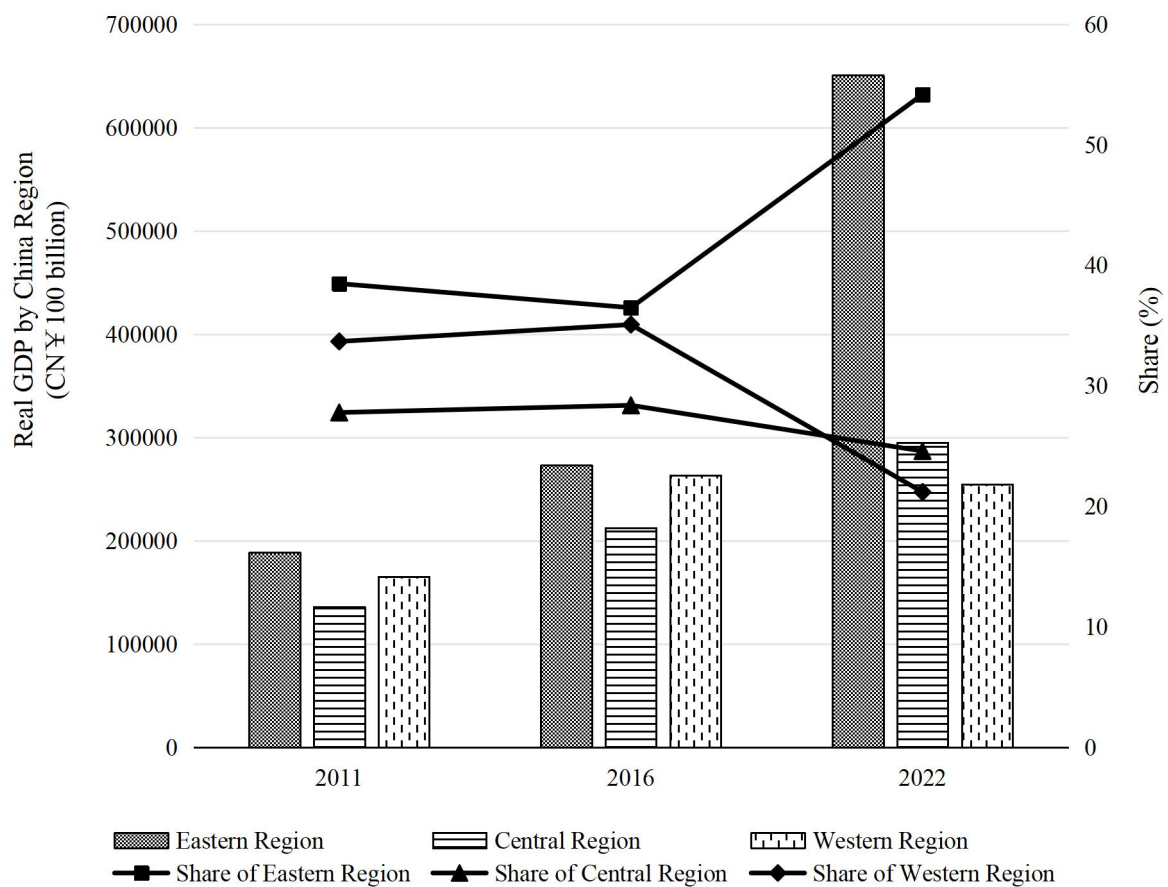


Figure 2.15: Real GDP by China Region (2011, 2016 and 2022)

Source: China Statistical Yearbook (various years)

As shown in Figure 2.15, the real GDP of the Eastern, Central and Western regions of China were all rising, but their share of the country's total appeared to be significantly different. Specifically, the real GDP of the Eastern region was growing most rapidly, from CN¥ 188,826.9 billion in 2011 to CN¥ 650,993.3 billion in 2022, with an average annual

increase of 20.4%. The proportion of real GDP in the Eastern region had risen from 38.5% to 54.2%, becoming the economic pillar of the country. The Central region's real GDP was less than that of the Western region in 2011 and 2016, but slightly more in 2022. The Central region's share of real GDP in the country first rose and then fell from 27.8% to 24.6%. The Western region followed the same trend but declined more, from 33.7% to 21.2%. As a result, the Eastern region had the fastest economic growth rate and a clear agglomerative economies effect, attracting factors of production from the Central and Western regions.

As shown in Figure 2.16, there are 16 provinces (including autonomous regions and municipalities directly under the central government) whose GDP growth rate in 2022 exceeds the national level (2.99%), of which four provinces, namely Guangdong, Jiangsu, Shandong, and Zhejiang, exceeded 6%. The top ten provinces in China in terms of GDP in 2022 are Guangdong, Jiangsu, Shandong, Zhejiang, Henan, Sichuan, Hubei, Fujian, Hunan, and Anhui. Amongst them, there are six in the Eastern region, three provinces in the Central region (Henan, Hubei and Hunan), and Sichuan in the Western region. Specifically, the GDP of Guangdong Province was CN¥ 12,911.9 billion, an increase of 1.9% year-on-year, ranking first in the country for the 34th consecutive year. The strong economic performance of the provinces highlights the resilience and vitality of China's economy.

According to Chi et al (2024), regional disparities in innovation capacity remain an obstacle to achieving balanced high-quality development in China. The Eastern region, which continues to dominate in terms of GDP share, is primarily driven by the service industry. In contrast, the Central region is undergoing industrial upgrading, while the Western region is navigating the transition from a resource-based economy to a more diversified development model. As China's economy shifts from high-speed to medium-

speed growth, the challenge of promoting spatially balanced and innovation-led development has become increasingly urgent.

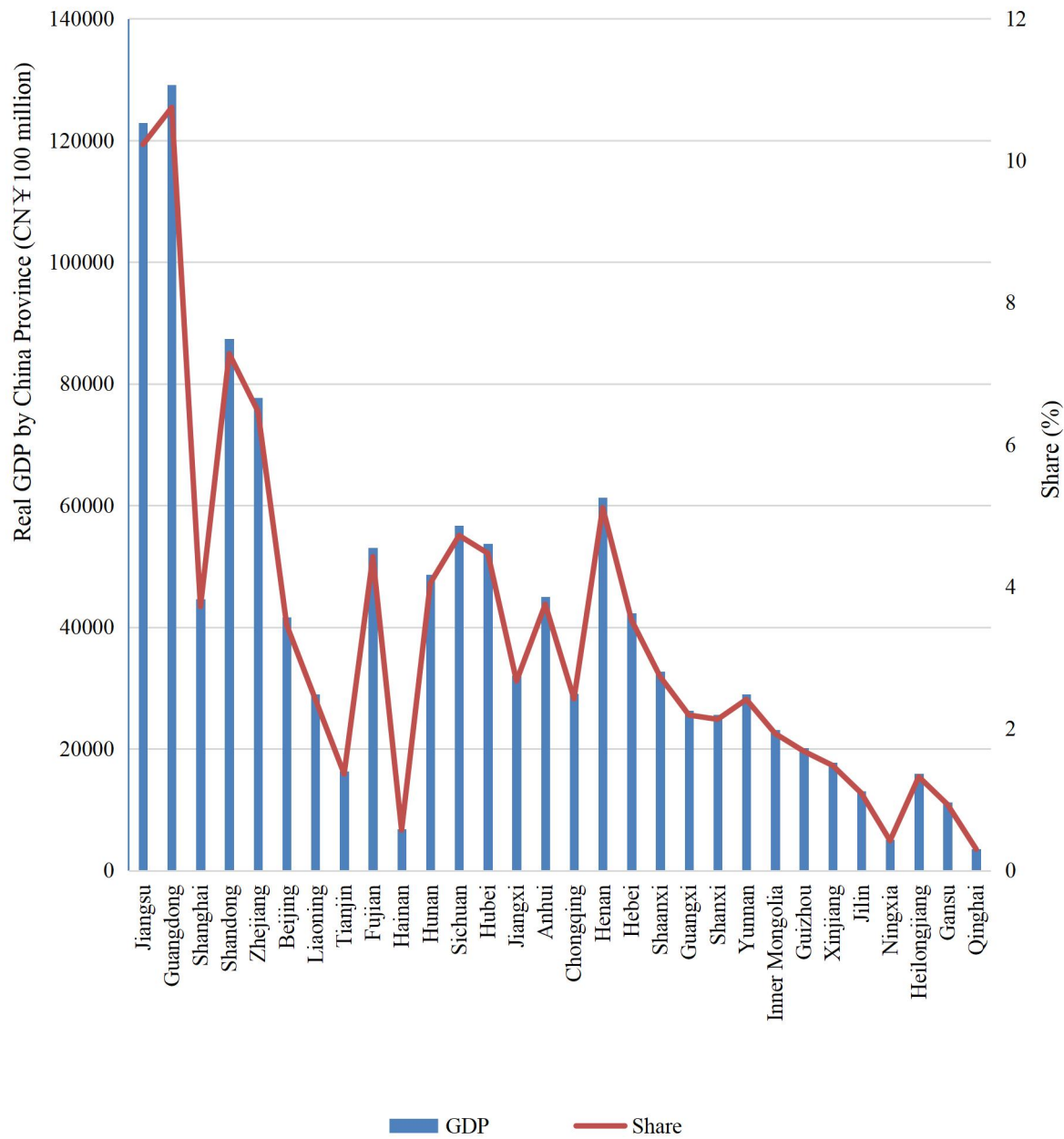


Figure 2.16: GDP by China province (2022)

Source: China Statistical Yearbook (2023)

2.5 A Remark

Since the reform and opening-up, China's economic strength, scientific and technological strength and comprehensive national power have increased significantly. The contradiction between a large economy but a low per capita level and a fast economic growth rate but low quality is increasing prominent. The crude mode of development that relies on factor inputs such as resources to drive economic growth is unsustainable. Hence, China's economy is realising a shift from factor-driven and investment-driven development to innovation-driven development. FDI plays an important role in China's opening-up and has been fully participated in the construction of China's economy. FDI, through its strong capital, advanced technology and management experience, has increased factor inputs and labour productivity. Also, promoted the technological progress of local enterprises through the technological spillover effect. Under the dual circulation new development paradigm, FDI serves as an important link between the internal and external circulations, helping China achieve higher-level opening-up and sustainable growth. Technology spillover is an important way for local enterprises to enhance their R&D level and independent innovation capability, which can alleviate the risk of industrial chain breakage and enable early crossing of the middle-income trap and the middle-tech trap.

However, there are significant geographical differences in FDI and R&D. The Eastern region attracts most of the FDI and R&D, while the Central and Western regions are growing rapidly, and the latecomer's advantage is obvious. In addition, with the intensification of geopolitics and trade friction between China and the US, FIEs are on a weakening trend in their investment efforts and innovation capacity in China. Moreover, they are more inclined to protect their core technologies and master the sales channels, which limits the breadth and depth of the technological spillover. Therefore, it is essential

to promote the transformation from opening-up based on flows of goods and factors of production to opening-up based on rules and related institutions. Besides, to improve the layout of development for all three regions, which can further positively impact FDI and technology spillover on China's economic growth.

Based on the past discussion on the nexus of FDI, technology spillovers and China's economic growth, China's FDI is undergoing three transformations. First, there is a shift from a factor- and investment-driven growth model toward an innovation-driven development paradigm. Second, spatial patterns are being reorganised to promote more balanced development across the Eastern, Central, and Western regions. Third, the marginal effect of FDI on economic growth is evolving, with diminishing returns in some regions and increasing significance in others, depending on local absorptive capacities and policy environments.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

This chapter systematically introduces the literature on FDI, technology spillovers and economic development. Chapter 3.1 is the introduction. Chapter 3.2 introduces relevant definitions and theories of FDI, technology spillover and economic development at home and abroad. Chapter 3.3 shows relevant empirical studies and determinants of FDI, technology spillover and economic development at home and abroad. Chapter 3.4 reviews the above literature and presents research gaps.

3.2 Theoretical Studies

3.2.1 Definitions of Foreign Direct Investment

International investment can be divided into foreign direct investment and foreign indirect investment. Their fundamental difference lies in whether they have control over the business activities of the fundraiser.

Foreign direct investment refers to capital export by investors, which is characterised by controlling part of the property rights of enterprises and directly participating in the operation and management, with the main purpose of obtaining profits. International direct investment can be divided into two forms: setting up new enterprises and controlling the equity of foreign enterprises. The establishment of new enterprises refers to the direct investment by investors in foreign countries, the establishment of new factories and mines or subsidiaries and branches, and the acquisition of existing foreign

enterprises or companies, et al., to engage in production and management activities. The control of foreign equity refers to the stock purchase of a foreign enterprise to a certain extent, to have the control of the foreign enterprise's equity. International direct investment is the derivative and expansion of domestic direct investment. With good credit status, advanced technology and scientific management experience, transnational corporations become the main body of FDI and often have monopoly advantages.

Foreign indirect investment refers to the transnational investment aimed at capital appreciation and in the form of obtaining interest or dividend. Also, taking the securities of the country to be invested as the object, that is, to buy medium-and long-term bonds in the international bond market or corporate stocks in the foreign stock market.

3.2.2 FDI and Economic Growth Theories

Since the 1960s, with the continuous enrichment of international direct investment practice and the improvement of relevant theories, scholars have made many explanations on the causes, locations, behaviours and functions of FDI.

First, macro theories of economic growth and national competitiveness, which explain the economic growth patterns as a whole and create and maintain sustainable competitive advantages. Solow (1956) first created the Solow Growth Model, also known as Neoclassical Economic Growth Model and Exogenous Economic Growth Model, which is an economic growth model within the framework of neoclassical economics and used to explain the relationship between savings, capital accumulation and economic growth. Moreover, capital is the endogenous variable, while technological progress is the exogenous variable. In the mid-1980s, economists represented by American economist Romer (1986) proposed the New Growth Theory to promote economic growth by

endogenous technology growth based on neoclassical Growth Theory. By introducing endogenous technological factors such as knowledge and human capital into the model, knowledge and human capital not only have the attributes of common goods, but also have spillover effect, so endogenous technology is the fundamental source and power of sustainable economic growth. According to the Competitive Advantage of Nations Theory of Porter (1990), an American business strategy manager, the economic development of a country can be divided into four progressive stages, namely, Factor-driven, Investment-driven, Innovation-driven and Wealth-driven. This theory is also applicable to the explanation of the competitive advantage of enterprises.

Second, theories of cross-border transfers and the drivers of international investment based on industry-level. Professor Vernon (1966) of Harvard University used the Theory of Product Life Cycle to divide the product life cycle into the stage of new product innovation, the stage of product maturity and the stage of product standardisation. Combined with location theory, it dynamically explains that the country's transfer of product production leads to foreign trade, foreign direct investment and foreign technology transfer behaviour. Amongst them, in the mature stage of products due to the sharp increase in the export volume of products, the monopoly technology owned by multinational companies gradually spread to foreign competitors, and imitation products began to appear. In order to pursue profits, multinational corporations set up branches abroad and transfer mature technologies. Japanese economist, Kojima (1978) proposed the Marginal Industry Transfer theory, that is, the marginal industries that have been or will be at a comparative disadvantage in China will be transformed into the comparative advantage industries of the host country through FDI. Amongst them, the labour-intensive industries

in developed countries are marginal industries at a disadvantage as compared to developing countries, so they can be transferred to developing countries for investment.

Third, theory of micro-behaviour of enterprises and competitive advantage, which emphasises the role of enterprises' behaviour on internationalisation. Heymer (1960), an American scholar, first used the Monopolistic Advantage Theory to explain the occurrence of international direct investment. The determinants of foreign direct investment of multinational corporations include advantages in advanced technology, advanced management experience, capital and economies of scale. British scholars Barclay and Casson (1976) adopted the new firm theory of American scholar Coase and the basic assumption of incomplete market. The Internalisation Theory is used to explain the FDI behaviour of multinational companies, and the goal is to eliminate the incomplete external market and high transaction costs. Dunning (1977), a British economist, proposed the Eclectic Paradigm of International Production and comprehensively proposed that a country's enterprises must have three advantages in FDI, namely, ownership advantage, internalisation advantage and location advantage.

The monopoly advantage, location, technology progress and other explanations involved in these classic FDI theories are the preconditions for enterprises in the host country to learn and imitate the technology of foreign enterprises. These theories systematically explain the mechanisms of economic growth, cross-border investment and the formation of competitive advantages of enterprises at both the macro and micro levels. From a macro perspective, the Solow Growth Model emphasises technological progress as the core driver of long-term economic growth, while Vernon's Product Life-cycle Theory and Kojima's Theory of Marginal Industrial Transfers focus on the dynamic transfer of

industries and production between different countries, revealing the role of international trade and cross-border investment as a driving force for global economic growth. From a micro perspective, Heymer's Theory of Monopoly Advantage, Barclay and Carson's Theory of Internalisation, and Porter's Theory of Competitive Advantage focus on how enterprises can gain competitiveness in the global marketplace through monopoly advantage, internalisation deals, and innovation strategies. Dunning's Theory of Eclectic Paradigm of International Production combines ownership advantages, internalisation advantages and location advantages to construct a comprehensive framework for the investment decisions of multinational enterprises. Together, these theories depict a multidimensional interaction between economic growth, international investment and enterprise competitiveness, providing comprehensive theoretical support for understanding global economic activity.

Several economists focusing on developing economies have made a number of meaningful points about the motivation and necessity of introducing FDI in developing countries or economies. The first category is the Stage of Economic Growth theory based on dynamic processes, which emphasises the progressive nature of the stages of economic growth. Rostow (1960), an American economic historian, as one of the pioneers of development economics, proposed the economic growth theory in stages and refined it in 1971. That is, social development is divided into six stages that must go through in turn: In the stage of traditional society, the stage of preparation for takeoff, the stage of taking off into self-sustained growth, the stage of maturity, the stage of high mass consumption and the stage of pursuing quality of life. In the take-off stage, the comparative advantage shifts from agricultural export to industrialised export of labour-intensive products and developing countries can improve the difficulty of capital shortage by using foreign capital.

The second category is based on the theory of the development finance gap in developing countries. Based on the Harrod-Domar Model of Neoclassical Growth Theory, the American economists Chenery and Strout (1966) put forward the Two-gap Model. It is an important theoretical basis for developing countries to use foreign capital. Developing countries can raise real economic growth by bringing in foreign capital to cover the domestic savings gap and the foreign exchange gap needed to finance imports. Hirschman proposed the Three-gap Model, which is a modification of the Two-gap Model. In addition to the savings gap and the foreign exchange gap, developing countries also have a technology gap, including technology, management and entrepreneurs, which limits the effective absorption of capital and can hardly be made up by domestic resources alone. Therefore, the technology gap of developing countries is an important demand driver for large-scale inflow of foreign capital, through which certain technology spillover effects can be obtained. In addition to the savings gap, foreign exchange gap and technology gap, the Four-gap Model also recognises the gap between the planned target and actual tax revenue of the government, and developing countries make up public funds by taxing the profits of foreign-invested enterprises.

After World War II, the vast number of Asian, African and Latin American countries ousted the colonial rule of Western developed countries and established national states with independent sovereignty. However, the economists still believe that they have not yet achieved the rich and powerful country and are still dependent on the Western developed countries to varying degrees economically. A typical pessimistic view is that FDI makes national economies dependent on foreign investment. Argentine economist Prebisch (1950) put forward the Core and Periphery Theory. The centre refers to the dominant capitalist industrial developed countries, and the periphery refers to the

developing countries that produce and export primary products. The unequal economic relationship between the centre and the periphery is caused by the economic, financial and technological disadvantages of the periphery, which eventually leads to the dependence of the periphery on the centre, and even extends from economic dependence to cultural dependence and ideological dependence. Frank (1966), a German-born scholar, proposed the theory of Development of Underdevelopment, arguing that under the secure-satellite international pattern, satellite countries could not achieve truly independent development.

The other view is more optimistic and emphasises the internal causes of economic development in developing countries. Fernando Henrique Cardoso (1982) of Brazil put forward the development theory of dependence. The economy of developing countries reflects the dual characteristics of dependence and development on developed countries. The Multinational Corporation Centre of UNCTAD (1992) put forward the engine theory of multinational corporations, pointing out that multinational corporations are the engine of economic growth of host countries in developing countries. This can increase the government revenue of host countries, generate technology spillover effect, develop human resources, improve the export structure and institutional change of host countries.

The above FDI and economic growth theories of developing countries all reveal the objective fact that the technological level of developing countries lags behind that of developed countries, as well as the impact of imported technology on the economic development of host countries and its transmission mechanism. Based on the above-discussed theories, Solow's (1956) model emphasizes capital accumulation and exogenous technological progress as sources of growth. However, it does not explain the mechanisms through which technology is acquired, particularly relevant for countries like China

receiving FDI inflows. The model provides a baseline for this study to embark on the issue of the role of technological progress in economic growth. Next, Romer (1990) introduced the idea that technological progress results from purposeful investment in knowledge and innovation, often influenced by externalities and spillovers. Hence, this study builds upon Romer's framework by positioning FDI as a channel of knowledge diffusion, particularly via technology spillovers, and examines their transmission to economic growth through both direct and indirect mechanisms.

3.2.3 Technology Spillover Theory

3.2.3.1 Technology Spillover and Technology Transfer

FDI can bring both technology spillover and technology transfer to the host country, but relatively speaking, technology spillover reflects more technology improvement benefits to the host country than technology transfer (Zhang, 2024).

Blomstrom and Kokko (1992; 2001), two of the most prominent scholars in the field of FDI spillovers, first proposed the definition of technology spillover. Technology spillover refers to a kind of external economic effect caused by the implementation of FDI by multinational corporations in host countries, which leads to the progress of local technology or productivity, but the multinational corporations cannot obtain all the benefits. Of course, the goal of FDI is to integrate global resources so as to maximise profits, and technological blockade exists to a certain extent. Therefore, technology spillover generally refers to the unconscious transfer or transmission of their technology by advanced technology owners in trade or other economic behaviours, including international technology spillover, domestic technology spillover, inter-industry technology spillover, and intra-industry technology spillover.

Teece (1977) explicitly introduced the concept of Technology transfer, and Kogut and Zander (1993) extended it to the process of technology transfer for firm internationalisation. Technology transfer refers to the process of technology output and input within or between countries, regions, industries and within the system of technology itself, including the transfer, transplantation, introduction, exchange and popularisation of technological achievements, information and capabilities. According to the direction of its transfer, it can be generally divided into two categories: bidirectional diffusion in geospatial location and unidirectional diffusion in different practice fields. According to the transfer mode, it can be divided into paid transfer and free transfer; According to the scope of transfer, it can be divided into international transfer and domestic transfer (Hajeesh, 2023).

3.2.3.2 Characteristic of Technology Spillover

Technology spillovers have the characteristics of economic externality, involuntary and interaction (Li, 2008).

First, the essence and primary characteristic of spillovers is economic externality (Kong et al., 2024; Yue et al., 2024; Zhao et al., 2024). FDI technology spillovers can bring benefits to the innovation of the host country (Ning et al., 2023). However, the export spillover multinational companies cannot gain from it or recover all the benefits. On the contrary, if the host country enterprises benefit from FDI spillovers and improve their own innovation level and catch up with the multinational companies, it may also bring negative impact on the multinational companies.

Then, involuntary means that technology spillovers are not the result of voluntary or active actions of multinational corporations (Kong et al., 2024). However, absorbing

technology spillovers can be a voluntary or active action for host enterprises, and it can even be promoted by building auxiliary facilities or formulating policies. The distinguishing standard between technology spillover and technology transfer is whether there is non-voluntary license in the former, while the latter is a technology sale contract reached on the premises of both parties voluntarily.

Additionally, interaction means that both the technology exporter (multinational corporation) and the input (host country enterprise) must participate in the occurrence of technology spillover, and the final effect is jointly decided by both parties (Yue et al., 2024; Behera, 2023). From a macro perspective, the market structure of the host country determines the degree of local market competition, and the more competitive market will produce more prominent technology spillover effect. From the micro perspective, the technological level of the host country determines whether the spillover effect can be fully absorbed.

Therefore, technology spillover also has a time lag (Kong et al, 2024) and is immeasurable (Yue et al., 2024; Tan et al., 2023). Technology spillover does not manifest itself immediately but takes some time and different channels to show spillover effects, and there is no clear indicator that can be measured directly and accurately (Li, 2008).

3.2.3.3 Theory of FDI Technology Spillover

There are abundant studies on the technological spillover of FDI, that is, the relationship between FDI and the technological progress of host countries, but a complete theoretical system has not been established.

First, the concept and sources of technological spillovers are presented, laying the initial theoretical framework for subsequent research. British economist, Marshall (1890) first proposed economic externality which stated technology not only has the competitiveness and exclusivity of traditional goods, but also has the economic externality, that is, technology spillover effect. Technology spillovers are an important factor of technological progress and economic growth. In the 1960's, MacDougall proposed technology spillover for the first time in his analysis of the general welfare effects of FDI on the host economy. Scholars such as Caves (1974) subsequently further refined the research in this area. For the first time, he comprehensively categorised the technological diffusion of multinational enterprises (MNEs) to host country enterprises into three kinds of externalities, namely, MNEs can break the original market monopoly of local enterprises, bring about competitive pressures and demonstration effects, and accelerate imitation and technological diffusion by local enterprises.

Second, the determinants and channels of technology spillovers from host countries have been proposed, focusing on the conditions under which spillover effect occurs and the mechanisms through which they are realised. Findlay (1978) constructed an endogenous dynamic model on FDI from developed countries to developing countries, and tested the effects of static characteristics, such as technology gap and foreign capital share on technology diffusion. The larger the technology gap between the home and host countries of the investment, the higher the rate of technological diffusion. At the same time, the higher the share of local capital of multinational enterprises (MNEs), the faster the rate of diffusion, and the more the host country's economy grows. On the basis of previous studies, Kokko (1992) systematically concluded two sources of occurrence of FDI technology spillover. One is demonstration, imitation and diffusion, which corroborates Findlay's

view of the technology gap. The other is competition, which confirms Caves' view of the competitive relationship between MNEs and local enterprises.

Additionally, the dynamics of technology spillover and international investment are then discussed, with technology spillover resulting from the investment behaviour of MNEs. Koizumi and Kopecky (1980) constructed a long-run model of international capital flows to analyse the effect of FDI on a country's economic growth. This model assumes that the technology contained in foreign capital has the nature of public goods and can bring additional spillover benefits to society. Wang and Blomstrom (1990) for the first-time constructed a basic model of the game between MNEs subsidiaries and local enterprises from a game-theoretic perspective, viewing spillovers as an endogenous phenomenon of strategic competition between the two. Both MNEs subsidiaries and local enterprises may affect the level of spillover through their investment decisions, that is, the more MNEs invests in new technologies, the more spillover there is. The more a local enterprise invests in learning, the greater its capacity to absorb spillovers.

Since the 1990s, the theoretical research on FDI technology spillover has broken through the original framework with multinational corporations as the core of analysis and further explored new phenomena such as technology strategic alliance. Drawing from Findlay (1978) and Wang and Blomström (1992), technology spillovers from FDI can be captured from indirect effects. Hence, this study addresses that gap by developing interaction terms to quantify the moderation role of absorptive capacity and innovation infrastructure. On this note, based on New Economic Geography (Krugman, 1991) and spatial econometrics (LeSage & Pace, 2009), spatial spillovers refer to economic effects diffused across geographic boundaries which highlight the inter-regional disparities.

3.3 Empirical Studies

3.3.1 Global Evidence on FDI and Spillovers

For a long time, foreign scholars have been controversial about FDI technology spillovers, and there are generally two views, namely, the existence of positive spillover and the absence of positive spillover.

First, Caves (1974), Globerman et al. (1979) are the pioneers in studying FDI technology spillover effect. Also, they certified that FDI has significant positive technology spillover effect and can push economic growth. Caves (1974) tested for positive technology spillovers from manufacturing industries' FDI in Canada and Australia in 1966 because the profitability or labour productivity of local enterprises was positively related to the share of foreign investment. Globerman (1979) reached the same conclusion for Canadian manufacturing in 1972. Specifically, the proportion of foreign investment is positively correlated with the labour productivity of local enterprises, indicating the existence of efficiency spillover effects within the industry. FDI-led and trade-led technology spillovers in Organisation for Economic Cooperation and Development (OECD) member countries was tested by Pooled Mean Group (PMG) method for both short-run and long-run periods, and showed a significant positive impact on economic growth during the period 1995 to 2018 (Zamani & Tayebi, 2022). This study emphasised the importance of external technology transfer for long-term growth and validates the technology absorption mechanism in endogenous growth theory.

Empirical studies in some developing countries have shown that FDI has a significant positive effect on economic growth, confirming the FDI-led growth model. FDI inflows in BRICS, Asian economies, Vietnam, as well as Middle East and North Africa

countries have positive externalities and boost the local economy (Rehman & Islam, 2023; Bakari & Sofien, 2019; Su et al, 2019; Hamdi & Hakimi, 2022). CS-ARDL model was adopted to measure that outward FDI positively and significantly promotes total factor productivity (TFP) in BRICS economies from 1990 to 2019 (Rehman & Islam, 2023). FDI inflows in India have contributed to economic growth in the long run and seem to have little impact in the short run (Rakshit, 2022). FDI in Pakistan has a positive impact on its economic growth in both the long and short term (Kanval et al, 2024). The East African region has significant spatial spillover effect of FDI, human capital development and government expenditure on regional economic growth over the period of 1992-2019 (Otieno, 2024). In Namibia, the interaction term of FDI and trade openness, government consumption expenditure, and human capital contributed to economic growth between 1990 and 2020 (Sunde, 2023). Some empirical studies have proved that FDI does not drive economic growth, but technology does. In Ghana, FDI did not affect economic growth between 1995 and 2017, but technology was positively affecting economic growth, while trade had a significant negative impact on economic growth (Obeng-Amponsah & Owusu, 2023). Furthermore, it has also been argued that there are regional differences in the spillover effect of FDI on regional economic growth (Otieno, 2024).

However, more scholars believe that there is no positive effect of FDI technology spillovers in developing countries, which may be insignificant, negative or require certain conditions and thresholds. There are some countries' FDI technology spillover insignificant and have no impact on host countries' economic growth, such as in Moroccan manufacturing (Haddad & Harrison, 1993), as well as in Brazil, Nigeria, and Vietnam (Epor et al., 2024; Hoang et al., 2022). The positive but insignificant effect of FDI and trade on economic growth in Brazil, Nigeria and Vietnam between 1990 and 2021 is

related to the repatriation of profits by MNEs to their home countries (Epor et al., 2024). A spatial econometric model was used to analyse to show that the high-quality labour force in neighbouring regions had a significant positive impact on local FDI. However, Vietnam has increasing FDI capital between 1990 and 2020, but its effect is still limited and detrimental to economic growth in the long run (Hoang et al., 2022). FDI in the European Union between 2009 and 2018 did not necessarily lead to poverty reduction and had a limited effect on economic growth (Adilla, 2024).

The technology gap and absorptive capacity of local enterprises versus MNEs is also necessary for technology spillovers. Brazilian firms in high technology, high technology knowledge-intensive services, and knowledge-intensive financial services, which have a smaller technology gap and higher absorptive capacity, may collect positive spillover (Morales & Moreno, 2020). Improved capabilities in human resource absorption, foreign inputs, enterprise size, and market concentration by MNEs in Indonesia from 2017 to 2019 can increase total factor productivity of manufacturing enterprises (Yasin et al., 2024). Backward spillovers from downstream MNEs in India's manufacturing sector from 2010 to 2018 are the only source of total factor productivity improvement and industry heterogeneity is a key driver of FDI spillover (Behera, 2023). Hence, FDI in middle-income countries, such as China, India, and Brazil, drove economic growth from 1972 to 2024, but there is considerable variation across regions and economic structures depending on the local capacity to absorb and utilise FDI (Yasin & Safdar, 2024).

This technology gap and absorptive capacity is also the threshold for FDI technology spillover. There is a host country development threshold for FDI, and only with a certain level of labour and technology can the threshold be crossed and technology

spillover be generated (Borenztein et al., 1998). Several empirical studies supported this point of view. For example, 95 countries' net inflows of FDI from 2008 to 2019 are positively correlated with technology transfer, advanced technology and managerial know-how, especially in developing countries. However, there is a threshold for both developed and developing countries to benefit from the country of origin of FDI through quantile regression model (Chan et al., 2024).

In addition, in recent years, more scholars have noticed that MNEs reserve their core technologies when making investments in order to minimise technological spillovers. When Northern enterprises engage in FDI, advanced technologies spillover to Southern enterprises and improve the quality of their products, so Northern enterprises strategically reduce the quality of their products to limit the amount of technological spillover (Morita & Nguyen, 2021). Similarly, although Vietnamese enterprises have received some modern technologies through large amount of FDI, they have more often received many old and obsolete technologies (Hoang et al., 2021).

The preceding empirical literature review reveals that scholars have employed diverse theoretical models and econometric techniques to investigate FDI-induced technology spillovers across various countries, industries, and time periods. Although a consensus exists that FDI can foster economic growth through technology diffusion (e.g., Zamani & Tayebi, 2022; Rehman & Islam, 2023), the empirical findings remain mixed. For instance, early studies such as Globerman (1979) documented a positive association between FDI and labour productivity, yet more recent research by Moralles and Moreno (2020) underscores the conditional nature of these effects, suggesting that technology spillovers are contingent on the host country's absorptive capacity. Additionally, Chan et al.

(2024) emphasise the importance of the source country of FDI, as it shapes the scope and depth of technology transfer. From a spatial perspective, Hoang et al. (2022) demonstrate that neighbouring regions' institutional quality and labour characteristics significantly mediate FDI inflows and associated spillovers. Collectively, these studies suggest that while FDI holds promise for enhancing productivity, its actual effectiveness varies substantially across contexts. The inconsistencies underscore the importance of accounting for host-country absorptive capacity, regional heterogeneity, and source-country characteristics in explaining the magnitude and direction of FDI-driven spillovers.

3.3.2 Evidence from China

The discussion on the impact of FDI and technology spillover on China's economic growth has been a hot research topic, although it started relatively late, and different themes have emerged with the changing times.

3.3.2.1 The Debate Over the Economic Impact of FDI

FDI and technology spillovers have a positive impact on economic growth in developing economies, and FDI promotes capital accumulation, innovation and sustainable development in host countries. This view has been empirically demonstrated in countries along the Belt and Road Initiative (BRI) and by the Organisation for Economic Co-operation and Development. More than 120 countries have substantially improved their local economies through foreign trade and outward FDI under the BRI between 2013 and 2019, especially in lower-income countries (Ma, 2022). Two-way FDI between China and OECD countries has had a technology spillover effect on the quality of China's economic growth. The higher the economic level and openness to the outside world, the easier it is to absorb international technology spillover (Wang et al., 2019). The scale expansion of FDI

promotes China's economic growth in terms of increasing employment opportunities, improving labour quality, promoting technological progress, and enhancing innovation capacity (Zhang, 2024; Zhao, 2024; Feng & Li, 2021). In addition, international technology spillover has generally shown an upward trend in China over the period 2003 to 2014 (Liu & Guo, 2019). For example, China's Chery Automobile significantly improved its product quality after hiring engineers who quitted from the Nissan-Dongfeng joint venture (Morita & Nguyen, 2021). However, FDI promoted China's economic growth in the short term, but may have a negative impact on economic growth in the long-term using the ARDL model (Sagheer & Ashraf, 2024).

3.3.2.2 Spatial Econometric Approaches to FDI Spillover

There are technology spillover effects and spatial effects of FDI in high-tech industries. Foreign R&D had a significant role in promoting the innovation performance of high-tech industries in 23 Chinese provinces (autonomous regions and municipalities directly under the central government) from 2007 to 2016 and had a significant positive spatial effect. However, there was no obvious spatial effect in the field of product innovation, and domestic R&D investment in the field of intellectual property rights played a positive role and had a spatial effect, with a higher degree of influence than foreign R&D investment (Han & Feng, 2023). The systematic GMM model test shows that there are three pathways of technological spillover effect of industrial agglomeration in China, namely, spatial agglomeration, specialisation spillover and technological network. Also, the enterprises in the centre of industrial agglomeration have stronger technological innovation ability; specialisation agglomeration has a significant positive impact on technological innovation; and technical cooperation network has a significant positive impact on promoting technological innovation, which is an important way of technological

spillover from industrial agglomeration (Xiaoyan et al., 2024). Past studies have tended to focus on FDI and its spillover effects, nevertheless studies on the spatial effects appear to be limited. Hence, there remains a significant gap in addressing the heterogeneous effects of FDI across China's diverse regional contexts. In particular, the distinct institutional environments and varying levels of innovation capacity in the Eastern, Central, and Western regions have not been adequately examined in relation to their differential capacities to absorb and benefit from FDI-induced technology spillovers.

3.3.2.3 Sectoral Evidence from High-Tech and Manufacturing Industries

The area of the relationship between FDI technology spillover and the quality of microenterprise innovation has been studied, and empirical studies have shown that FDI technology spillover promotes the improvement of the quality of innovation of Chinese enterprises. In terms of enterprise types, FDI technology spillover based on geographic proximity of Chinese A-share listed enterprises have a positive impact on the quality of innovation of Chinese enterprises, especially for non-state-owned enterprises and small and medium-sized enterprises. However, it has no impact on the quality of innovation of state-owned enterprises and large enterprises, as examined in a two-way fixed-effects model from 2009 to 2019 (Yue et al., 2024). In terms of spillover channels, the innovation quality of regional FDI by Chinese industrial enterprises had a significant impact on the innovation quality of local enterprises between 1998 and 2013, and mergers and acquisitions (M&A) FDI had a more positive spillover effect than greenfield investment, with significant intra-industry benefits or demonstration effects (Tan et al., 2023).

In terms of the transmission mechanism, the degree of financing constraints and R&D investment are important transmission mechanisms between FDI technology

spillover and enterprises innovation quality (Yue et al., 2024). Unlike the inter-industry linkage effect, the FDI technology spillover effect amongst supply chain firms and its generation mechanism have been studied. Chinese enterprises can generate FDI technology spillover directly through supplier-customer linkages between 2009 and 2020, suggesting that there are inter-enterprises technology spillover from FDI. On this note, the channels for their generation are knowledge transfer channels and supply chain optimisation allocations, which are mainly manifested in state-owned enterprises, small and medium-sized enterprises, the manufacturing industry, and high-technology industries (Li et al., 2024).

3.3.2.4 Sources and Regional Heterogeneity in FDI Spillovers

The differences in the sources of FDI technology spillover and the regional differences in capital attraction. In terms of the source of FDI, the technology spillover effect of FDI on mainland Chinese enterprises mainly comes from developed countries or economies. Whereas it is not significant in China's Hong Kong, Macao and Taiwan, developing countries, and the British Virgin Islands and the Cayman Islands (Li et al., 2024). In terms of where FDI is induced, different studies draw inconsistent conclusions. The expansion of FDI in the Eastern region promotes its regional innovation capacity, while it is not significant in the Central and Western regions (Zhao, 2024). However, empirical results based on the C-D production function suggest that FDI has technological spillover and regional heterogeneity for high-tech industries in the Eastern, Central, Western and Northeastern regions between 2012 and 2021 (Zhao et al., 2024). Given that FDI can have a negative impact on economic stability and coordinated social development (Zhang, 2024), all regions should give priority to their respective comparative advantages,

deal with the issue of balanced development, and promote FDI and local factor inputs to achieve coordinated regional economic development in China (Zhao et al., 2024).

3.3.2.5 Measurement of Technology Spillover

In addition, there is difficulty in measuring technology spillovers. Regional FDI technology spillovers and geographic proximity of enterprises at the micro level have been constituted as an interaction variable, which has been used as a new indicator of FDI technology spillover that mitigates the endogeneity problem. However, existing indicators of FDI technology spillovers suffer from technological difficulties in measurement at the micro level (Yue et al., 2024).

While a substantial body of research affirms that FDI contributes positively to China's economic growth, its impact is neither uniform nor consistent across development stages, regional contexts, or methodological approaches. Foundational studies such as Globerman (1979) identified productivity gains at the industrial level, whereas more recent analyses within the Chinese context (Bobek et al., 2024) underscore FDI's significant contribution to per capita GDP, moderated by institutional quality variables such as the rule of law and property rights protection. Zhang et al. (2024) further argue that FDI supports high-quality development in China primarily through green and innovation-led channels, though such benefits tend to be concentrated in the Eastern region, with limited spillovers observed in the Central and Western regions. In contrast, Sagheer and Ashraf (2024), using time-series methods, caution that while FDI may yield short-term economic gains, it could exert adverse effects over the long run. Additionally, Chan et al. (2024) highlights that the origin of FDI plays a critical role in shaping its technological and developmental contributions.

3.4 The Determinants of Economic Growth

3.4.1 Trade Openness

Many foreign literatures have studied the relationship mechanism between trade openness and economic growth, whereby trade openness promotes economic growth through the transfer of technology, absorption of new knowledge, raising of wages and the expansion of market size. Empirical studies in economies such as Organisation for Economic Cooperation and Development member countries, BRICS countries, Asian economies, Middle East and North Africa countries and Latin American countries have proved that trade openness has a significant positive impact on economic growth. International trade in Organisation for Economic Cooperation and Development member countries can transfer technology while upgrading human capital skills (Zamani & Tayebi, 2022). Aggregate productivity in the BRICS countries is influenced by macroeconomic factors such as trade openness, innovation, human capital and institutional quality (Rehman & Islam, 2023). Through fixed and random effects empirical studies, trade openness in 24 Asian economies shows positive economic externalities (Bakari & Sofien, 2019). Trade openness in 13 Middle East and North Africa countries allows local firms to tap into overseas markets and increase their profits, as well as create jobs and raise wages (Hamdi & Hakimi, 2022). A panel regression model for 11 Latin American countries demonstrates that trade openness positively moderates the relationship between international direct investment and outward foreign direct investment, allowing domestic firms to absorb new knowledge from foreign partner firms and further internationalise (Borda Reyes et al., 2019).

However, there are some contrary views that trade openness has a negative impact on economic growth. By constructing an autoregressive distributed lag model, trade

openness in India has a negative impact on economic growth and exports should be expanded further (Rakshit, 2022). Several literatures has creatively examined the interaction of FDI and trade openness. For example, the interaction variable of FDI and trade openness plays an important role in economic growth in Namibia (Sunde, 2023). Trade openness drives China's economic growth. In terms of drivers, China's trade openness positively promotes technology spillovers from the import trade channel (Liu & Guo, 2019). In terms of the driving path, China's trade facilitation significantly increases the innovation level of local firms, especially non-state-owned firms, non-central cities, and medium-and high-technology industries, and its impact path is mainly realised through technology spillover effects and threshold effects (Zhao & Li, 2022).

3.4.2 Government Expenditure

Government spending in many economies has a significant positive impact on economic growth, the green economy, and spatial spillovers. Panel data for 24 developing countries over the period 1982 to 2014 demonstrate that government spending significantly boosts FDI inflows in the long run (Othman et al., 2018). Macroeconomic variables such as government consumption expenditure in Namibia play an important role in economic growth (Sunde, 2023). In South Korea, government spending has improved environmental quality and the government leads the development of a green economy (Bulus & Koc, 2021). In an empirical analysis using the Spatial Durbin Fixed Effects (SDM-FE) model and balanced panel data from the World Development Indicators for the period 1992-2019, government expenditures in East Africa have a significant spatial spillover effect on regional economic growth (Otieno, 2024).

Government spending in China reflects similar findings. Panel data for 271 prefecture-level cities in China over the period of 1998 to 2018 confirm that local fiscal expenditures directly used to attract capital can trigger vicious competition amongst regions to attract capital, thereby suppressing FDI inflows to the region. While local fiscal expenditures can achieve net FDI inflows by improving the regional investment environment (Hu & Yang, 2021). Chinese FDI is positively correlated with government spending on the environment and shows positive spillover effects (Zhang et al., 2019). Administrative policies can increase investment in education (Zhang & Zhang, 2024). However, China's fiscal spending is no more an incentive for economic growth, rather, fiscal spending promotes economic growth with a threshold effect, i.e., it can only be revealed under the condition of satisfying absorptive capacity (Liu & Luo, 2020).

3.4.3 Total Population

Population is one of the basic elements of economic development. The population size, its structure and geographical distribution, and the accumulation of human capital are all important factors affecting the coordinated and sustainable development of the economy and society.

Population size growth is an important factor for economic growth. In *The Wealth of Nations*, the classical economist Smith (1776) suggested that the increase in national wealth depended on an increase in labour productivity and increase in the number of workers. In 1817, classical economist Ricardo in *On the Principles of Political Economy and Taxation* suggested that land revenue grows with population. Whereas negative population growth will lead to future economic growth stagnation, if factors of demographic transition and quality improvement are present, then positive externalities

will arise, and negative population growth will not necessarily lead to negative economic stagnation (Jones, 2022). Focusing on the improvement of the quality of the population is an important driver for economic growth and further development of old age in the future (Adda & Dustmann, 2023).

Human capital accumulation plays a significant role in economic growth. Early 1960s, Theodore Schultz introduced the concept of human capital. Schultz (1993) considered human capital as a productive investment in human beings, including in the use of education and training to enhance skills or knowledge to increase productivity and profitability, characterised by incremental returns and with certain spillover effects. In conjunction with FDI, the level of human capital in the host country is positively correlated with the quality of FDI and effective technology spillovers. Moreover, host country employees who are trained can effectively absorb foreign technology, increase the level of FDI and contribute to high-quality economic development (Jahanger, 2021).

China has been a populous country since ancient times, and there have been many studies on the internal mechanism of population and economic growth. First, the geographical distribution of China's population has certain regional differences (Ma & Liu, 2022), and there is a certain tendency of mobility, which interacts with economic development. Hu (1935) first put forward the "Hu Huanyong Line", that is, the geographical distribution of China's population is divided into two basic difference areas, Southeast and Northwest, with the Heilongjiang-Tengchong line as the boundary. The area east of this line is home to 94.4% of the country's population, while the western half accounts for only 5.6% of the country's population. This line is not only the population line, but also the economic line and the ecological line, which has remained basically stable for

many years. Also the factor of economic development has an increasing impact on the spatial distribution of China's population. After the reform and opening-up, Hu Huanyong line of the Southeastern region of the population from a relatively balanced change to the Yangtze River Delta, Pearl River Delta and other places of agglomeration. Whereas the Northwest of the population distribution of the concentration trend is declining (Li et al., 2017).

Amongst them, the correlation amongst population, economy and environment of the 26 cities in the Yangtze River Delta urban agglomeration has gradually increased, with high-level coordinated cities such as Shanghai, Hangzhou and Nanjing as the core, leading to the improvement of the coordination level of the neighbouring cities. Also, the near-coastal cities are higher than the far-coastal cities, and the cities with a lower degree of coordination amongst population, economy and environment are faced with a lack of motivation for demographic and economic development (Xiao & Guo, 2021). There are differences in population mobility and its effect on economic growth in the Eastern, Central and Western regions, with the Eastern having a high net population inflow rate but only a median GDP growth rate, the Central having a largely negative net population inflow rate, and the Western having a stable net population inflow and contributing to GDP growth, but with a high degree of dispersion in the lower GDP growth rate (Yan et al., 2023).

Second, as China's population ages, the talent dividend will gradually replace the demographic dividend (Ma & Liu, 2022), and human capital will continue to accumulate, driving sustainable economic growth. In contrast to India's demographic and economic situation, China has achieved impressive economic growth over the past 40 years, with

population control policies being one of the major factors (Yunker, 2024). The labour factor contributes to China's economic development, and China's demographic dividend and education dividend are enhanced with the advancement of industrial advancedisation (Huang, 2024). However, China has entered an ageing society since 2000, and in 2022 the total population will be negative for the first time in nearly 61 years and officially enter a phase of rapid negative growth, and the demographic quantity dividend that has long driven economic growth is diminishing (Zhang & Zhang, 2024; Cai, 2020). China's population has experienced a new normal of sustained low fertility and demographic decline (Ma & Liu, 2022), and the demographic transition has a significant negative impact on economic growth (Zhang & Zhang, 2024). The key to nurturing the second demographic dividend is to improve and accumulate human capital for the future through the development of education and training, thereby increasing labour force participation and total factor productivity (Cai, 2020). Human capital is a driver that positively contributes to technology spillovers in the import trade channel and the FDI channel (Liu & Guo, 2019). R&D capital investment and R&D personnel investment can influence international technology spillovers in terms of innovation quality (Feng & Li, 2021).

Empirical results based on provincial panel data of 30 provinces, municipalities and autonomous regions in China from 2001 to 2022 show that population quantity-quality transition can promote economic growth, i.e., improved population quality mitigates the impact of declining population size on economic growth. Also, there is a significant positive effect of structural shift in population quality on economic growth, (Zhang & Zhang, 2024). The quality of the population usually refers to a combination of factors, such as the population's cultural quality, professional skills, and physical quality, which can affect a country's economic growth, innovation capacity and technology absorption

capacity. High-quality population development is a major event in China's economic development, and improving the overall quality of the population is a guarantee to support Chinese-style modernisation. It is necessary to stabilise the population growth rate while optimizing the industrial structure, and to promote the continuous improvement of educational human capital as well as the reasonable mobility of rural labour (Huang, 2024).

3.5 Econometric Approaches in Empirical Studies

The empirical studies on the effects of FDI and technology spillovers employs a range of econometric techniques, each with distinct strengths and limitations. Traditional studies frequently adopt panel data models, particularly Fixed Effects (FE) and Random Effects (RE) estimators. These methods are widely used to control for unobserved heterogeneity across provinces or firms (Baltagi, 2005; Hsiao, 2003). However, both studies do not account the spatial dependence which is an important omission when regional interactions and geographic spillovers are expected to play a significant role in influencing growth outcomes.

To address endogeneity, particularly dynamic endogeneity in growth models, many studies employ the Generalized Method of Moments (GMM), notably the difference and system GMM approaches developed by Arellano and Bond (1991) and Blundell and Bond (1998). These estimators are especially useful when dealing with reverse causality between FDI and growth or when lagged dependent variables are included. However, GMM is not without limitations; its effectiveness relies heavily on the validity of instruments, and weak instruments can lead to biased and inefficient estimates.

In recent years, spatial econometric models have gained attention with regards to growing awareness of spatial autocorrelation in regional economic data. The Spatial

Autoregressive (SAR) model incorporates spatial lags of the dependent variable to capture feedback effects from neighboring regions (Anselin, 1988; LeSage & Pace, 2009). The Spatial Error Model (SEM) instead focuses on spatial dependence in the error term (Anselin & Bera, 1998), which helps account for omitted spatially correlated factors. While both models improve upon non-spatial methods by recognizing spatial structure, they do not fully capture the complexity of spillover channels.

More advanced approaches such as the Spatial Durbin Model (SDM) include spatial lags of both dependent and independent variables, thereby allowing for the estimation of direct, indirect, and total effects simultaneously (LeSage & Pace, 2009; Elhorst, 2014). Despite its theoretical advantages, SDM remains underutilized in empirical FDI literature, particularly in studies attempting to model direct, indirect (moderated), and spatial effects within the same framework. Hence, this study adopts the dual approach which enables a more comprehensive analysis of the mechanisms through which FDI and technology spillovers both within and across regions contribute to China's economic growth by explicitly modelling spatial and indirect relationships.

3.6 Research Gaps

To highlight the key contributions of existing studies on FDI, technology spillovers, and economic growth; Table 3.1 provides a summary of representative empirical studies in terms of research context, methodological approach, principal findings, and key limitations. The table presents the past studies on horizontal versus vertical spillovers, regional and spatial effects, and sectoral variations. However, significant gaps remain. Notably, the mechanisms of spatial spillovers are still insufficiently explored, the moderating role of absorptive capacity lacks empirical testing, and the heterogeneous effects of FDI across China's regions remain poorly understood.

Table 3.1: Literature summary

Author	Year	Country/Region	Methodology	Key Findings	Limitations
Bobek et al.	2024	China & India	Panel regression with lags	FDI positively affects GDP in China, not in India	Mechanisms not fully explained
Zhang et al.	2024	266 prefecture-level cities in China	PLS-SEM structural equation modeling	FDI promotes high-quality development through innovation and green growth pathways	Regional heterogeneity exists; effects not significant in the western region
Han & Feng	2023	23 provinces in high-tech industries in China	Spatial panel regression model	Foreign R&D has significant positive spatial spillover effects on innovation performance	Innovation measured mainly by product innovation; lacks sectoral differentiation
Zhao	2024	Eastern, Central, and Western China	Fixed effects panel regression	FDI positively contributes to innovation-driven growth, more significant in Eastern China	Does not account for spillover effects on neighbouring regions
Li et al.	2023	China A-share listed firms	Supplier-customer network + FE regression	FDI enables inter-firm technology spillovers via supply chain links	Sample limited to listed firms; representative ness concerns
Chan et al.	2024	95 countries including China	Panel data + quantile regression	FDI significantly promotes technology transfer, with stronger effects in developing countries	Lacks in-depth exploration of China's internal spatial differences

Building upon the reviewed literature, this study's conceptual framework and variable selection are theoretically grounded and empirically justified. First, FDI and technology spillovers are introduced as core explanatory variables. FDI not only directly contributes to economic growth but also enhances total factor productivity through technology transfer, management practices, and capital accumulation (Globerman, 1979; Chan et al., 2024). Technology spillovers are captured using R&D indicators, which have been shown to play a critical moderating role in the absorption of foreign technologies (Moralles & Moreno, 2020). Second, trade openness is included as an enabling factor for cross-border knowledge flows and productivity improvements (Zamani & Tayeb, 2022; Chan, 2024). Third, government expenditure proxies institutional quality and state capacity in allocating public resources, potentially moderating the FDI-growth relationship (Hu & Yang, 2021). Finally, population is introduced as a structural control variable influencing both economic scale and FDI absorptive capacity (Ma & Liu, 2022). These variables are integrated into the empirical model in the subsequent chapter to systematically investigate the relationships between FDI, technology spillovers, and economic growth under spatial heterogeneity.

From a theoretical perspective, although a significant body of research has utilised exogenous and endogenous growth theories (Solow, 1956; Romer, 1990; Lucas, 1988) to explain the contribution of FDI to growth via technology spillovers, the role of regional heterogeneity remains underexplored. On this note, the dual circulation development paradigm, which represents a strategic shift from quantity-driven to innovation-led and quality-focused growth, remains largely absent from theoretical formulations. There is a notable lack of integrated frameworks that reflect how external openness interacts with internal innovation systems to support sustained development in the Chinese context. This

gap is especially critical given China's unique institutional environment and regionally diversified economic structure, which necessitate context-sensitive theoretical extensions.

From an empirical standpoint, several critical gaps also persist. First, there is a lack of studies that empirically examine the interaction between FDI and technology spillovers particularly those that assess how different levels of R&D capacity moderate the growth effects of FDI across regions. Second, spatial econometric models remain underutilised in the literature despite their ability to capture inter-regional spillovers and dependencies. Few studies fully exploit spatial weight matrices to measure the intensity and structure of spillovers across provinces, thereby limiting the accuracy of regional policy implications.

In summary, this study complements existing theoretical and empirical studies by considering whether the two core explanatory variables (FDI and technology spillovers) are correlated with the outcome variable (economic growth), respectively. It further incorporates trade openness, government expenditure and population as control variables to enhance the robustness of the analysis. Additionally, given the relative scarcity of literature investigating the moderating effect of FDI and technology spillover on China's economic growth, this study offers valuable insights by addressing endogeneity concerns, thereby providing a more nuanced understanding of their interactive impact.

CHAPTER 4

METHODOLOGY

4.1 Introduction

This chapter employs a methodological framework that consists of direct effects, indirect effects and spatial effects of FDI and technology spillover on economic growth in China. Chapter 4.1 is the introduction. Chapter 4.2 introduces the conceptual framework about the impact of FDI and technology spillover on economic growth in China. Chapter 4.3 shows relevant variables, such as FDI, technology spillover, trade openness, government expenditure and population, especially the interactive variable between FDI and technology spillover. Chapter 4.4 describes details of data collection. Chapter 4.5 illustrates the model estimation, including cross-sectional dependence, Augmented Mean Group estimator and spatial model analysis.

4.2 Conceptual Framework

As mentioned in the previous chapter, this study intends to formulate a model to explore the impact of FDI and technology spillover, to assess the direct and indirect effects of technology spillover and FDI on China's economic growth, and to analyse the spatial effects of FDI and technology spillover on China's economic growth. At the same time, there are macro-influencing factors as control variables in this study, namely, trade openness, government expenditure and population.

The study is grounded in the endogenous growth theory (Romer, 1990; Lucas, 1988), which emphasizes that long-term economic growth is driven by knowledge accumulation, innovation, and human capital. FDI contributes to growth not only directly,

by increasing capital formation, but also indirectly through technology transfer and productivity gains. The spillover effects occur through demonstration, competition, labor mobility, and backward–forward linkages. The theory also posits that these effects are heterogeneous, varying by absorptive capacity and regional conditions. This study also adopts interaction terms and spatial econometric techniques. Interaction terms help model how the effects of FDI on economic growth are moderated by technological absorptive capacity (e.g., R&D capital stock). Spatial econometric models capture interregional spillovers, consistent with the idea that regional growth is not independent but influenced by neighbouring regions (Fingleton & Le Gallo, 2008). Based on the review of past studies, the conceptual framework of this study has been developed as shown in Figure 4.1.

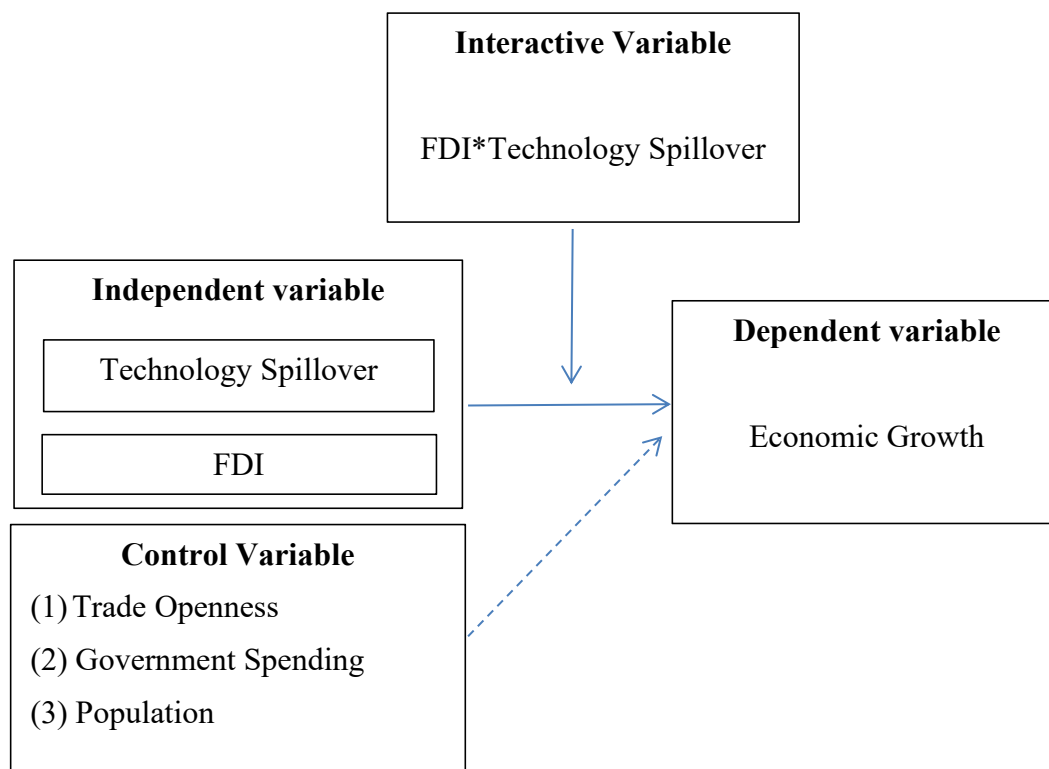


Figure 4.1: Conceptual framework

Figure 4.1 illustrates the conceptual framework linking FDI, technology spillover, and economic growth under China's dual circulation paradigm. FDI and R&D capital are central explanatory variables, with interaction terms capturing indirect effects and spatial lags capturing regional spillover effects. The framework is guided by the direct effects: FDI influences GDP through capital injection and production capacity expansion; indirect effects: FDI enhances productivity via technology spillovers, moderated by R&D; and spatial effects: economic activities in one region affect others through geographic proximity and policy diffusion.

Utilising the spatial Durbin fixed effects model with balanced panel data for the period 1992-2019, Otieno (2024) found that FDI, human capital and government expenditure have significant spatial effects on East African's economic growth, but with regional variations. Ebghaei and Akkoyunlu Wigley (2018) adopted panel data method to estimate the value-added and total factor productivity equations of Turkish manufacturing enterprises from 2003 to 2011, and the empirical results supported the role of exports in the transmission of FDI spillover effects. Morales and Moreno (2020) used a threshold regression model and when FDI was set as a threshold and institution-dependent variable, local firms in Brazil may suffer negative productivity spillovers unless their absorptive capacity was strong. Morita and Nguyen (2021) explored a model that combines quality-enhancing technology spillovers with the international duopoly model of vertical product differentiation, which shows that the matrix of technology spillovers carefully chooses the balance point between product quality and technology spillovers. Using the ARDL cointegration method, Sunde (2023) found that FDI, the interaction term of FDI and trade openness, and macroeconomic variables such as domestic investment, government consumption expenditures, and human capital drove Namibia's economic growth over the

period of 1990 to 2020. Hoang et al. (2021) proposed a logistic regression model to assess how FDI firms directly and indirectly affect the ability of Vietnamese firms to implement technological innovation.

Wang et al. (2019) incorporated two-way FDI into Romer's endogenous growth model and based on the international R&D spillover model, used the two-way FDI technology spillover data of China to OECD countries from 2006 to 2016 for quantitative verification of the theoretical model propositions. Morita and Nguyen (2021) explored a model that combines quality-enhanced technology spillover with an international duopoly model of vertical product differentiation, which shows that the parent of technology spillover carefully chooses the balance point between product quality and technology spillover. Feng and Li (2021) empirically studied the characteristics and channels of international technology spillovers that affect China's innovation quality. The conceptual framework shows that FDI and technology spillover have a significant relationship to China's economic development. Yue et al. (2024) found that FDI technology spillovers based on geographic proximity improve the innovation quality of non-state-owned enterprises and small and medium-sized enterprises in China through a bidirectional fixed-effects model utilising data on Chinese A-share listed firms for the period 2009-2019. Zhao et al., (2024) analysed of China's high-tech industry data from 2012 to 2021 by using the C-D production function and concluded that FDI has a technological spillover effect on the nation's high-tech industry. However, there is heterogeneity in the regions, and the coordinated development of the regional economy is yet to be resolved.

The basic endogenous driving force of economic development is based on technological innovation, and the driving force of technological development not only drives from domestic endogenous power, but also exists international channels, that is,

technology spillover brought by international capital flow. The technology spillover of international capital flows will generate exogenous innovation impetus, which will bring additional development impetus to the target country. This source of exogenous power complies with some basic principles of classical economy, industrial economy and international economy, and therefore has some inherent characteristics, which can be summarised as bidirectional, cluster and time-lag. Amongst them, clustering is based on the characteristics of micro-enterprises, which will not be repeated here, while symmetry is derived from the comparative advantages of various countries in the international economy at present, and the characteristics of technology spillover also have similar comparative advantages. Therefore, the economic and technological differences between the two countries cannot completely build a one-way technology investment and transmission, but a mutual influence. At the same time, the spillover effect has a time lag.

4.3 Description of Variables

4.3.1 Dependent Variable

With regard to the selection of the dependent variable, single or composite indicators can be selected for measurement from the perspective of economic growth. Common measures include GDP or its growth rate, GDP per capita or its growth rate, total factor productivity, or composite indicators. Considering the maturity of the established studies and the need for robustness of the model used in this paper, this study selected real GDP as the basic measure of economic growth and subsequent modelling. First, real GDP reflects the growth in the volume of output of all final goods and services in a country, synthesising the economy total volume, and is the most used indicator in economic research and policy analysis. Second, real GDP is measured in base-period prices, eliminating distortions caused by inflation or deflation, reflecting the real growth of the

economy, and is mainly used for vertical comparisons. Third, real GDP is easy to combine with other variables for the basic measure of real economic value added in different regions, facilitating cross-regional studies. In addition, this data is a core indicator released regularly by the China National Bureau of Statistics, and the data quality is high, which makes the conclusions of the study more generalisable and persuasive. Therefore, as compared to other indicators, real GDP is more intuitive and comprehensive and can meet the needs of this study.

4.3.2 Independent Variable

In terms of the independent variables design, research in the same field usually assumes that international capital flows will also lead to technological flows, and that such flows will be generated to a large extent through country-to-country direct capital investment (FDI). This capital-technology combination is very close to the definition of capital accumulation-technological efficiency in the Solow Growth Model. Therefore, it is therefore often defined as a technology spillover effect. China's economic growth cannot be separated from the impact of FDI and technology spillover in the long run. The main objective of this paper is the impact of FDI and technology spillovers on China's economic growth, so it mainly uses FDI and technology spillovers as the core explanatory variables.

FDI inflow is used as the core metric for FDI. FDI inflows directly reflect multinational enterprises' actual capital investment and technology transfer commitments, and are more effective than stock metrics, such as FDI stock, at capturing the impact of current economic activity. FDI inflows in China's provinces are directly influenced by local foreign investment policies, making them suitable for analysing policy effectiveness. This indicator aligns with international standards set by the OECD and UNCTAD, facilitating cross-provincial and cross-national comparisons.

R&D capital stock is used to measure technology spillovers. It transforms technological progress from an exogenous variable in the Solow model into a quantifiable indicator, and it is a key input in the knowledge production function, directly determining the potential for technology spillovers. In contrast, R&D flow indicators fail to reflect the long-term effects of knowledge accumulation, while human capital indicators focus on personnel quality but ignore the support of material bases such as R&D facilities for technology diffusion; the number of patents only captures explicit knowledge that has been patented, neglecting implicit technological spillovers such as equipment and processes. R&D capital stock is the only comprehensive indicator that can simultaneously quantify the scale of knowledge accumulation, the basis for technology absorption, and the potential for long-term spillovers. Specifically, the perpetual inventory method (PIM), assuming a 9.6% depreciation rate and using deflated R&D expenditure in 2010 constant prices is used as suggested by Hall and Mairesse (1995).

4.3.3 Interactive Variable

Furthermore, as for the aspect of FDI mechanism impact and its technology spillovers on GDP, the existence of such a mechanism may be affected by some other factors, which include the interaction of FDI and technology spillovers. Considering this issue, this study introduces interactive variables in the subsequent model design for analysis in order to carry out interactive effect analysis to draw more valid conclusions. This study aimed to assess the technology spillover effect and the indirect effect of FDI on China's economic growth.

The core purpose of constructing an interaction variable between FDI and technology spillover is to test the synergy effect between the two, that is, whether the

impact of FDI on economic growth depends on the technology spillover mechanism, or vice versa. In the context of China's domestic circulation driving international circulation, the interactive variable can quantify whether FDI generates a multiplier effect when the technology spillover conditions are mature. This interaction variable can solve the problem of omitted variable bias. If only FDI and technology spillover variables are included separately, it may overestimate or underestimate their independent effects, and ignore the actual dynamic interaction between the two.

A positive coefficient indicates that higher R&D enhances the productivity effect of FDI, consistent with absorptive capacity theory. A negative coefficient, conversely, would suggest diminishing returns or possible inefficiencies in translating foreign inputs into domestic productivity gains.

4.3.4 Control Variable

In terms of the macroeconomic control variables setting and exogenous conditions, this study mainly selects relevant variables such as trade openness, government expenditure and population. Trade openness, also known as foreign trade dependence, measures how much the amount of a country or region's import and export trade in a given year accounts for the total GDP of the country or region in that year. If trade openness is high, it indicates that the economy of the country or region has a high degree of dependence on foreign markets; conversely, it indicates a low degree of dependence. The main purpose of government expenditure is to maintain the healthy operation and effectiveness of the market, which is to use the visible hand to support the invisible hand, so it will promote or inhibit economic growth to varying degrees. Rostow (1960) divided economic development into six stages in his theory of stages of economic development,

and the structure and total amount of fiscal expenditures will vary with different stages of economic development. Population is the basis for economic growth, which in turn drives population growth at certain stages. The higher the economic level, the slower the rate of population growth tends to be. As a large population country, China continues to promote the optimisation and adjustment of its population structure and has basically achieved a shift in the pattern of population growth from the traditional type with a high rate of natural increase to the modern type with a low rate of natural increase.

4.4 Data Collection

This study focused on the direct effects, indirect effects and spatial effects of FDI and technology spillover on China's economic growth. Therefore, a quantitative analysis method and official secondary data were used. The sample is the balanced panel data of 30 mainland provinces (autonomous regions and municipalities directly under the Central Government, hereinafter referred to as provinces) in National Bureau of Statistics for the period from 2000 to 2022. Real FDI inflows by province were denominated in U.S. dollars as published by the China National Bureau of Statistics and converted into CNY according to the annual average exchange rate of CNY against the U.S. dollar for that year, and the GDP deflator was used to take into account the elimination of the impact of price level changes.

According to the provisions of the Foreign Investment Law, Hong Kong, Macao, and Taiwan are all parts of China. Therefore, investments from these regions are not considered as foreign investment. However, due to Hong Kong and Macao being separate customs territories and free ports, their investments in mainland China have consistently been treated as foreign capital in economic statistics. Similarly, investments from Taiwan in mainland China are governed by the Foreign Investment Law. To align with the current

statistical standards, the foreign investment data used in this study included investments from Hong Kong, Macao, and Taiwan in mainland China.

In addition, the samples were divided into three regions, namely Eastern, Central and Western regions, according to the Statistical Bulletin of FDI in China from Ministry of Commerce of China, based on geographic location. This division is consistent with China's 'Hu Huanyong Line' spatial economic pattern, reflecting systematic differences in resource endowments, policy preferences, and technology absorption capabilities between regions. New economic geography (Krugman, 1991) points out that development gaps between regions can lead to heterogeneous spillover effects, which is consistent with the findings of this study regarding the intensity gradient of FDI technology spillovers.

The reason for choosing China was that China was the largest developing country in the world, and China's development experience can provide reference for other developing countries. The latest study proved that FDI has a significant positive impact on the high-quality development of the economy (Xu, 2023). However, this study did not consider the impact of technology spillovers on the economy, nor did it consider regional differences. Therefore, it is necessary to systematically investigate the direct effects, indirect effects and spatial effects of FDI and technology spillovers on China's economic growth in the dual circulation new development paradigm. To sum up, this study obtained the variables shown in Table 4.1, and collected corresponding economic data from the relevant database of the China National Bureau of Statistics from 2000 to 2022 as follows:

Table 4.1: Variables and Data

Variable Properties	Variable Abbreviation	Indicator	Data Sources
Dependent Variable	GDP	Real GDP	Calculated according to China Statistical Yearbook
Independent Variable	FDI	Real FDI Inflow	Calculated according to China Statistical Yearbook
	TS	R&D Capital Stock	Calculated according to China Statistical Yearbook
Control Variable	Trade	Trade Openness	Calculated according to China Statistical Yearbook
	Gov	Real Government Expenditure	China Statistical Yearbook
	Pop	Population	China Statistical Yearbook

4.5 Model Estimation

The study employed the Augmented Mean Group (AMG) estimator, incorporating constant and trend terms, to account for heterogeneity and cross-sectional dependence. Cross-sectional dependence tests were performed to validate the AMG model suitability. The methodology is organised into model specification, data description, estimation procedure, and diagnostic tests.

4.5.1 Cross-sectional Dependence

In this study, cross-sectional dependency tests were first performed to determine if all units in the same cross-section were correlated prior to performing panel data analysis. In a well-specified balanced panel model, cross-section dependence tests were employed,

as confirmed by Husaini and Lean (2022) and Munir et al (2020). This study employed the Pesaran, Friedman and Frees tests (Pesaran, 2004; Friedman, 1937; Frees, 1995) to assess the presence of cross-sectional dependence. The null hypothesis asserts no cross-sectional dependence on the data.

H_0 : Data do not have cross-section problems.

H_1 : Data have cross-section problems.

If there is no cross-sectional dependence, the traditional panel data model, i.e., Fixed Effects Model or Random Effects Model, can be selected. Assuming that the individual effects of the cross-sectional units are fixed, then the Fixed Effects Model is chosen; Assuming that the individual effects are random variables, then the Random Effects Model is chosen. If there is cross-sectional dependence, then Augmented Mean Group (AMG) estimator is chosen, which is more suitable for analysing long-term equilibrium relationships and is applicable to balanced panel data with strong heterogeneity.

AMG is robust to cross-sectional dependence and slope heterogeneity, which are both relevant given China's provincial disparities. Compared to GMM, AMG avoids instrument proliferation and is well-suited to long panels with moderate N and T. Compared to PMG, AMG permits more heterogeneity, which aligns with regional variation in FDI and R&D spillovers. Compared to fixed effect models, AMG accommodates both cross-sectional dependence and heterogeneous dynamics. Compared to CCEMG (Common Correlated Effects Mean Group), AMG is better at capturing dynamic common factors while maintaining heterogeneous convergence paths, which is crucial for analysing

provincial spillover effects, as these are jointly determined by national reforms and local characteristics.

4.5.2 Augmented Mean Group (AMG) estimator

China's economic development cannot be separated from the direct impact of FDI and technology spillover. Sang (2019) and Sang (2021) argued that China has been actively absorbing FDI, utilising technology spillovers, benchmarking against high-standard international economic and trade rules and promoting the construction of a higher level of a new open economic system, which has boosted China's economic growth. In this study, the New Growth Theory (Romer, 1986) was used as the baseline theory and endogenous technological factors were introduced into the model. Endogenous technological not only has the attributes of ordinary goods but also has spillover effects and therefore is the fundamental source and driving force of sustained economic growth.

The underlying production function is:

$$Y = AK^{\alpha}L^{\beta} \quad \text{Equation (1)}$$

Where,

Y : Gross output.

A : Technology level.

K : Capital.

L : Labour.

α, β : output elasticity of capital and labour.

The first research objective of this study is to identify the direct impact of FDI and technology spillover on China's economic growth. Considering the effects of foreign trade

openness, government expenditure and the population's function to achieve objective one is as follows:

$$Y = A^{\lambda} K^{\alpha} L^{\beta} T^{\gamma} G^{\delta} \quad \text{Equation (2)}$$

Where,

T : Trade openness.

G : Government expenditure.

P : Population.

λ, α, β : Output elasticities of technology level, capital and labour.

The multiple regression linear Equation 3 is constructed as follows:

$$GDP_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 TS_{it} + \beta_3 Trade_{it} + \beta_4 Gov_{it} + \beta_5 Pop_{it} + \varepsilon_{it} \quad \text{Equation (3)}$$

Where,

GDP_{it} : Real GDP for province i in year t .

FDI_{it} : Real FDI inflow for province i in year t .

TS_{it} : Technology spillover for province i in year t .

$Trade_{it}$: Trade openness for province i in year t .

Gov_{it} : Real government expenditure for province i in year t .

Pop_{it} : Population for province i in year t .

ε_{it} : Error term for province i in year t .

α : intercept.

β : coefficient, marginal contribution of variables to GDP_{it} .

In this study, when measuring technology spillover, since there is no direct measurement of technology spillover in each country, the more popular perpetual inventory method (Zhang et al., 2004) is used, i.e., estimating the TS of each region at constant prices after a base year. This formula can be written as follows:

$$TS_{it} = TS_{it-1}(1 - \delta_{it}) + TSin_{it} \quad \text{Equation (4)}$$

Where, i refers to i th province, and t refers to t th year. Equation 4 contains two variables, TS input and TS, and one parameter, economic depreciation rate. The R&D capital stock in the base year is $RDcap$, and the new R&D input in each year is expressed by $TSin$ for the determination of the economic depreciation rate. The depreciation rate of 9.6% derived by Zhang et al. (2004) is adopted in this study.

Given that all the variables are in different units, they should be transformed into natural logarithmic form in order to achieve an optimal fit (Husaini et al., 2023). The variables in Equation 1 are transformed into natural logarithmic form, i.e., Equation 5.

$$\ln GDP_{it} = \alpha + \beta_1 \ln FDI_{it} + \beta_2 \ln TS_{it} + \beta_3 \ln Trade_{it} + \beta_4 \ln Gov_{it} + \beta_5 \ln Pop_{it} + \varepsilon_{it} \quad \text{Equation (5)}$$

This study aimed to assess the indirect effects of technology spillover and FDI on China's economic growth. Liu and Guo (2019) argued that certain drivers positively contribute to the technology spillovers from China's FDI channel, which in turn enhances its technological innovation capacity and its position in the global value chain. In order to achieve the second research objective, this study included an interactive variable, namely $FDI*TS$. In addition to the direct effect, FDI can influence China's economic growth through technology spillover. The coefficient of the interactive variable determines the

moderating role of technology spillover on FDI in affecting China's economic growth. This technique was also adopted by Husaini et al. (2023) and Husaini et al. (2024). Therefore, this study added the interactive variable between FDI and technology spillover in Equation 6 as follows:

$$GDP_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 TS_{it} + \beta_3 FDI * TS + \beta_4 Trade_{it} + \beta_5 Gov_{it} + \beta_6 Pop_{it} + \varepsilon_{it}$$

Equation (6)

Convert all the variables in Equation 6 into natural logarithmic form, i.e., Equation 7 below:

$$\ln GDP_{it} = \alpha + \beta_1 \ln FDI_{it} + \beta_2 \ln TS_{it} + \beta_3 \ln FDI * TS + \beta_4 \ln Trade_{it} + \beta_5 \ln Gov_{it} + \beta_6 \ln Pop_{it} + \varepsilon_{it}$$

Equation (7)

The sign of β_1 and β_3 is the key hypothesis of this study. First, if FDI is significant with negative sign and FDI_TS is significant with positive sign, this infers that FDI reduces economic growth, but technological spillover moderates this unfavourable impact. Foreign enterprises investing in host countries with the aim of profit maximisation can negatively affect the economy through profit repatriation to the home country, technological blockades, or the capture of local and foreign sales channels (Epor et al., 2024). However, technology spillovers can help local enterprises to introduce, absorb and transform into new technologies, enhance international competitiveness, thus moderating the negative impact of FDI on economic growth (Feng & Li, 2021).

Second, if both FDI and FDI_R&D are significant with negative sign, this suggests that FDI reduces economic growth and that technology spillover enhances this unfavourable effect. Foreign enterprises invest in host countries with the aim of maximising profits, which can reduce the dynamism of the host economy through profit

repatriation to the home country, technological blockades or market monopolies (Epor et al., 2024). Additionally, technological spillovers may in some cases reinforce the adverse effects of FDI on economic growth. In particular, when a few foreign enterprises monopolise high technology or market channels, local enterprises find it difficult to absorb the spillovers, which in turn widens the technological gap and innovation capacity and leads to a continuous loss of viability (Hoang et al., 2022).

Third, if both FDI and FDI_TS are significant with positive sign, it indicates that FDI drives economic growth and technology spillover enhances this favourable effect. FDI brings capital, advanced technology, management experience, and export channels to the host country, which directly contributes to productivity enhancement and industrial upgrading, and thus promotes the host country's economic growth (Zhang, 2024). This is typical investment-driven economic growth. The positive impact of FDI on economic growth is further enhanced by the fact that local firms fully absorb technology spillovers through imitation, demonstration, competition and talent flow to improve their innovation capacity and international competitiveness (Yue et al., 2024). FDI and technology spillover interact with each other to optimise the allocation of resources, forming a virtuous circle.

Fourth, if FDI is significant with positive sign, but FDI_R&D is significant with negative sign, this infers that FDI promotes economic growth, but technology spillover reduces this favourable effect. FDI brings capital, technology, management experience and export channels to the host country, and therefore promotes host country economic growth (Zhao, 2024; Feng & Li, 2021). However, through patent protection, technological blockade and monopolisation of high-end talents, foreign-invested enterprises make it difficult for local enterprises to obtain effective spillover technologies and continuously

lose their survival space, thus weakening the positive contribution of FDI to the economy (Epor et al., 2024; Hoang et al., 2022).

4.5.3 Spatial Model Analysis

Rüttenauer (2024) found that considering potential spatial dependencies helped to avoid biased inferential statistics and biased point estimates. Since the analysis of ordinary regression results may miss geospatial and locational factors that can have a large impact, corresponding assumptions should be established to add spatial factors to the spatial measurement model. The essence of spatial measurement is the logic of the model constructed with statistical tests and regression analysis. In spatial econometrics, spatial effects are characterised by two key features: spatial dependence and spatial heterogeneity. Spatial dependence means that spatial data from different regions may be dependent on each other, and spatial heterogeneity means that spatial data from different regions may have different dependencies.

The third objective of this study aimed to analyse the spatial effects of foreign direct investment and technology spillover on China's economic growth. Liu and Guo (2019), through an empirical analysis of China's spatio-temporal evolution, argued that FDI technology spillovers exhibit a clear intra-regional agglomeration effect, with the Eastern region being a high-efficiency spillover area, the Central region being a middle-spillover area, and the Western region being an inefficiency spillover area. Feng and Li (2021) suggested that technology spillovers differ in Eastern, Central and Western regions in China, and Gao et al. (2023) suggested that the relationship between FDI on economic development in Eastern, Central and Western regions is inconsistent. There may be geospatial correlations between FDI and technology spillovers in different regions. FDI directly affects economic growth through abundant capital, high technology and advanced

management experience, while technology spillovers indirectly affect economic growth through channels such as imitation and demonstration, competition and personnel mobility. There may be regional agglomeration effects of FDI and technology spillovers, leading to spatial heterogeneity. Also, spatial effects make it possible for neighbouring regions to influence each other through factor flows and knowledge diffusion. Therefore, failure to consider the dependence and heterogeneity of FDI and technology spillovers on the economic development of different Chinese regions may lead to biased measurement results.

In order to accurately examine the spatial effects of FDI and technology spillover on China's economic growth, this study constructed a spatial econometric model to capture the spatial correlation between regions. Spatial econometric models mainly adopt spatial lag model, spatial error model and spatial Durbin model. The spatial lag model is applicable to the existence of spatial correlation of the dependent variable and the research of spatial spillover effect of the dependent variable. If there is spatial interdependence of the dependent variables, i.e., the economic growth of one region is directly related to the growth of neighbouring regions, then the spatial lag model is constructed. The following is Equation (8):

$$GDP_{it} = \rho WGDP_{it} + \beta_i X_{it} + \varepsilon_{it} \quad \text{Equation (8)}$$

Where, ρ is spatial autoregressive coefficient of the dependent variable, measuring the effect of spatial lag term $WGDP_{it}$ on GDP_{it} ; W is 30x30 spatial distance weight matrix; β_i is regression coefficient, X_{it} is independent variables of FDI, technology spillover, trade openness, government expenditure and population in year t of province i ; β_i is the corresponding regression coefficient, and ε_{it} is error term. Convert the variables in Equation 8 to natural logarithmic form, i.e., Equation 9 as shown below:

$$\ln GDP_{it} = \rho W \ln GDP_{it} + \beta_0 + \beta_1 \ln FDI_{it} + \beta_2 \ln TS_{it} + \beta_3 \ln Trade_{it} + \beta_4 \ln Gov_{it} + \beta_5 \ln Pop_{it} + \varepsilon_{it} \quad \text{Equation (9)}$$

Spatial error modelling is applied to the presence of spatial correlation in the error terms, controlling for unobserved spatial effects interfering with the relationship between the independent and dependent variables, rather than direct spatial interactions between the dependent or independent variables. In order to exclude the interference of unobserved spatial effects on the estimation results, to accurately explain the direct influence of the independent variables on the dependent variable, and to ensure that the results are robust and factual, a spatial error model is developed, i.e., Equation 10 and Equation 11:

$$GDP_{it} = \beta_0 + \beta_1 X_{it} + \mu_{it} \quad \text{Equation (10)}$$

$$\mu_{it} = \theta W \mu_{it} + \varepsilon_{it} \quad \text{Equation (11)}$$

Where, μ_{it} is error term; θ is spatial error coefficient, used to judge the impact of the error term on GDP_{it} ; W is spatial weight matrix. If there is spatial dependence in the error term, this proves that there are omitted variables or unobservable random errors present and spatially correlated. The variables in Equation 10 are transformed into natural logarithmic forms as following Equation 12:

$$\ln GDP_{it} = \beta_0 + \beta_1 \ln FDI_{it} + \beta_2 \ln TS_{it} + \beta_3 \ln Trade_{it} + \beta_4 \ln Gov_{it} + \beta_5 \ln Pop_{it} + \mu_{it} \quad \text{Equation (12)}$$

If both the dependent variable and the error term show significant spatial correlation, then the spatial lag model or the spatial error model cannot fully reveal the underlying logic of the spatial effect. On the other hand, the spatial Durbin model captures both models and is suitable for analysing the combined spatial interactions of dependent and independent variables. This model helps to better capture spatial autocorrelation in the

data, both by considering the presence of spatial dependence in the dependent variable and by examining the presence of spatial spillover effects in the independent variable. In other words, the spatial Durbin model can analyse how the economic growth of a region is affected by the economic growth of neighbouring regions, and how independent variables such as FDI and technological spillover in a region affect the economic growth of neighbouring regions through spillover. If the economic growth of a region is influenced not only by the economies of neighbouring regions, but also by the independent variables of neighbouring regions, a spatial Durbin model can be developed, i.e., Equation 13:

$$RGDP_{it} = \rho W GDP_{it} + \beta_i X_{it} + \theta W X_{it} + \varepsilon_{it} \quad \text{Equation (13)}$$

Convert the variables in Equation 13 to natural logarithmic form, i.e., Equation 14 below:

$$\begin{aligned} \ln GDP_{it} = & \rho W \ln GDP_{it} + \\ & \beta_0 + \beta_1 \ln FDI_{it} + \beta_2 \ln TS_{it} + \beta_3 \ln Trade_{it} + \beta_4 \ln Gov_{it} + \beta_5 \ln Pop_{it} + \\ & \theta_0 + \theta_1 W \ln FDI_{it} + \theta_2 W \ln TS_{it} + \theta_3 W \ln Trade_{it} + \theta_4 W \ln Gov_{it} + \theta_5 W \ln Pop_{it} + \varepsilon_{it} \end{aligned} \quad \text{Equation (14)}$$

The spatial Durbin model can degenerate into a spatial lag model or a spatial error model. If the spatial lag coefficient of the dependent variable is 0 ($\rho=0$) and the error term is spatially correlated, the spatial Durbin model degenerates into a spatial lag model. If the coefficient of the spatial lag term of the independent variable is 0 ($\theta=0$), the spatial Durbin model degenerates to a spatial error model. In multi-model comparisons, the lower of the Akaike Information Criterion values for the spatial lag model, the spatial error model, or the spatial Durbin model is the most appropriate to be selected.

This study employs an inverse distance-based spatial weight matrix (W) to capture the geographical interdependence among provinces. Specifically, the weights are calculated as the inverse of the geographic distance between the centroids of each pair of provinces, under the rationale that spatial proximity increases the likelihood of economic interaction. Provinces closer in distance are assumed to have stronger spillover effects in terms of foreign direct investment (FDI), technology diffusion, and economic growth. To ensure comparability across units, the matrix is row-normalised so that the sum of each row equals one. This allows the interpretation of spatial lags as weighted averages of neighbouring regions' values. The choice of inverse distance-based weighting is theoretically consistent with studies of regional diffusion (LeSage & Pace, 2009), and empirically suitable for examining spatial externalities in the Chinese context.

To confirm the relevance of including spatial dynamics, Moran's I statistics are computed for key variables such as GDP growth, FDI, and R&D capital. The significant and positive values obtained provide strong evidence of spatial autocorrelation, justifying the use of spatial econometric models in this study. Spatial model selection is now supported by both theoretical and empirical criteria. SLM is preferred not only due to AIC and LM tests but also because it captures both endogenous and exogenous spatial effects, consistent with the study's emphasis on FDI spillovers across provinces.

While this study acknowledges the importance of addressing econometric issues such as endogeneity, heteroskedasticity, autocorrelation, multicollinearity, and stationarity, the diagnostic test results are explicitly not presented in detail to maintain the focus on the structural and spatial econometric strategy. The use of the Spatial Lag Model (SLM) and the Augmented Mean Group (AMG) estimator already incorporates several key controls

that address these concerns. Specifically, the AMG estimator, as developed by Eberhardt and Teal (2010), allows for heterogeneous slope coefficients across cross-sectional units and effectively corrects for cross-sectional dependence and unobserved common factors, which are common sources of bias in panel data analysis. Similarly, the SDM, as outlined by LeSage and Pace (2009), directly accounts for spatial dependence and spillover effects, enabling accurate estimation of both direct and indirect influences of FDI and technology spillovers. However, SLM has better AIC and R-squared results, which is better to explain the dataset. Future extensions of this research could incorporate a more extensive robustness framework to facilitate replication and cross-country comparisons.

4.5.4 Interpretation of Coefficients

In spatial econometric models such as the Spatial Durbin Model (SDM), the interpretation of coefficients extends beyond simple direct relationships and includes spatial and interactive effects. This section explains the meaning of each key coefficient in the context of the current study, focusing on how FDI and technology spillovers influence regional economic growth.

Direct Effect:

The coefficient on FDI in the baseline model represents the direct impact of foreign direct investment on the economic growth of a province. A positive and statistically significant coefficient suggests that higher FDI inflows directly contribute to GDP growth within the province receiving the investment. This aligns with traditional endogenous growth theory, where capital inflows facilitate capital deepening, technological upgrading, and productivity gains.

Interactive Term:

The interaction term between FDI and R&D captures how the effectiveness of FDI depends on the level of local technological absorptive capacity. If the coefficient of this interaction term is positive and statistically significant, it implies that regions with higher R&D stocks are better positioned to leverage the benefits of FDI, thereby achieving greater economic gains. Conversely, a negative or insignificant coefficient would indicate that local innovation infrastructure does not significantly condition the impact of FDI.

Spatial Lag of the Dependent Variable (ρ):

The spatial autoregressive parameter ρ reflects the degree of spatial dependence in regional economic growth. A positive and significant ρ implies that GDP growth in one region is positively influenced by growth in its neighbouring regions indicating regional spillover effects or economic clustering. A negative value would suggest competitive or divergent regional dynamics.

Spillover Effects (θ Parameters):

The SDM includes spatial lags of independent variables such as FDI and R&D. θ parameters quantify how a unit change in neighboring regions' independent variables (e.g., FDI, R&D) affects the dependent variable (e.g., GDP growth) in the focal region, holding local conditions constant. Positive θ would represent that one province will affect neighbouring province by positive spillovers and knowledge diffusion. Negative θ would suggest that one province has competition or crowding-out effect and technology hoarding to neighbouring province.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

The main investigation of the relationship between foreign direct investment (FDI), R&D capital stock and economic growth in China are discussed in this chapter. Chapter 5 included five sections to discuss the investigation findings. First, Chapter 5.1 discusses the introduction. Second, Chapter 5.2 provides descriptive results. Third, Chapter 5.3 presents empirical results. Fourth, Chapter 5.4 discusses the results. Lastly, Chapter 5.5 illustrates a remark of this chapter.

This study's general objective is to investigate the direct effects of FDI and technology spillover on China's economic growth. Then, this study evaluated the indirect effects of FDI and technology spillover on China's economic growth. Thirdly, this study conducted analysis on the spatial effects of FDI and technology spillover on China's economic growth. This study collected 30 provinces data from China Statistical Yearbook of the National Bureau of Statistics from 2000 to 2022. Also, Stata software version 17 was used to generate descriptive statistics, cross-sectional dependence test, Augmented Mean Group estimator, Lagrange Multiplier test and Spatial Lag Model for the analysis.

5.2 Descriptive Statistics

Descriptive statistics provide a systematic approach for analysing datasets, enabling the identification of their key characteristics. This study employed STATA software to compute the mean, standard deviation, and extreme values of the dataset. In the summary of descriptive statistics, real GDP is designed as the dependent variable, while real FDI and

R&D capital stock serve as independent variables. Trade openness, real government expenditure, and population were included as control variables. To address partial heteroskedasticity and enhance data smoothness, natural logarithmic transformations were applied to all variables, as detailed in Table 5.1. Table 5.1 consists of 690 observations from 30 provinces across mainland China over a 23-year span (2000-2022).

Table 5.1: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max	Observations
GDP	8.8849	1.0863	5.5748	11.291	690
FDI	7.7756	1.5622	3.8662	12.218	690
R&D	5.7556	1.8065	-0.1627	9.7019	690
Trade	-1.7133	0.9885	-4.8761	0.5372	690
Gov	7.2661	1.0366	4.1082	9.3501	690
Pop	8.1699	0.7558	6.2480	9.4481	690

Note: GDP represents log of real gross domestic product; FDI represents log of real foreign direct investment; R&D represents log of research and development capital stock; Trade represents log of trade openness; Gov represents log of real government expenditure; Pop represents log of population.

Real GDP was selected as the dependent variable to represent economic growth. The values of real GDP ranged from 5.5748 to 11.291 with a mean value of 8.8849. Additionally, the standard deviation provides an indication of the dispersion of the dataset around its mean; a higher standard deviation reflects greater variability within the data. The observed standard deviation of 1.0863 suggesting a degree of heterogeneity in the economic growth patterns across China.

Real FDI and research and development (R&D) capital stocks serve as the independent variables and primary explanatory factors in this analysis. Economic growth is

often sustained by external capital support, with FDI playing a crucial role in China's development. To control for inflationary effects, China's FDI inflows have been log-transformed. The minimum and maximum log value of China's FDI inflows is 3.8662 and 12.218, respectively, with a mean of 7.7756 and a standard deviation of 1.5622, indicating a notable level of heterogeneity. Long-term economic growth is largely driven by technological advancements, represented in this study by R&D capital stock. The values of R&D capital stock range from -0.1627 to 9.7019, with a mean of 5.7556 and a standard deviation is 1.8065, further demonstrating substantial heterogeneity in technological investment across regions.

This study also incorporated trade openness, real government expenditure, and population as control variables, each transformed using natural logarithms. Trade openness is defined as the ratio of total imports and exports to GDP, offering insight into China's engagement in international trade and its potential correlation with economic growth. The values for trade openness range from -4.8761 to 0.5372, with a mean of -1.7133 and a standard deviation of 0.9885. Notably, this mean is lower than the standard deviation, diverging from several scholars' findings on China's openness in specific sectors and with certain Asian countries. Real government expenditure, theoretically a driver of economic growth, has been adjusted for inflation and log-transformed. It ranges between 4.1082 and 9.3501, with a mean of 7.2661 and a standard deviation of 1.0366. Population is also a key factor influencing economic growth, and in this study, its log-transformed values range between 6.2480 and 9.4481. The mean value of 8.1699 exceeds the standard deviation of 0.7558.

5.3 Empirical Results

5.3.1 Cross-Sectional Dependence Test

Table 5.2: Cross-sectional dependence test

CSD Test	Random Effect	Fixed Effect
Pesaran (2004)	24.207***	28.111***
Friedman (1937)	155.232***	171.833***
Frees (1995)	4.679***	4.890***

Note: ***, ** and * represents significance at the 1%, 5% and 10% significance levels, respectively

Table 5.2 presents the results of cross-sectional dependence test, which is utilised to detect interdependencies amongst observations in cross-sectional data. However, as indicated in Table 5.2, the results revealed significance levels below 1% for both random and fixed effects across the six variables, leading to a rejection of the null hypothesis. The finding confirmed the presence of cross-sectional dependence within the panel dataset. Such dependence introduces the risk of pseudo-regression, whereby the model may suggest spurious relationships that do not reflect true associations amongst the variables.

Given the detected cross-sectional dependence amongst observations, this study adopted the Augmented Mean Group (AMG) estimator as an appropriate methodological approach. The AMG estimator provides robust estimates in panel data models exhibiting cross-sectional dependence, as it effectively manages heterogeneity and accounts for cross-sectional dependencies through common factors, yielding more reliable parameter estimates. Unlike traditional estimation methods, the AMG estimator is particularly advantageous when cross-sectional units exhibit interdependence.

Additionally, the analysis included the Common Correlated Effects Mean Group (CCEMG) estimator, with comprehensive results available in Appendix 1. Overall, AMG demonstrates superior performance and yields more consistent outcomes. Accordingly, this study proceeded with the AMG estimator in the subsequent analyses.

5.3.2 The Augmented Mean Group Results for Direct Effects

Table 5.3 presents the direct and indirect effects of FDI and technology spillovers on China's economic growth, as estimated using the AMG estimator (Eberhardt & Bond, 2009; Eberhardt & Teal, 2010).

Table 5.3: Full sample for direct model (AMG)

Variable	Constant	Constant and Trend
FDI	-0.0016	-0.0015
TS	0.1091***	0.1177***
Trade	-0.0045	-0.0035
Gov	0.0387***	0.0363***
Pop	0.1656	0.0969

Note: FDI represents log of real foreign direct investment; R&D represents log of research and development capital stock; Trade represents log of trade openness; Gov represents log of real government expenditure; Pop represents log of population.

***, ** and * represents significance at the 1%, 5% and 10% significance levels, respectively

First, the direct effects of each variable were analysed. The coefficients of both R&D capital stock and real government expenditure on real GDP were significant and positive at 1% significance level in the direct model with a constant term. This finding indicated that technology spillover and real government expenditure played significant and positive roles in driving economic growth. Conversely, the explanatory variable real FDI and the control variable trade openness were both insignificant and negatively associated

with real GDP in the direct model with a constant term. This suggested that real FDI and trade openness may not substantially contribute to economic growth and may, in fact, exerted a slight negative effect. Additionally, while the control variable population is positive, it is not significant in the direct model with a constant term, indicating a potential positive, albeit non-significant, influence on economic growth.

In the direct model with both constant and trend terms, similar results were observed. Technology spillover and real government expenditure remained significant and positively associated with real GDP, supporting the view that technology spillover and government expenditure promoting China's economic growth. In contrast, real FDI and trade openness continue to be insignificant with negative coefficients, suggesting a potential dampening effect on growth. Population, while positive, remained insignificant, indicating a possible but unsubstantiated positive effect on economic growth.

Thus, following the *ceteris paribus* assumption, the results from the direct model with a constant can be interpreted as follows: 1% increase in technology spillover is associated with 0.11% increase in real GDP, holding other variables constant. Similarly, 1% increase in real government expenditure corresponds to 0.04% increase in real GDP, again while controlling other factors. In the direct model incorporating both constant and trend terms, the interpretations remain consistent: 1% increase in technology spillover results in 0.12% increase in real GDP, while 1% increase in real government expenditure yields 0.04% increase in real GDP, with all other variables held constant.

5.3.3 The Augmented Mean Group Results for Direct Effect by Region

Table 5.4 reports the direct effects between FDI, technology spillover and China's economic growth by Eastern, Central and Western regions by using Augmented Mean

Group estimator (Eberhardt & Bond, 2009; Eberhardt & Teal, 2010) with constant as well as constant and trend.

Table 5.4: Direct model by region (AMG)

Variable	Model	Eastern Region	Central Region	Western Region
FDI	Constant	0.0013	-0.0100	0.004
	Constant and Trend	0.0033	-0.0133	-0.0095
TS	Constant	0.3820***	0.2016***	0.2302***
	Constant and Trend	0.3648***	0.1911***	0.2258***
Trade	Constant	0.0108	-0.0042	-0.0046
	Constant and Trend	0.0224*	0.0026	-0.0110**
Gov	Constant	0.0548**	0.052	0.0732**
	Constant and Trend	0.0497***	0.0396***	0.0561**
Pop	Constant	0.3460*	-0.3173	1.0000***
	Constant and Trend	0.2463	-0.087	0.6052**

Note: ***, ** and * represents significance at the 1%, 5% and 10% significance levels, respectively

5.3.3.1 Eastern Region

Table 5.4 presents the results for the Eastern region of China. The direct model indicated that both real FDI and technology spillover exerted a direct effect on real GDP in this region. Specifically, the coefficients for technology spillover, real government expenditure, and population are significant and positively associated with real GDP in the direct model with a constant term. Conversely, while the coefficients for real FDI and trade

openness are positive, they are not statistically significant in the direct model with a constant.

In the direct model that included both constant and trend terms, the coefficients for technology spillover, trade openness, and government expenditure remained significant and positively correlated with real GDP at 1% significance level. However, the coefficients for real FDI and population continue to be positive but not significant in this model.

These findings suggested that technology spillovers and government expenditure significantly and positively contributed to real GDP in both the direct model with a constant and in the model with both constant and trend. Furthermore, the results indicated that technology spillovers have a markedly greater positive impact on real GDP as compared to real government expenditure.

Ultimately, the analysis revealed that while both population and trade openness have positive contributions to real GDP, the effects of technology spillovers and government expenditure in the Eastern region exhibited greater magnitudes as compared to the full sample. In brief, the results in Table 5.4 indicated that the positive effects of these variables are considerably enhanced in the Eastern region relative to the broader sample.

Based on the *ceteris paribus* assumption, this study interpreted the results from the direct model for the Eastern region as follows: 1% increase in technology spillover is associated with 0.38% increase in real GDP, holding other variables constant. Similarly, 1% increase in real government expenditure leads to 0.05% increase in real GDP, while 1% increase in population corresponds to 0.35% increase in real GDP, with other variables held constant.

In the direct model that incorporated both constant and trend terms for the Eastern region, the interpretations are as follows: 1% increase in technology spillover results in 0.36% increase in real GDP, while 1% increase in trade openness leads to 0.02% increase in real GDP, and 1% increase in real government expenditure again yields 0.05% increase in real GDP, all else being equal.

5.3.3.2 Central Region

Table 5.4 presents the results for the direct and indirect models pertaining to the Central region of China. Initially, the direct model assesses the direct effects of real FDI and technology spillovers on economic growth in this region. The coefficient for technology spillovers is both positive and statistically significant at 1% level in the direct model with a constant term. This finding indicated that this core explanatory variable has a significant and positive effect on economic growth. In contrast, the coefficients for real FDI, trade openness, and population are not statistically significant and are associated with negative signs in the direct model with a constant. Furthermore, the coefficient for real government expenditure is also not significant, albeit positive, in this model. Consequently, there is insufficient evidence to support the notion that these variables significantly contributed to economic growth.

In the direct model that included both constant and trend terms, the coefficients for technology spillover and real government expenditure remained significant at 1% level and exhibited positive signs. This suggested that both technology spillovers and government expenditure played a role in promoting economic growth. However, the coefficients for real FDI and population remained not significant and negative, while the coefficient for trade openness is positive but also not statistically significant in the direct model with

constant and trend. Thus, there is again insufficient evidence to confirm that these variables contributed to economic growth

In summary, the results for the Central region are consistent with those of the full sample regarding the direct model. However, the positive impact of technology spillovers on economic growth in the Central region is stronger than that observed in the full sample, though weaker than the effects found in the Eastern region.

According to the *ceteris paribus* assumption, the results for the direct model pertaining to the Central region are interpreted as follows: 1% increase in technology spillover is associated with 0.20% increase in real GDP, holding other variables constant. Similarly, in the direct model that incorporates both constant and trend terms, 1% increase in technology spillover leads to 0.19% increase in real GDP, while 1% increase in real government expenditure results in 0.04% increase in real GDP, with other variables held constant.

5.3.3.3 Western Region

Table 5.4 presents the results of both the direct and indirect models for the Western region of China. In the direct model with a constant term, the coefficients for technology spillover, real government expenditure, and population are all positive and significant. Specifically, technology spillovers and population are significant at 1% level, while real government expenditure is significant at 5% level. These findings indicated that technology spillovers, government expenditure, and population size significantly and positively contributed to economic growth, with population exerting a stronger influence on economic growth than either technology spillover or government expenditure.

Conversely, technology spillovers are not significant but positive, and trade openness is insignificant with a negative coefficient in the indirect model with a constant term. This suggested that real FDI and trade openness do not significantly affect real GDP. In other words, there is no empirical evidence to support the notion that these two variables drive economic growth.

In the direct model with both constant and trend terms, the coefficients for technology spillover, real government expenditure, and population remained positive and significant. However, trade openness exhibited a significant negative coefficient at 5% level. This indicated that while technology spillovers, government expenditure, and population significantly and positively contribute to economic growth, trade openness has a detrimental effect on growth in this model. Additionally, the coefficient for real FDI is insignificant but positive, suggesting a lack of evidence supporting the claim that real FDI contributes to economic growth in the Western region.

Thus, the conclusions drawn from both the direct model with a constant term and the direct model with constant and trend terms are largely consistent, reaffirming the significance of technology spillovers, government expenditure, and population in driving economic growth while highlighting the limited role of real FDI and the negative impact of trade openness.

According to the *ceteris paribus* assumption, the results for the direct model in the Western region can be interpreted as follows: 1% increase in technology spillover is associated with 0.23% increase in real GDP, holding all other variables constant; 1% increase in real government expenditure results in 0.07% increase in real GDP, again holding other variables constant; and 1% increase in population leads to a significant 1% increase in real GDP, while controlling for other factors. In the direct model with both

constant and trend terms, the interpretations remain similar: 1% increase in technology spillover yields 0.23% increase in real GDP; 1% increase in trade openness correlates with 0.01% decrease in real GDP; 1% increase in real government expenditure results in 0.06% increase in real GDP; and 1% increase in population leads to 0.61% increase in real GDP, holding other variables constant.

The results, as a comparison to the full sample, the Western region exhibited a consistent positive direct effect of technology spillovers and real government expenditure on economic growth, with a more pronounced impact than observed in the overall sample. Moreover, the Western region demonstrated a significant and positive effect of population on economic growth, a relationship that is not significant in the full sample. This suggested that both technology spillovers and real government expenditure exerted a stronger positive influence on economic growth in the Western region than in either the mainland or Central region, underscoring the critical role of population in driving economic growth within the Western context. Furthermore, while both the Eastern and Western regions display a positive correlation between technology spillovers and real government expenditure, the impact of technology spillovers on real GDP is greater in the Western region compared to the Central region yet remains weaker than that observed in the Eastern region.

5.3.4 The Augmented Mean Group Results for Indirect Effects

Interactive term can capture complex relationships between variables and increase the ability to explain variation in the dependent variable, thus improving the model's goodness-of-fit. The indirect effects illustrate the indirect role of technology spillover on the relationship between real FDI and real GDP. The results indicated that the coefficient for the interactive term (FDI_TS) on real GDP is positive but not statistically significant.

This suggested that the interaction between FDI and technology spillover did not significantly contribute to China's economic growth.

Table 5.5: Full sample for indirect model (AMG)

Variable	Constant	Constant and Trend
FDI	-0.0314**	-0.0269
TS	0.0992***	0.1275***
FDI_TS	0.0251	0.0286
Trade	-0.0060	-0.0072
Gov	0.0401***	0.0349***
Pop	0.0743	-0.0101

Note: FDI represents log of real foreign direct investment; R&D represents log of research and development capital stock; FDI_R&D represents the interaction term between FDI and R&D; Trade represents log of trade openness; Gov represents log of real government expenditure; Pop represents log of population.

***, ** and * represents significance at the 1%, 5% and 10% significance levels, respectively

5.3.5 The Augmented Mean Group Results for Indirect Effect by Region

Table 5.6 reports the indirect effects between FDI, technology spillover and China's economic growth by Eastern, Central and Western regions using Augmented Mean Group estimator (Eberhardt & Bond, 2009; Eberhardt & Teal, 2010) with constant as well as constant and trend.

Table 5.6: Indirect model by region (AMG)

Variable	Model	Eastern Region	Central Region	Western Region
FDI	Constant	-0.129	-0.0649**	-0.0245
	Constant and Trend	0.1943	-0.0582**	-0.0245
TS	Constant	0.2383	0.1361***	0.2066***
	Constant and Trend	0.5453*	0.1406***	0.2109***

Table 5.6 continued

FDI_TS	Constant	0.1382	0.0818***	0.0552**
	Constant and Trend	-0.1748	0.0611***	0.0365
Trade	Constant	0.0174***	-0.0065	-0.008
	Constant and Trend	0.0218**	0.0025	-0.0141***
Gov	Constant	0.0424*	0.0369*	0.0708***
	Constant and Trend	0.0496***	0.0299***	0.0613**
Pop	Constant	0.1906	-0.2182***	0.7917*
	Constant and Trend	0.045	-0.0245	0.4559

Note: ***, ** and * represents significance at the 1%, 5% and 10% significance levels, respectively

5.3.5.1 Eastern Region

Furthermore, the indirect model assesses the indirect effects of the interaction between technology spillover and real FDI on real GDP in the Eastern region. The results indicated that the coefficient for the interaction term (FDI_TS) is positive but not statistically significant. This finding suggested that real FDI and technology spillovers do not significantly interact, implying that neither factor substantially drives real GDP.

In summary, the results provided insufficient statistical evidence to support the notion that real FDI and technology spillovers interact to influence real GDP. Consequently, this study concluded that the findings for the Eastern region aligned with those of the full sample presented in Table 5.3, demonstrating no evidence of interaction between real FDI and technology spillovers on real GDP.

5.3.5.2 Central Region

Furthermore, the indirect model reveals the presence of an interaction effect between the two core explanatory variables on the dependent variable in the Central region. Specifically, the coefficient for real FDI is significant at 5% level and exhibited a negative sign, while the coefficient for technology spillover is significant at 1% level and is positive in the indirect model with a constant term. These results indicated that real FDI negatively impacted real GDP in the Central region, whereas technology spillovers positively influenced real GDP. The coefficient for the interaction term (FDI_TS) is positive and significant at 1% level, suggesting that an increase in technology spillovers mitigates the negative impact of real FDI on real GDP. This finding indicated a significant interaction between real FDI and technology spillovers in promoting real GDP, thereby demonstrating that technology spillovers moderate the adverse effects of real FDI on economic growth.

In the indirect model that included both constant and trend terms, the coefficients for real FDI and R&D capital stock remained significant but exhibited opposite signs. Additionally, the coefficient for the interaction variable (FDI_TS) is significant and positive. The results from this model mirrored those of the model with a constant, reinforcing the presence of a moderating effect of technology spillovers on the relationship between real FDI and real GDP in the Central region.

As a comparison to the full sample and the Eastern region, the findings regarding the interaction variable in the Central region are markedly different, underscoring the necessity for regional analysis. While no interaction was observed in the full sample or the Eastern region, the moderating effect of the interaction is notably pronounced in the Central region.

5.3.3.3 Western Region

The coefficient for technology spillover on real GDP is significant and positively correlated at 1% critical value in the indirect model with a constant. This finding indicated that technology spillover significantly and positively contributed to economic growth. Conversely, the coefficient for real foreign direct investment (FDI) is negative but not statistically significant in this model. Regarding the interaction variable, the coefficient for FDI_TS is significant and positive in the indirect model with a constant. This suggested a significant interaction between real FDI and technology spillovers in influencing real GDP within the indirect model that included a constant term.

However, while the coefficient for technology spillover remained significant and positive, the interaction variable is positive but not statistically significant in the indirect model with both constant and trend terms. This implied a lack of empirical evidence to support the notion that real FDI and technology spillovers interact in a manner that effectively drives economic growth. In summary, the interaction variable in the indirect model exhibited different levels of significance across the regions. Specifically, it is not significant in the Eastern region, whereas it is significant in the Central region. Additionally, only one interaction variable is significant in the Western region. These results indicated that the Central region demonstrated the most substantial moderating effect of technology spillover on real FDI in influencing real GDP. In contrast, the Western region exhibited some significant moderating effects, while the Eastern region showed no evidence of such moderating influence.

5.3.6 Empirical Results of the Spatial Effect Analysis

Moran's I (Moran, 1948) quantified the degree of similarity in attribute values amongst spatially adjacent or nearby units. This statistical measure can be employed to

assess the presence of spatial correlation within a model. In this study, the null hypothesis posits that there is no spatial correlation present in the model.

Table 5.7: Full sample for lagrange multiplier test

Test	Statistic	Df	P-value
Spatial error:			
Moran's I	20.393	1	0.000
Lagrange Multiplier	394.491	1	0.000
Robust Lagrange Multiplier	368.453	1	0.000
Spatial lag:			
Lagrange Multiplier	29.570	1	0.000
Robust Lagrange Multiplier	3.533	1	0.060

In this study, the null hypothesis asserts that there is no spatial correlation in the model. According to Table 5.7, the P-value of Moran's I is less than 5%, leading to the rejection of the null hypothesis and indicating the presence of significant spatial autocorrelation. Following spatial econometric principles, the regression model residuals are first calculated, after which the Lagrange Multiplier Test (LM Test) is conducted. This test typically encompasses four statistics designed to detect various forms of spatial dependence: the LM-Error Test (Burridge, 1980) and its improved Robust LM-Error Test (Bera & Yoon, 1992), the LM-Lag Test (Anselin, 1988), and its further enhanced Robust LM-Lag Test (Bera and Yoon, 1992). The null hypothesis for all four LM tests is that there is no spatial correlation amongst the model residuals. The results presented in Table 5.7 indicated that all four LM tests rejected the null hypothesis at a significance level of 1%, thereby confirming the presence of spatial error effects and spatial lag effects. The Spatial Durbin Model (SDM) integrates both the Spatial Error Model (SEM) and the Spatial Lag

Model (SLM), accounting for the spatial lag effects of both the dependent and explanatory variables.

Table 5.8: Regression results of panel data for the full sample

Item	Full Sample	
	Spatial Lag Model	Spatial Durbin Model
FDI	0.0221*	0.0166
TS	0.0507**	0.0607
Trade	0.0139	-0.0029
Gov	0.1286**	0.2627***
Pop	-0.0196	-0.0699
W_FDI	-	0.1111***
W_TS	-	0.0846*
W_Trade	-	0.1689***
W_Gov	-	0.1655**
W_Pop	-	0.4486
W_GDP(-1)	0.7145***	-
Akaike Information Criterion	-5.9673	-5.7847
R-squared	0.9979	0.9975

Note: GDP represents log of real gross domestic product; FDI represents log of real foreign direct investment; R&D represents log of research and development capital stock; Trade represents log of trade openness; Gov represents log of real government expenditure; POP represents log of population.

***, ** and * represents significance at the 1%, 5% and 10% significance levels, respectively

Table 5.8 presents the spatial regression results for the Spatial Lag Model (SLM) and Spatial Durbin Model (SDM) across the full sample. The analysis of the full sample is particularly pertinent. Firstly, the coefficients for the core explanatory variables, namely real Foreign Direct Investment (FDI) and research and development (R&D) capital stock, exhibit positive and statistically significant relationships at 10% and 5% level, respectively. Specifically, 1% increase in real FDI corresponds to 0.02% increase in real Gross

Domestic Product (GDP), while 1% increase in R&D capital stock leads to 0.05% increase in real GDP.

Secondly, the coefficient for real government expenditure, identified as a control variable, is also positive and significant at 5% level, suggesting that 1% increase in real government expenditure results in 0.13% increase in real GDP. In contrast, the control variable for trade openness is not statistically significant despite its positive sign, while the population variable is significant with a negative sign.

Furthermore, the coefficient of $W_GDP(-1)$ associated with the spatial lag model is critical for understanding the nature of spillover effects, as it indicates that the real GDP of an individual province is influenced not only by its own characteristics but also by variations in the real GDP of adjacent provinces, suggesting that synchronised economic cycles can stabilise regional development expectations. In the full sample, a positive spillover effect is observed; specifically, 1% increase in the real GDP of neighbouring provinces is associated with 0.71% increase in the real GDP of individual provinces.

Finally, the Akaike Information Criterion (AIC) for the SLM is recorded at -5.9673. R^2 value is 0.9979, indicating a high goodness-of-fit for the model in the full sample.

In contrast, the coefficients for real FDI and R&D capital stock, which serve as core explanatory variables, are positive yet statistically insignificant in the Spatial Durbin Model (SDM) for the full sample. Secondly, the coefficient for real government expenditure, identified as a control variable, is positive and significant at 1% level, indicating that 1% increase in real government expenditure results in 0.26% increase in real GDP. The control variables for trade openness and population exhibit negative signs and are not statistically significant.

Thirdly, the coefficients associated with the spatial weighting matrix and independent variables in the SDM suggest that neighbouring provinces exert a notable

influence on a given province. W_FDI is interpreted as reflecting spillover effects generated by the ability of neighbouring provinces to absorb foreign investment, indicating that coordinated regional FDI policies can promote cross-border knowledge diffusion and industrial upgrading. W_TS , which captures spatially lagged technology spillovers, is now interpreted in light of regional innovation networks and knowledge diffusion. W_Trade is interpreted as reflecting spillover effects from market integration in neighbouring provinces, indicating that coordinated trade policies can reduce transaction costs and expand shared economic opportunities. W_Gov is interpreted as capturing the spillover effect of public investment or fiscal governance in neighbouring provinces, indicating that strong regional coordination in policy can yield mutual economic benefits. W_Pop is interpreted as capturing the spillover effect of labor market dynamics in neighboring provinces, indicating that flexible migration policies can optimize human capital allocation across regions.

Specifically, the coefficients for real FDI and R&D capital stock indicate that improvements in neighbouring provinces positively impact the corresponding province. For instance, 1% increase in real FDI in neighbouring provinces leads to 0.11% increase in real FDI in a given province, while 1% increase in R&D capital stock in neighbouring provinces resulting in 0.08% increase in real FDI in the respective provinces. Similarly, enhancements in trade openness and real government expenditure in neighbouring provinces correspondingly increase trade openness and real government expenditure in the given province; specifically, 1% increase in trade openness or real government expenditure in a neighbouring province result in 0.17% increase in the respective measures in the given province. This highlights the positive effects of trade openness and real government expenditure on economic growth. However, the spatial weighting coefficient for

population is positive but statistically insignificant, indicating a lack of substantial impact from neighbouring province to a given province.

Additionally, the Akaike Information Criterion (AIC) serves as a measure for assessing the goodness-of-fit of statistical models, aiming to select those with strong explanatory power while avoiding overfitting. A lower AIC value suggests a better model fit with the data and reduced complexity. In this analysis, the AIC for the SDM is recorded at -5.9673, which is smaller than that of the SLM, indicating that the SLM model is superior. Furthermore, R^2 value for the SLM is 0.9979, demonstrating a higher level of model fit than SDM. Overall, since the SLM presents a larger R^2 value compared to the SDM, it is deemed the superior estimation method for the full sample.

5.3.7 Empirical Results of the Spatial Effect Analysis by Region

Spatial Lag Model (SLM) and Spatial Durbin Model (SDM) are two commonly used models in spatial econometrics, mainly used to analyse spatial correlation and spatial spillover effects. The core difference between the two is the treatment of spatial lag terms of independent and dependent variables. Table 5.9 presents the spatial regression results for the Spatial Lag Model and Spatial Durbin Model across the Eastern, Central, and Western regions.

Table 5.9: Regression results of panel data for region

Item	Eastern Region		Central Region		Western Region	
	Spatial Lag Model	Spatial Durbin Model	Spatial Lag Model	Spatial Durbin Model	Spatial Lag Model	Spatial Durbin Model
FDI	0.0225	0.0292	0.0005	0.0119	0.0546**	0.0564***
TS	0.0799	0.1139	0.1349***	0.1885***	0.1239*	0.1475*
Trade	0.0571	0.0256	0.0906**	0.0614*	0.0367*	0.0202
Gov	0.2043***	0.2921***	0.1539***	0.3941***	0.2116*	0.2896***
Pop	0.4259***	0.3229**	-0.1981	-0.1435	0.3989	0.4180
W_FDI	-	0.0676*	-	0.0726***	-	0.0795*
W_TS	-	0.0431	-	-0.0300	-	-0.0094
W_Trade	-	0.1684*	-	0.0763**	-	0.1039***
W_Gov	-	0.1712	-	0.0356	-	0.1304
W_Pop	-	-0.1479	-	0.3715	-	0.8160
W_GDP(-1)	0.4982***	-	0.5118***	-	0.4176**	-
Akaike Information Criterion	-5.3954	-5.3814	-6.5996	-6.5291	-5.4896	-5.4648
R-squared	0.9961	0.9961	0.9978	0.9977	0.9965	0.9965

Note: GDP represents log of real gross domestic product; FDI represents log of real foreign direct investment; R&D represents log of research and development capital stock; FDI_R&D represents the interaction term between FDI and R&D; Trade represents log of trade openness; Gov represents log of real government expenditure; POP represents log of population.

***, ** and * represents significance at the 1%, 5% and 10% significance levels, respectively

5.3.7.1 Eastern Region

The empirical analysis for the Eastern region encompasses eleven provinces in mainland China, covering the period from 2000 to 2022. Initially, the coefficients for the core explanatory variables, real Foreign Direct Investment (FDI) and technology spillover are found to be positive but statistically insignificant in the Spatial Lag Model (SLM). This lack of significance suggests insufficient evidence to support the hypothesis that growth in

real FDI and technology spillovers contributed to real Gross Domestic Product (GDP) growth.

Secondly, the coefficients for the control variables, namely government expenditure and population, exhibited positive and statistically significant relationships at the 1% level. Specifically, 1% increase in real government expenditure correlates with 0.20% increase in real GDP, while 1% increase in population corresponds to 0.43% increase in real GDP. Conversely, the control variable for trade openness presents a positive sign but did not achieve statistical significance.

Furthermore, the analysis revealed a positive spillover effect from neighbouring provinces to individual provinces within the SLM framework; that is, 1% increase in real GDP in neighbouring provinces resulting in 0.50% increase in real GDP in each province. The Akaike Information Criterion (AIC) for the model is recorded at -5.3954, indicating a reasonable fit. Additionally, R^2 value is 0.9961, which signifies a strong goodness-of-fit for the SLM within the Eastern region. Similarly, in the Spatial Durbin Model (SDM) for the Eastern region, the coefficients of the core explanatory variables, real Foreign Direct Investment (FDI) and research and technology spillovers remained positive but statistically insignificant. Conversely, the coefficients for the control variables, including government expenditure and population, exhibited positive and statistically significant relationships at 5% level. Specifically, 1% increase in real government expenditure and population correlates with a respective increase of 0.29% and 0.32% in real Gross Domestic Product (GDP).

However, the control variable for trade openness, while also positive, did not achieve statistical significance. Furthermore, the spatial weighting matrix within the SDM, along with the coefficients of the independent variables, indicates that neighbouring

provinces in the Eastern region exerted a measurable influence on the given provinces. Notably, changes in real FDI and trade openness in neighbouring provinces positively impact on the given province, with 1% increase in real FDI and trade openness in neighbouring provinces resulting in 0.07% and 0.17% increase in real FDI and trade openness in the given province, respectively. This finding underscores the beneficial effects of enhanced real FDI and trade openness on economic growth.

Conversely, the spatial weight coefficients for research and development capital stock and government expenditure, while positive, are statistically insignificant. Additionally, the spatial weight coefficients for population are both negative and insignificant, indicating a lack of impact from changes in neighbouring provinces on the given province and suggesting limited relevance for economic growth within the Eastern region.

The Akaike Information Criterion (AIC) for the SDM in the Eastern region is recorded at -5.3814, indicating that the SLM demonstrated a lower AIC compared to the SDM. R^2 value is 0.9961, reflecting a strong goodness-of-fit for the model. Overall, the results for the core explanatory and control variables in the SDM aligned with those observed in the SLM.

5.3.7.2 Central Region

The Central region analysis presents empirical findings for eight provinces in mainland China spanning the years 2000 to 2022. Initially, the coefficients for the core explanatory variables, real Foreign Direct Investment (FDI) and technology spillovers in the Spatial Lag Model (SLM) are positive. However, while the coefficient for R&D capital stock was statistically significant, the coefficient for real FDI remained insignificant. This

outcome indicated that a 1% increase in technology spillovers was associated with 0.13% increase in real Gross Domestic Product (GDP), suggesting that real FDI did not exert a significant effect on real GDP within this region.

Secondly, the coefficients for the control variables, trade openness and real government expenditure are both positive and statistically significant in the SLM. Specifically, 1% increase in trade openness and real government expenditure correlates with respective increases of 0.09% and 0.15% in real GDP. Conversely, the control variable for population exhibited a negative and insignificant relationship, indicating no discernible impact on economic growth. The SLM results further revealed a positive spillover effect from neighbouring provinces, with 1% increase in real GDP in neighbouring provinces linked to a corresponding 0.50% increase in real GDP for individual provinces. Additionally, the Akaike Information Criterion (AIC) for the SLM is recorded at -6.5996, while R^2 value of 0.9978 further attests to the favourable model fit.

In the Spatial Durbin Model (SDM) for the Central region, the coefficients for the core explanatory variables remained positive. Similar to the SLM, the coefficient for real FDI is insignificant, while the coefficient for technology spillover is statistically significant at 1% level, indicating that 1% increase in technology spillovers leads to 0.19% increase in real GDP. The control variables trade openness and real government expenditure also exhibited positive coefficients, significant at 10% level. Specifically, 1% increase in trade openness and real government expenditure results in respective increases of 0.06% and 0.39% in real GDP. However, the control variable for population in the SDM remained negative and insignificant, echoing the findings in the SLM.

Furthermore, the spatial weighting matrix in the SDM highlights the influence of neighbouring provinces on the given province. Changes in real FDI and trade openness in

neighbouring provinces positively impact the given province, indicating that 1% increase in real FDI and trade openness in neighbouring provinces will lead to increases of 0.07% and 0.08% in real FDI and trade openness, respectively, in the given province. This finding emphasises the interconnectedness of economic activities across provincial borders in the Central region.

The results from the Spatial Durbin Model (SDM) for the Central region further substantiate the positive effects of real FDI and trade openness on economic growth, consistent with the findings of the Spatial Lag Model (SLM). Notably, while the spatial weight coefficient for technology spillovers is negative, the coefficients for real government expenditure and population are positive, all lacking statistical significance. This suggested that changes in these variables in neighbouring provinces do not exhibit a significant impact on the given provinces within the Central region, nor do they underscore their importance for economic growth. The Akaike Information Criterion (AIC) for the Central region in the SDM is recorded at -6.5291, indicating that the AIC for the SLM is smaller, thus rendering it a superior model. Additionally, R^2 value of 0.9977 further confirms the model's strong fit.

5.3.7.3 Western Region

As for the Western region, empirical results are derived from eleven provinces between 2000 and 2022. Initially, the coefficients for the core explanatory variables, real FDI and technology spillover in the SLM are both positive and statistically significant. Specifically, 1% increase in real FDI and technology spillover is associated with 0.05% and 0.12% increase in real GDP, respectively, in the Western region. Furthermore, the coefficients for the control variables, trade openness and real government expenditure, are

both positive and significant at 10% level, indicating that 1% increase in each will lead to increase of 0.04% and 0.21% in real GDP, respectively. Conversely, the variable population, while positive, remained statistically insignificant. The SLM results indicated a positive spatial spillover effect between neighboring provinces and individual provinces; 1% increase in real GDP of neighbouring provinces correlates with 0.42% increase in real GDP of individual provinces. The AIC for the SLM in the Western region is reported at - 5.4896. R^2 value is 0.9965, indicating a good model fit.

In the Western region, the coefficients of the core explanatory variables, real Foreign Direct Investment (FDI) and research and technology spillover are both positive and statistically significant within the Spatial Durbin Model (SDM). Specifically, 1% increase in real FDI and technology spillover is associated with 0.06% and 0.15% increase in real GDP, respectively. Furthermore, the coefficient of the control variable, real government expenditure, is positive and significant at 1% level, indicating that 1% increase in real government expenditure results in 0.29% increase in real GDP. However, the control variables, trade openness and population, while positive, remained statistically insignificant in the SDM.

The spatial weight matrix and the coefficients of the independent variables in the SDM revealed that neighbouring provinces in the Western region exerted a positive influence on the given province. Specifically, 1% increase in real FDI in neighbouring provinces corresponds to 0.08% increase in real FDI in the given province. This underscores the positive impact of real FDI development on economic growth in the Western region, consistent with findings from SLM. Nevertheless, the spatial weight coefficient for R&D capital stock is negative and insignificant, aligning with observations from both the Eastern and Central regions. Additionally, the spatial weight coefficients for

real government expenditure and population are positive yet insignificant, indicating a lack of significant impact from changes in neighbouring provinces on the given province within the Western region, mirroring the results observed in the Central region.

The Akaike Information Criterion (AIC) for the SDM in the Western region is -5.4648, indicating that the SLM, which has a lower AIC, is a more favourable model. R^2 value of 0.9965 demonstrates a high goodness-of-fit for the model, slightly surpassing that of the Eastern region but falling short of the Central region. In conclusion, the findings for the core explanatory and control variables in the SDM for the Western region are consistent with those in the SLM, reinforcing the preference for the SLM due to its superior AIC value and equivalent R^2 value.

In summary, based on the AIC minimisation criterion and the significant spatial autocorrelation dual criterion of the spatial lag model (SLM), the spatial lag coefficients of the full sample are higher than those within the three major regions, reflecting the core-periphery gradient diffusion characteristics. The flow of factors and knowledge diffusion across provincial boundaries generate stronger spatial externalities. When examining regional differences, the Central region has the largest spatial effect coefficient, the lowest AIC, and the highest R^2 , indicating its status as a growth pole, consistent with the radiating effect characteristics of the 'Central Rise' strategy. The Western region has the smallest coefficient but the largest spatial weight for FDI, reflecting an element capture-type spillover mechanism. The Eastern region has the only significant population variable, reflecting a dominant agglomeration economy mechanism. Although SDM is also significant, SLM has a lower AIC and simpler explanatory power, satisfying the parsimony principle, and is therefore selected as the final model.

5.4 Discussion of the Results

5.4.1 Discussion on Direct Effect

5.4.1.1 Foreign Direct Investment

After the reform and opening-up, the scale of China's utilisation of FDI has been expanding, ranking first amongst developing countries for the 31st consecutive year. In the early stage of reform and opening-up, there was a double gap in China's economic construction, FDI accelerated China's capital accumulation, and brought advanced management experience and technical knowledge, opened up the international market, and enhanced the international competitiveness and innovation ability of local enterprises. At the same time, multinational enterprises (MNEs) FDI urgently need to promote the international gradient transfer of labour-intensive industries and product production. Hence, China's comparative advantages, such as abundant and cheap labour, huge market, good infrastructure, complete industrial sectors, and stable political situation, fit the demand for FDI transfer (Zhang & Dai, 2023). If MNEs need to transfer knowledge and technology intensive industries, they will focus on the comparative advantage formed by the institutional quality of the host country, and therefore often invest in developed countries.

This study showed that the promotion of FDI on China's economy at this stage is insignificant with negative sign. This result reflects that there is a foreign capital crowding-out effect in some regions of China (such as excessive local government protection of domestic enterprises to inhibit technology spillover), which is consistent with the conclusion of Zhang & Dai (2023) that market segmentation weakens the positive impact of FDI, but differs from the conclusion of Liu et al. (2019) that FDI in coastal areas significantly promotes growth. This suggests the importance of regional heterogeneity. The

first reason is that the traditional low-cost advantage of FDI introduction is gradually losing, while new comparative advantages are waiting to be formed (Zhang & Dai, 2023). China has optimised and upgraded its own industrial structure, vigorously developed independent R&D, and narrowed its technological gap with developed countries. Second, the natural profit-driven nature of FDI superimposes complex high-end technology blockade and trade friction. High-tech FDI is influenced by trade protectionism and geopolitics and sees China as a potential competitor rather than a mutually beneficial partner. Therefore, unwilling to invest in the largest developing country, and is committed to keeping China at the lower end of the global industrial chain. Therefore, China's economy lacks the positive impact of high-end FDI, the upgrading of the industrial chain is limited, the external circulation is suppressed to a certain extent, and the internal circulation of the economy has to be increased.

Similarly, FDI in the Eastern, Central and Western regions of China has no significant impacts on regional economic growth. China's economic growth has always presented a dual economic structure, that is, the developed Eastern coastal areas and the underdeveloped Central and Western regions. This is mainly due to geographical location, natural resources, national policies, social history and culture and other factors. Relatively speaking, the Eastern region is dominated by the sea. Due to its geographical advantages, it has become one of the earliest regions to attract FDI. Coupled with its market size and preferential policies, it has become the window of China's opening-up to the outside world, and its high level of economic development has formed a virtuous circle effect. In the Central and Western regions, the economic foundation is relatively weak, the industrial chain is imperfect, the supporting facilities are insufficient, the market scale is relatively small, the consumption power and the industrial agglomeration degree are insufficient, and

the imported FDI is dominated by low-value-added industries. Although the Central and Western regions have absorbed less FDI, they have gradually realised economic catch-up by undertaking the industrial transfer of the Eastern region. In short, the Eastern region has attracted a large amount of FDI, and its marginal income has gradually declined, and the spillover effect has reached saturation, and it is difficult to bring significant economic growth. Although the Central and Western regions benefit from the weak economic foundation and irrational industrial structure, FDI is mostly concentrated in primary industries, which fails to produce effective spillover effect in these regions and fail to promote high-end industries and technological innovation, resulting in insignificant economic growth.

5.4.1.2 Technology Spillover

Technology spillover has contributed significantly to China's economic growth, mainly through research and development activities to promote technology absorption, innovation diffusion, and productivity improvement.

In the direct model, China's technology spillover plays a very significant positive role in promoting economic growth. Technology spillover has the greatest positive impact on economic growth amongst the five variables. These results validate the core viewpoint of the endogenous growth theory - that knowledge accumulation is the engine of long-term growth, and its influence surpassing government spending phenomenon is highly consistent with the theoretical framework emphasizing R&D-driven innovation proposed by Ali and Akhtart (2024). Under the dual circulation new development paradigm, China is promoting innovation-driven development policy. FDI technology spillover promotes technology absorption and production efficiency improvement through R&D activities, strengthens local enterprises' independent innovation, and has a significant positive impact

on economic growth. Firstly, technological progress is an endogenous variable of economic growth, driving long-term economic growth (Romer, 1986). Multinational enterprises in developed countries have advanced technology, management experience and production mode. FDI can generate technology spillover through comprehensive channels, such as demonstration effect, competition effect, correlation effect and personnel flow effect, thus improving the technical level and product quality of local enterprises in China. Secondly, R&D investment improves innovation capability (Yue et al., 2024). Technology spillover enables local Chinese enterprises to “learning from doing” and increase R&D investment for long-term development, thus improving the absorption, application, innovation ability and international competitiveness of enterprises, and promoting economic development to a greater extent. As a result, technology spillover drives corporate innovation through R&D investment and promote China's economic growth.

In addition, the main goal of global resource allocation of multinational enterprises (MNEs) is to obtain huge profits, and technology spillovers are often inevitable, but it is not voluntary. According to the product life cycle theory, MNEs usually transfer outdated technologies and products that lose profits to the host country. At the same time, MNEs will protect their core technologies and latest patents to prevent the host country enterprises from imitating or even surpassing, so as to maintain competitive advantage and super profits. Therefore, high technology cannot be bought without it, and China must speed up the realisation of self-reliance in high level science and technology. The effective absorption and utilisation of technology spillover is the basis for promoting China's technological progress and economic development. However, low-quality FDI cannot promote Chinese enterprises' innovation and economic growth (Yue et al., 2022; Yue et al., 2024).

Similarly, in the direct model, technology spillovers in the Eastern, Central and Western regions all play a very significant positive role in promoting economic growth. However, the technology spillover has the largest positive effect on economic growth in the Eastern region, followed by the Western region and the Central region. The Eastern region is the most economically developed region in China, with perfect infrastructure, reasonable industrial structure, large investment in research and development, more pilot opening-up to the outside world, attracting more foreign investment and the most significant technology spillover effect. First of all, the Eastern region has good basic conditions in all aspects and is also the region with the highest level of science and technology and absorption capacity. Most of China's high-tech industries and enterprises gather here, attracting many FDI and technology, forming a good technology spillover environment. Secondly, enterprises in the Eastern region have high scientific and technological content, and their R&D investment and independent innovation capability far exceed that of the Central and Western regions. Many universities and scientific research institutions have attracted a large number of talents from the Central and Western parts of the country to migrate to the east, providing strong human support for technology research and development in the Eastern region. Thirdly, there are many trials of reform and opening-up in the Eastern region, and the government has taken the lead in introducing many policies to attract foreign investment and encourage technological innovation, further guaranteeing the spillover effect of technology.

The positive effect of technology spillover on economic growth in Western region is weaker than that in Eastern region, but stronger than Central region. As a comparison to the Eastern region, the Western region has a weak economic foundation, imperfect infrastructure, underdeveloped science and technology, and a low degree of opening-up to

the outside world. Therefore, the positive promoting effect of technology spillover on economic growth is weaker than that of the Eastern region. First of all, the infrastructure, scientific and technological resources and high-end talents in the Western region are relatively weak, the ecological environment is fragile, the soil erosion is serious, the degree of internationalisation is low, and the environment for the full occurrence of technology spillover is lacking. Secondly, the industrial structure of the Western region is mainly resource-based and labour-intensive, and the ability to absorb and utilise external technology spillover in high-tech industries is limited, which is difficult to fully transform into productive forces.

As a comparison to the Central region, the Western region has a strong national policy support, more opportunities for international cooperation, and greater advantages in resource endowment and emerging industries. Therefore, the positive effect of technology spillover on economic growth is stronger than that of the Central region. First, the national policy support is strong, the implementation of the policy of the “developing the West”, Belt and Road Initiative (BRI) and the China Railway Express policy implementation has greatly improved the investment environment in the Western region. It has created better conditions for the entry and technology spillover of foreign enterprises. Since 2000, China has implemented the policy of “Developing the West”, which involves infrastructure construction, industrial development and technology introduction. Four landmark projects, including the West-east gas transmission project, West-east electricity transmission project, South-to-North water diversion project and Qinghai-Tibet Railway project, have been completed and are beginning to reap benefits. The BRI, proposed since 2013, has enabled the Western region to increase economic and trade cooperation with neighbouring countries, such as Central Asia and South Asia, for example, green energy cooperation.

Moreover, since 2011, the China-Europe Railway Express has laid out three international logistics and land transport routes in the Western, Central and Eastern regions of China, strengthening the trade between the three regions of China and Europe and countries along the BRI. Secondly, abundant natural resources and the rapid development of the new energy industry provide important support for technology spillovers. The Western region is rich in energy, mineral resources and other industries as well as solar energy, wind energy and other new energy industries offer comparative advantages. These attract some foreign enterprises to enter, forming a technology demonstration effect, improving local production efficiency and economic output, technology spillover effect is significant, and promote the sustainable growth of the Western region economy.

As a comparison to the Eastern and Western regions, the Central region has few regional advantages, low degree of internationalisation, relatively weak industrial structure, low logistics profits, and insufficient research and development efforts. Therefore, the positive effect of technology spillover on economic growth is weakened. First of all, the Central region is located in the inland of China, neither coastal nor adjacent to landlocked countries, and the degree of internationalisation is low, resulting in a small number of foreign enterprises and technology introduction, and relatively limited sources of technology spillover. Secondly, the industrial structure of the Central region is weaker than that of the Eastern region but better than the Western region. The high-tech industry is relatively small, the policy support is insufficient, and the attraction of foreign investment is not big. Although the Central region is a national comprehensive transportation hub, most of the industries transferred to the Eastern region are energy-intensive and low-technology industries (Gao et al., 2023), with relatively low added value, so the innovation capacity and technology absorption capacity of local enterprises are weak.

Amongst the five variables in this study, technology spillovers are the only ones that play a significant positive role in promoting economic growth in almost every province. The main reason is that technology spillovers can enable local enterprises to improve their technological level and innovation ability, promote industrial upgrading, enhance human capital and enterprise competitiveness, and thus promote economic growth.

5.4.1.3 Trade Openness

From the full sample of the country, trade openness has no significant effect on China's economic growth. This result reveals that the dominant role of domestic demand in driving growth under the dual circulation strategy is strengthening. This finding extends the trade technology spillover theory proposed by Grossman and Helpman (1991), indicating that in economies with stronger policy intervention, the effectiveness of the traditional trade growth mechanism may decline. China has strengthened its inward-looking economic policies and relied on strong domestic consumption and investment, while gradually reducing the share of traditional manufacturing and transitioning to high value-added, high-tech industries. The degree of trade openness in the Eastern region is significantly higher than that in the Central and Western regions, and the free trade area has achieved a full coverage. The country's foreign trade dependence has gradually declined, and the driving effect of foreign trade on emerging industries has not yet been reflected. In key areas such as telecommunications and finance, the Chinese government has adopted certain regulatory measures to restrict foreign investment from entering and market competition in order to safeguard national security and interests. It can be seen that China's economy is shifting from an extensive export-oriented growth model to a dual-cycle pattern, and the relative importance of trade openness in overall economic growth has declined.

From a regional perspective, the trade openness of the Eastern and Western regions has a significant positive impact on regional economic growth, while the Central region does not. The trade openness of the Eastern region has a positive effect, reflecting the technological diffusion and economies of scale brought about by export-oriented manufacturing climbing the global value chain, consistent with the export learning effect in new trade theory. The Central region did not pass the test, a result consistent with its transitional status as a bridge between the Eastern and Western. Export-oriented industries have not yet formed the same agglomeration externalities as in the Eastern region, resulting in a weak export learning effect. On the other hand, the tariff reductions and foreign investment inflows brought by inland open channels, such as the China-Europe Railway Express and the Yangtze River Golden Waterway, are insufficient to offset the competitive pressure from the Eastern and Western regions on local industries. Therefore, the net impact of trade openness is neutralised, resulting in statistical insignificance. Conversely, the Western region exhibits a significantly negative effect under the same conditions, consistent with the ‘Dutch disease’ mechanism, the surge in exports of resource-based products has driven up the real exchange rate of the local currency, suppressing investment and employment in the local tradable sector, while tariff reductions in border trade further exacerbate competitive displacement of low-value-added industries.

5.4.1.4 Government Expenditure

The significant positive effect of government expenditure in the results (but with a coefficient smaller than that of R&D) supports the role of public capital accumulation in the endogenous growth theory. However, it contrasts with the “policy crowding-out effect” proposed by Rodrik (2018), indicating that China’s fiscal expenditure may have been more effective in avoiding the crowding-out of private investment. Government expenditure has

played a positive role in social security, infrastructure construction, stimulating consumption, promoting industrial upgrading, scientific and technological innovation, and responding to major challenges, which has directly boosted China's economic growth. First, government spending on public services, such as healthcare, education, social security and unemployment has improved people's living standards and consumption power and indirectly promoted economic growth. Second, the Chinese government invests heavily in infrastructure projects such as transportation, energy and communication, which facilitates the life of residents and the production of enterprises, promotes the development of construction, building materials, machinery and other related industries. Also, directly increases employment opportunities, increases residents' income, and then drives consumption growth, forming a significant economic multiplier effect and strengthening the internal economic circulation.

Thirdly, China's fiscal expenditure has been promoting the development of industries with high-added value, high-tech content and low pollution to accelerate the optimisation and upgrading of industrial structure and technological innovation of enterprises. Moreover, measures such as special funds, research and development subsidies and talent introduction have effectively promoted the development of emerging industries, such as high-tech, artificial intelligence and clean energy and green industries such as new energy and new materials. It has enhanced the internal driving force for economic growth and sustainable development. Additionally, in the face of major natural disasters such as earthquakes, mudslides and floods, as well as public health crises such as the COVID-19 pandemic. The government spending played a leading role, ensuring that people's lives and businesses production resumed as soon as possible by rapidly increasing spending and deploying resources, and enhancing the resilience of the economy.

The positive effect of government expenditure on China's economic growth is different in different regions, with the largest positive effect in Western region, followed by Eastern region, and the smallest in Central region. The Western region has the largest positive economic growth effect of government expenditure, mainly because of its backward infrastructure, weak economic foundation, weak private enterprises, and low level of science and technology. Therefore, it has the greatest dependence on government expenditure and “Developing the West” and other policies and is in the stage of increasing marginal effect of government expenditure. The Eastern region has a solid economic foundation, a complete market economy, a high level of scientific and technological innovation, developed foreign trade, and strong ability to attract investment, so the marginal effect of government expenditure is relatively diminishing. However, due to the industrial upgrading, marketisation process and the ability to attract foreign investment in the Central region is not as good as that in the Eastern region. Also, the intensity of infrastructure investment and policy support is not as good as that in the Western region, so the marginal income of government expenditure is relatively low.

5.4.1.5 Population

The insignificant positive result of population growth confirms the assertion made by Guo et al. (2020) regarding the “waning of traditional demographic dividend”. It also implies that the driving force of China's economic growth has shifted to quality-driven factors such as “engineer dividend”, complementing the existing quantitative population theories. First, the demographic dividend is decreasing. China's comparative advantage of cheap labour since the reform and opening-up is disappearing, and the double pressure of ageing and declining birth rate is coming, which makes the demographic dividend gradually weakening and the growth potential of domestic demand is insufficient (Wang,

2024). Second, there is heterogeneity in population distribution. The quantity and quality of urban population and human capital in the Eastern region are gradually improving, while the quantity and quality of labour force in the Central and Western regions are relatively low, with large regional differences in population offsetting the extent of economic growth. Third, China has become a service and technology power, and industrial transformation and upgrading requires high-quality human resources (Zhang & Zhang, 2024), but the surplus of low-skilled labour coexists with the shortage of high-skilled labour.

Amongst the effects of population on economic growth in the three major regions of China, the Western region has the most significant positive driving effect, followed by the Eastern region, while the Central region is not significant. The significant positive coefficient in the Eastern region validates the human capital agglomeration theory, high population density improves total factor productivity through knowledge spillovers and matching efficiency. First, economic development depends more on technology and capital. Most of the provinces in the Eastern region have negative population growth, and the proportion of high value-added industries and services is increasing, which requires technology, capital and a large number of high-end talents. This in turn attracts a large number of high-end talents from the Central and Western regions by virtue of the high wages and excellent supportive environment (Yan et al., 2023). However, the population growth is relatively concentrated in low-skilled labourers, and the driving effect on the economy becomes smaller. Second, the high rate of population inflow, deepening ageing, and relatively high population density have put pressure on public services and the natural environment. The marginal effect of population growth is reduced by the higher costs of

transportation, housing and logistics in the eastern part of the country, as well as by the higher consumption of resources and serious environmental pollution.

The Central region's negative and insignificant population reflects the typical dilemma of population net outflow, lagging structural transformation. First, population outflow is more serious (Yan et al., 2023). More working population in the Central region is moving to the Eastern region due to higher wages and development opportunities, resulting in insufficient supply of local labour, especially in small cities and counties, which directly affects the development of local industries. Secondly, there is little policy support, and traditional industries are upgraded slowly, resulting in a relatively low quality of population. The industrial structure of the Central region is dominated by traditional manufacturing and agriculture, with generally low technological content and innovation capacity, while the low quality of the population does not promote industrial upgrading, resulting in the population's insignificant contribution to economic growth.

The population variable in the Western region is significantly positive, indicating the neoclassical growth logic of labour scarcity, high output elasticity and policy-driven growth. Firstly, the high level of net population inflow is still in the demographic dividend period, which matches with industrial development. As an underdeveloped region, the trend of population flow to the Eastern region has slowed down and population return has strengthened (Yan et al., 2023). While the local infrastructure is relatively weak and industrial development is relatively backward, the population increase can provide sufficient labour for infrastructure construction, labour-intensive and natural resource-intensive manufacturing industries, which directly promotes economic growth. Second, policies such as developing the West, the Belt and Road Initiative, and green energy have increased the demand for population. The relevant policies have attracted domestic and

foreign investments and projects, which require not only low and middle-level labour, but also high-end talents. The increase in population in the Western region, in addition to natural growth, and the various types of talents attracted from the Central and Eastern regions (Yan et al., 2023), directly or indirectly contributes to economic growth.

5.4.2 Discussion on Indirect Effect

This study further considers the extent of the combined impact of FDI and technology spillovers on economic growth. First, FDI and technology spillover do not significantly interact and contribute to economic growth in China. This result suggests that technology spillovers do not reduce the negative impact of FDI on economic growth. This result suggests that technology spillover does not moderate the negative impact of FDI on economic growth. This is directly related to regional heterogeneity, as the Eastern region accounts for more than 85% of China's imported FDI and is also the region with the strongest technology spillover effect. Thus, the insignificant interaction term for the Eastern region behaves similarly to the interaction term for the full sample of China.

In addition, the effect of the interaction term between FDI and technology spillover on economic growth is heterogeneous across the three regions. The interaction term of FDI and technology spillover has the largest positive effect on economic growth in the Central region, followed by the Western region, while the Eastern region has no significant effect. The reasons for heterogeneity include differences in regional development stages, variations in the intensity of policy intervention, and regional gradients in infrastructure conditions.

First of all, the Eastern region has a high degree of marketisation and optimisation of industrial structure, active private enterprises, a concentration of high-end talents, strong

local innovation capacity, and more adequate competition. As a result, the space for marginal technological spillover naturally narrows, which is in line with the convergence effect expected in the endogenous growth theory. And foreign-invested enterprises try to strengthen the protection of intellectual property rights, limit or prohibit high-tech spillovers, and domestic wage gap gradually narrowing the attraction of talent, the marginal contribution to industrial upgrading is relatively small. Therefore, technology spillovers do not reduce the impact of FDI on economic growth in the Eastern region.

Secondly, the Central region, as a typical representative of medium-level developed areas, is currently in a critical stage of technological catch-up. Consistent with the research conclusion of Wang et al. (2020) on the Yangtze River Economic Belt, this type of region not only possesses the infrastructure for absorbing foreign technologies and abundant and inexpensive labor resources but also maintains a strong demand for advanced technologies. Therefore, it can maximize the technological spillover effects of FDI. The difference in the intensity of policy intervention provides an important explanation. Central provinces have adopted institutional innovations such as the “Chain Leader System” to systematically guide foreign-invested enterprises to establish collaborative networks with local innovation entities (Liu & Zhang, 2021). This policy-driven organized absorptive capacity effectively amplifies the economic benefits of technological spillovers.

In addition, the Western region is strongly supported by policies, rich in natural resources and energy. The infrastructure construction in the Western region is vigorous but still weak, which partially offsets its policy advantages and leads to a weaker regulatory effect of technology spillover compared to the central region. This finding echoes the assertion by Zhang and Li (2023) that “digital divide hinders technology diffusion”, and

also provides empirical support for the necessity of the “East Data West Computing” project.

5.4.3 Discussion on Spatial Effect

Firstly, in the spatial lag model, one of the core explanatory variables, namely real Foreign Direct Investment (FDI) , significantly contributes to China's economic growth. This result is consistent with previous studies and with the findings in the indirect model of this study. Otieno (2024) also argued that FDI has a significant spatial spillover effect on economic growth in the East African region. Kanval et al. (2024) argued that FDI has a positive impact on both long-run and short-run economic growth in Pakistan, and Sunde (2023) argued that there is an FDI-led growth. On the contrary, Hoang et al. (2022) found that FDI in neighbouring provinces of Vietnam has no effect on the growth of the host province, and Obeng-Amponsah and Owusu (2023) argued that FDI without technological support is not significant for economic growth in Ghana. Positive spatial spillovers indicate that the net benefits of FDI will only be evident when geographical proximity facilitates knowledge diffusion or when infrastructure coordination occurs. This is consistent with the endogenous growth theory, and the spatial lag term captures the long-term integration effects that are overlooked in static models.

The nature of foreign investment is to pursue profit maximisation, and since the reform and opening-up, FDI has played an important role in China's economic growth. On the one hand, from the point of view of direct effect, foreign capital makes up for the problem of insufficient local capital, increases new employment opportunities, and improves the labor remuneration and consumption capacity of Chinese labour force. On the other hand, from the point of view of indirect effect, foreign capital drives the agglomeration of related industries and the integrity of the industrial chain and often

demonstrates and spreads the advanced technology and management experience non-subjectively, which makes the international competitiveness of Chinese enterprises to be improved to some extent. Improvement of international competitiveness of Chinese enterprises.

A successful example of FDI in practice is the Tesla Giga Shanghai (TGS), which was established at the end of 2019. TGS is Tesla's first manufacturing plant outside of the U.S. and the first wholly foreign-owned company in China's automotive industry. In terms of TGS's earnings, TGS has bypassed tariff barriers and non-tariff barriers in achieving localised production, reduced operating costs, such as raw materials, logistics costs, and labour, and increased profits and international market share. Its sales revenue was US\$1.76 million in 2018 and rapidly rose to US\$18.15 million by 2022 (Han et al., 2023). In terms of gains in China, TGS promotes employment and industry chain aggregation, with TGS employing around 20,000 Chinese workers and over 95% of its suppliers coming from local Chinese sources, directly contributing to local consumption and economic growth (Han et al., 2023). Of course, the impact of FDI on economic growth has some limitations and requires conditions, such as an appropriate technology gap, strong technology absorption capacity and a well-established industrial chain.

Second, in the spatial lag model, another core explanatory variable, namely development (R&D) capital stock, also contributes significantly to economic growth, and its positive effect is almost double that of real FDI. The first reason is the richness of the channels of technology spillover. FDI tends to be more inclined to drive up GDP directly through inputs of primary factors of production such as capital, natural resources and unskilled workers (Porter, 1990). Whereas, technology spillovers have a time lag, and spill over to local firms through a variety of spillover channels, such as demonstration,

competition, linkages, and mobility of people spillovers to local enterprises (Caves, 1974; Kokko, 1992).

The second reason is that the cumulative effect of technology spillover is significant. In the process of industrial transformation and upgrading, China prefers to introduce advanced production factors through FDI, i.e., modern communication, information, higher education manpower, et al. (Porter, 1990). Also, local firms digest and absorb involuntary technological spillovers and are able to realise independent innovation through their own R&D capabilities, so as to be able to promote sustainable economic growth for a longer period of time, in a wider range of fields, and at a deeper level. In addition, technological spillovers often occur through spatial and spatial factors. In addition, technology spillovers often promote regional coordinated development through spatial spillover effects. For example, China's developed Eastern coastal regions are transferring industries to the less developed Central and Western regions.

Tesla Giga Shanghai (TGS) completed its first overseas vehicle R&D centre, Shanghai R&D Centre, in 2021, and set up 28 laboratories with original engineering development by Chinese teams, e.g., independently developed Tesla's first simulation system for assembly of electronic components on production lines (Han et al., 2023). Indirect technology spillovers from Tesla can enhance the market competitiveness and innovation capacity of local peer firms and upstream and downstream firms through multiple channels. This is more sustainable than the impact of abundant capital brought by FDI on economic growth.

In the spatial lag model, government expenditure positively contributes to economic growth in China. This is consistent with the findings of Sunde (2023) for Namibia and Otieno (2024) for East Africa. While large enterprises can efficiently allocate

resources by replacing market competition with the visible hand, governments need to compensate for market failures and give full play to the visible hand in economic regulation (Chandler, 1977). It is also interesting to note that government expenditure has the largest impact on economic growth amongst all variables. The main reason is that government expenditure can comprehensively and systematically provide economic support, promote the development of new industries, and enhance the ability to resist economic counter-cyclicity, reflecting the ruling philosophy of wholeheartedly serving the people.

In terms of practical examples, the Chinese Government has continued to promote the construction of infrastructure such as charging piles, consumer subsidies, tax exemptions, and other supportive policies, especially in terms of license plate control, reduction of traffic restrictions, and parking fees (Han et al., 2023), to promote consumer acceptance, market expansion, and technological innovation of new energy vehicles, which has helped automakers such as BYD (Liu & Li, 2024) and TGS (Khaleel et al., 2024; Li, 2023) reduce costs and enhance their competitiveness in the domestic and international markets.

On the contrary, neither foreign trade openness nor population plays a significant role in China's economic growth. The former is internally due to export dependence on low value-added products, lack of core technology and internal cyclical development, while the external causes are the intensification of trade friction between China and the United States and the increase in external risks such as geopolitics. Also, the disappearance of demographic dividend, ageing and industrial structure upgrading have weakened the driving force of population on the economy. In addition, the competitive effects of neighbouring provinces, especially the siphoning effect of population from the developed

Eastern region, may have further dampened the positive impact of these variables on economic growth.

In the spatial lag model, China's economic growth has positive spatial autocorrelation characteristics and spatial spillover effects. This is consistent with the findings of Huo and Song (2022) and Song and Liu (2022) for the Guangdong-Hong Kong-Macao Greater Bay Area, as well as Wang and Li (2022) for Beijing-Tianjin-Hebei and Hou et al. (2024) for the Yangtze River Delta. Significant spatial spillover of FDI suggests that provinces benefit from neighbouring regions' investment through labour mobility, cross-regional supply chains, and shared infrastructure networks such as China's Belt and Road corridor. First, regional synergistic development policies enable provinces to share policy dividends. The Chinese Government has formulated systematic regional synergistic development policies to promote the free flow of factors of production and the linked development of the regional economy, such as the regional integrated development policies of Beijing-Tianjin-Hebei, the Yangtze River Delta, and the Guangdong-Hong Kong-Macao Greater Bay Area. Also, the policies of the rise of central China and the development of the Western region, and the policy of gradual opening-up of the free trade zones from the coasts to the borders and the inland areas.

The synergy of China's multiple policy overlaps and the construction of a large, unified factor market have resulted in the largest cross-regional spillover effect of China's full sample. This is mainly manifested in the spillover of projects, technology, capital and high-end talents from the Eastern region to the Central and Western regions. Also, the spillover of enclaves, natural resources and cheap labour from the Central and Western regions to the Eastern region, forming a cooperative relationship with complementary advantages.

Secondly, infrastructure and public services are shared across domains, and market needs and industrial chain are extended across domains. Input and improvement of logistics infrastructure, such as high-speed rail, highway, aviation, public transportation and subway in neighbouring province is the basis for strengthening economic ties of neighbouring provinces, and public services such as communication, medical care and education will exert siphon and radiation effects on neighbouring provinces. This will not only directly drive the neighbouring province's economic growth, but also indirectly to give the province to play a spillover effect, driving the improvement of its infrastructure, the quality of the population to improve, the flow of capital, market demand and industrial chain synergistic development.

In addition, there are cross-domain spillovers of technology. Technological progress and innovation are endogenous to economic growth (Romer, 1990), and economic growth can further promote technological progress and knowledge accumulation. Technological progress and R&D innovation in neighbouring provinces will spill over to the giving province through cross-domain exemplars, demonstrations, linkages, and personnel mobility, et al. This diffusion and agglomeration effect will promote technological progress and industrial upgrading in the province, which will in turn generate conduction of economic growth. Beijing and Shanghai both have strong science and technology innovation capabilities, and through the regional integration and coordinated development policy, they spill out advanced technologies to Tianjin, Hebei, and Jiangsu, Zhejiang, and Anhui, respectively, thus contributing to the overall upgrading of the regional economy.

In the spatial lag model, government expenditure and population in the Eastern region are able to drive economic growth separately. As the most economically developed

region in China, government spending in the Eastern region is used to improve the quality of infrastructure and public services, increase investment in R&D and education, and give appropriate financial subsidies to high-tech industries, which promotes economic cooperation and technological innovation between the Eastern region and other regions. As the most densely populated region, the Eastern region's higher-quality population and strong spending power have attracted an inflow of high-end people from the Central and Western regions, further promoting sustainable growth in the innovation-driven economy.

For example, in May 2022, Tesla Giga Shanghai (TGS) recruited approximately 100 R&D personnel in Shanghai Lingang, including but not limited to software engineers, hardware engineers, and energy engineers (Han et al., 2023). The positive effect of population on economic growth is greatest in the Eastern region, emphasising the importance of continuing to attract and cultivate top talent.

On the contrary, the positive effects of foreign direct investment (FDI), R&D capital stock and trade openness on economic growth in the Eastern region are not significant. Because under the dual circulation new development paradigm, domestic demand has become the main driving force of economic growth, and the technology gap between home and abroad has become smaller, foreign enterprises protect their core technology and high technology in order to maintain monopoly advantages and high profits, so these three elements lack high-tech content to some extent and do not significantly promote economic growth.

The spatial spillover effect of economic growth in the Eastern region is significant, but relatively small amongst the three regions. This is because in the Eastern region, the economic growth of neighbouring provinces drives the economic growth of a given province through multiple channels, such as infrastructure interconnection, industrial chain

collaboration, consumer market sharing and technological spillovers. However, the more developed internal economy and strong endogenous innovation capacity of the provinces in the Eastern region give more economic spillovers to the neighbouring central region. Whereas, the economic dependence on the neighbouring Central region is limited, whereby the spillover effect in the Central region is relatively small amongst the three regions.

In the spatial lag model, technology spillover, trade openness and government expenditure in the Central region can drive economic growth respectively. As the region with the largest technological spillover effect in China, the technological gap between R&D capital stock in the Central region and foreign-invested enterprises is large. Therefore, the spillover effect can promote technological progress, product innovation and production process innovation, which improves the productivity and competitiveness of enterprises. Trade openness can increase the import and export volume of the Central region, increase the attractiveness to foreign investment, and fully utilise both domestic and foreign resources and two markets. Government expenditures have received relatively less policy support than in the Eastern and Western regions, but improved infrastructure and public services have contributed to coordinated regional development.

In contrast, FDI and population in the Central region do not contribute significantly to economic growth. This is because FDI mainly invests in labour-intensive or resource-intensive low value-added industries, the proportion of sole proprietorships has increased, the enclave model is not conducive to technological spillovers, and the short-term benefits of FDI are offset by the intensity of pollution control. The labour force is abundant, but the demographic dividend is diminishing, and the loss of high-end population to the east is serious, which plays a negative role in economic growth.

The spatial spillover effect of economic growth in the Central region is the largest amongst the three regions. The economic growth of the neighbouring province in the Central region will drive the economic growth of the giving province, and its economic growth has a significant spillover effect on both the Eastern and Western regions. The reason lies in its hub location connecting the east and west, the main receiving place of industrial transfer from the Eastern region, the policy support of the rise of Central China and the strong complementarity of resources and other factors. At the same time, there is a large gap between the economic level of the capital cities in the central region and that of the neighbouring regions, and the former has led to the extension of the industrial chain of the latter, so the spillover effect is more significant.

In the spatial lag model, FDI, technology spillover, trade openness and government expenditure in the Western region can significantly promote economic growth. The Western region is most lacking in capital and advanced technology, while FDI brings capital, technology and management experience, which not only improves production efficiency but also increases jobs and income, and drives the development of upstream and downstream industrial chains. R&D capital stock promotes the upgrading of resource-based and primary processing industries and the development of high value-added industries and brings about a significant technological spillover effect. Trade openness further increases import and export efforts, expands foreign markets, introduces advanced technology, equipment and management experience, further exerts economies of scale, and promotes the transformation of comparative advantages into competitive advantages. Government spending improves infrastructure and public services, enhances livelihood protection, and has the largest positive push effect on economic growth in the Western region. This is consistent with the performance of government spending in the direct effect

in this study. On the contrary, the Western region has serious population loss, limited demographic dividend and is dominated by primary labour force.

The spatial spillover effect of economic growth in the Western region is the smallest amongst the three regions. This is because the Western region is economically underdeveloped, geographically relatively closed, with relatively weak infrastructure and weak economic radiation capacity, which constrains interregional coordination and linkages.

5.5 A Remark

As shown in Table 5.10, empirical discussion indicates technological dominance, the dual nature of FDI and spatial hierarchy. First, technological dominance. In the direct effect model, technology spillovers can significantly promote economic growth in China, especially in the eastern region, while the marginal effects of traditional factors such as FDI and foreign trade are declining. This fully verifies that China's new development pattern, which is dominated by the domestic circulation and mutually reinforced by the domestic and international dual circulation, is taking shape. China's economy has gradually entered the innovation-driven growth and consumption-driven growth modes. Technology spillovers benefit from scientific and technological innovation, and government spending provides public services and a business environment for the market economy, and they increase social productivity and comprehensive national power. As a result, China's economic growth was becoming more internally driven.

Table 5.10: Summary of Empirical Discussion

Items	Direct Effect Model		Indirect Effect Model		Spatial Effect Model	
	Full Sample	Three Regions	Full Sample	Three Regions	Full Sample	Three Regions
FDI	x	x	--	Eastern: x Central: -- Western: x	+	Eastern: x Central: x Western: ++
Technology Spillovers	+++	Eastern >Western >Central	+++	Eastern: + Central: +++ Western: +++	++	Eastern: x Central: +++ Western: +
FDI_TS	N/A		x	Central >Western	N/A	
Spatial Spillovers	N/A		N/A		+++	+++ Central>Eastern >Western
Key Regional Pattern	Eastern region: Strongest tech-driven growth		Central/Western region: Tech-FDI synergy offsets negatives		Central region: Dominant spillover hub	

Note: x represents no significant; -- represents negative significance at the 10% significance level; +++, ++ and + represents positive significance at the 1%, 5% and 10% significance levels, respectively; N/A represents not applicable.

Second, the dual nature of FDI. In the indirect effects model, technology spillovers do not moderate the negative impact of FDI on China's economic growth. Although there are high-tech foreign enterprises such as Tesla Giga Shanghai stationed in China (Han et al., 2023), the overall technological content of foreign investment is on the low side, and the driving effect of industrial upgrading and technological spillovers is not strong, and it is necessary to open up to the outside world to attract high-quality FDI.

Furthermore, the interaction effect showed obvious regional heterogeneity. Similar to the full sample, the interaction effects in the Eastern region are not significant, indicating that the marginal contribution of FDI is weakening, suggesting that the region needs to shift towards more advanced innovation-driven policies. The Central and Western regions exhibit typical dual characteristics, especially the Central region, where FDI alone has an inhibitory effect or is insignificant, but through technology spillover channels, it can produce significant synergistic effects. This inhibition-promotion transformation explains the complexity of the FDI impact mechanism, with its ultimate effect depending on whether it can form a positive interaction with local innovation elements.

Third, spatial hierarchy. In the spatial lag model, China's economic growth has a positive spatial spillover effect. The Central region has the strongest spatial spillover effect in regional coordinated development due to its central location. The Eastern region, however, has weaker spatial spillover effects than the Central region due to excessive industrial concentration, which has led to rising production factor costs and diminishing marginal returns. The Western region is constrained by infrastructure shortcomings, and despite receiving preferential policies, its spatial spillover intensity lags behind that of the Eastern region.

The regional heterogeneity identified in this study can be further attributed to three major structural differences: industrial structure gradients, innovation ecosystem maturity, and technology absorption capacity. From the perspective of industrial structure, the eastern region has formed an upstream-downstream synergy dominated by the service industry and high-tech manufacturing. Benefiting from the Yangtze River Delta Integration and Guangdong-Hong Kong-Macao Greater Bay Area plans, its trade openness has significantly improved productivity through the learning effect of the global value chain.

The Central region is in a transitional phase of deindustrialisation, characterised by high-energy-consuming heavy chemicals and low-value-added traditional manufacturing, with high industrial homogeneity; the positive impact of trade openness on locally related industries is offset by the crowding-out effect. The Western region has a high proportion of resource-based industries, low trade openness efficiency, and resource export revenues that appreciate the exchange rate and suppress manufacturing.

From the perspective of the innovation ecosystem, the Eastern region has a high density of universities, research institutes, and venture capital institutions, and the diverse exchange of knowledge reinforces the innovation dividends of population aggregation. The Central region has relatively dispersed R&D resources and a sparse industry-academia-research cooperation network, making it difficult to convert population scale into patents and new products. The Western region's innovation entities are mainly central enterprises and resource-based state-owned enterprises, but there is a lack of private science and technology enterprises, which limits the depth of technology absorption.

From the perspective of technological absorption capacity, the Eastern region boasts a high stock of human capital and well-developed digital infrastructure, enabling it to rapidly assimilate and re-innovate foreign direct investment (FDI) and imported technologies. The Central region, while possessing the Central Region Rise policy, and a labour cost advantage, faces challenges such as the outflow of highly skilled talent and deficiencies in digital infrastructure, resulting in a high threshold for technological absorption. In recent years, the Western region has enhanced its absorption capacity in certain areas through initiatives such as East Data West Computing, and the construction of science and technology innovation corridors in central cities. However, it remains constrained by insufficient financial depth and low levels of marketisation, resulting in

regional heterogeneity in the net effects of trade openness and population changes in growth.

CHAPTER 6

CONCLUSION

6.1 Conclusion

Chapter 6 consists of seven sections. First, Section 6.1 presents a brief introduction to this chapter. Second, Section 6.2 summarises the results on the three research objectives. Third, Section 6.3 is the contribution to body of knowledge and the stakeholders. Fourth, Section 6.4 provides policy implications. Then, Section 6.5 discusses the limitation of this study and Section 6.6 presents recommendations for future research. Finally, Section 6.7 proposes summary of this chapter.

6.2 Summary of the Result

This study selected the overall sample of China's 30 provincial panel data from 2000 to 2022 and divided it into three sub-samples based on differences in geographic location, and quantitatively analysed the effects of foreign direct investment, technological spillover on economic growth, and heterogeneity amongst the three major regions of China by using the direct model, indirect model, and the spatial lag model. The specific conclusions are as follows:

First, in the direct model, the promotional effect of technology spillovers on economic growth is significantly stronger than that of government expenditure, confirming that China's economy has entered a stage of innovation-driven development, which is consistent with the expectations of endogenous growth theory. The intensity of technology spillover effects in the Eastern region is approximately 1.7 times that of the Central and Western regions, reflecting its mature innovation ecosystem.

Secondly, in the indirect model, the interaction term between FDI and technology spillovers is not significant, suggesting that China's FDI is shifting from technology acquisition-oriented to market-seeking-oriented, and that traditional technology spillover mechanisms may be weakening. The interaction terms for the Central and Western regions are significant, indicating that the net effect of FDI depends on local innovation capabilities, it may crowd out resources in the short term, but in the long term, it needs to rely on technological synergy.

Additionally, in the spatial lag model, spatial dependence reveals provincial growth linkage mechanisms. Specifically, government spending spillovers are strongest, highlighting the multiplier effect of cross-regional infrastructure construction. The Central region has become a core spillover hub thanks to its geographical advantages, serving as a bridge between the Eastern region's technology hub and the Western region's resource belt.

6.3 Contribution of the Study

6.3.1 Contribution to Body of Knowledge

This study explored the nexus between foreign direct investment (FDI), technology spillover and economic growth, which enriches the empirical support on the impact of FDI and technology spillover on economic growth in developing countries, especially in China, and provides inspiration for in-depth research in academia.

(i) By extending endogenous growth theory through the inclusion of spatial dynamics and regional heterogeneity, the study enriches Romer's framework by acknowledging the externalities beyond regional borders.

(ii) By quantifying interaction effects between FDI and R&D, the study advances the literature on absorptive capacity, demonstrating empirically that FDI's growth effects are contingent, not automatic.

(iii) In relation to China's dual circulation strategy, the findings challenge the notion that growth is primarily driven by external FDI by showing the importance of internal innovation capability and inter-provincial linkages.

6.3.2 Contribution to the Stakeholders

First, the government should formulate differentiated regional innovation policies based on endogenous growth theory under spatial constraints, with a focus on optimising the spatial layout of technology spillovers. The government should carry out localised institutional innovation based on the comparative advantages of different regions, promote the organic combination of an efficient market and a conditionally active government, and advance the construction of a unified national market. At the same time, the three regions should give full play to the decisive role of the market in resource allocation, while focusing to the key role of the government in providing basic social security and a business environment that is legalised, market-oriented and internationalised, so as to achieve a higher-quality domestic circulation and a higher-level international circulation.

Specifically, the Eastern region should attract high-tech foreign investment and enhance its capacity to absorb and spill over technology; the Central and Western regions should increase policy, technical, and high-end talent support, vigorously attract resource, labour, and green energy-intensive foreign investment, and promote cross-regional technology spillover and coordinated regional economic development. The three regions should strengthen cross-regional coordination and cooperation to avoid falling into a vicious cycle of low-level duplication of investment and construction, and homogenised

competition between regions. They should exercise caution when considering high-energy consumption, high-pollution, and low-tech industrial projects, and establish a differentiated technology transfer system characterised by Eastern leadership, Central reception, and Western support.

Secondly, multinational enterprises should refer to the technology gap theory when making investment decisions and adopt differentiated investment strategies based on the technology absorption capacity of different regions to deeply lay out the global industrial chain. The first reason is that investment liberalisation is a direct manifestation and motivation of economic globalisation, and China has continuously raised its level of opening-up to the outside world to attract foreign investment and contribute to economic globalisation. In the 2022 Foreign Direct Investment Confidence Index (FDICI) report released by the Kearney Global Business Policy Council (GBPC), China's ranking has risen two places to 10th. Especially between 2021 and 2022, China's effective policy of preventing the outbreak of New Crown Pneumonia has led to a rapid economic recovery and supply chain stabilisation, boosting global investor confidence in the Chinese economy.

The second reason is that foreign-funded enterprises should seize the opportunity to fully utilise China's mega-market size and economic growth potential, and share the dividends brought to the world by China's economic growth. China has a stable political situation, a complete industrial support system and an ever-improving capability of independent innovation. Moreover, China has a huge market with a population of 1.4 billion and an upgrading consumption structure. Foreign companies can maximise their profits in China and therefore regard it as one of the best places to invest. The third reason is that the Chinese market has become an arena to test whether foreign companies have international competitiveness. The Chinese market is highly competitive, with not only

local enterprises but also a large number of foreign enterprises competing for the market. In the fierce market competition, quite a lot of middle-end and low-end products have already achieved good quality and low price and have a high share in the Chinese market and the world market, while the profit margin is getting narrower. Therefore, foreign-funded enterprises need to invest in China's innovation and industrial chain, accelerate localised innovation and R&D, set up multinational R&D centres, and continuously launch new products and services to meet the diversified new demands for consumption upgrading.

Furthermore, Chinese domestic enterprises should adjust their FDI competition and cooperation strategies and implement a composite development path of ‘neighbouring learning, reverse innovation, and gradual transfer’ in strategic emerging industries. The first reason is that the fundamental driving force for the transformation of China's economic growth mode and the enhancement of its international competitiveness is the improvement of the independent R&D and innovation capacity of local enterprises. Enterprises are the main body of innovation, both participating in economic activities and promoting the use of science and technology innovation in production practice. The collection of innovative power of countless enterprises is the micro-basis for the formation of industrial competitive advantages and the guarantee of China's sustained economic growth. The second reason is that Chinese local enterprises should actively absorb technological spillovers, strengthen their independent R&D capabilities, and enhance their economic efficiency and core competitiveness. Chinese local enterprises should not stop at the short-lived prosperity brought by low-cost factors, but should actively learn from their modern enterprise systems and advanced business management models through cooperation and exchanges with foreign-funded enterprises, as well as take the market as

the guide to continuously develop new products and processes, provide new services, and continuously enhance their importance in the global value volume.

6.4 Limitations of the Study

First, the generalisability of the results lacks comparative validation. Because of limited time and effort, this study mainly focused on the single sample of China and did not conduct quantitative research on other developing countries, which may lead to biased results and lack of universal validation of the results. As the largest developing country, China is exploring the path of gradual and high-level reform and opening up, and the relationship between FDI, technology spillovers and economic growth may have special characteristics. For example, many other developing countries do not have regional differences and strong government intervention capabilities similar to China. Therefore, it may be difficult to directly generalise the findings of this study to other developing countries.

Second, the limitations of the three regional divisions. The Eastern, Central, and Western regions adopted in this study are based on commonly used official expressions, but the economic level of some provinces in recent years does not match the region. For example, Liaoning and Hebei provinces in the Eastern region are not economically advanced, while Anhui province in the Central region is very impressive in its innovative capacity as a rising star. But there is no more scientific classification.

Third, the mechanism of micro-level technology spillover lacks verification. From the micro level, the technology absorbed by enterprises can further spread to peers and upstream and downstream enterprises, and the benign development of many enterprises can promote the progress of the whole industry and international competitiveness. This

study quantitatively analysed technology spillovers from a macro perspective but lacks a quantitative analysis of the effect of micro enterprises digesting and absorbing foreign technologies and fully utilising technology spillovers.

Fourth, methodologically, this study acknowledges that the potential for endogeneity between FDI and growth remains a concern despite the use of AMG and SLM estimators. The spatial models, while powerful, depend heavily on the correct specification of the spatial weight matrix, and misspecification can introduce bias. Additionally, proxies for technology spillovers (e.g., R&D capital stock) are limited by data availability and construction assumptions (e.g., depreciation rate, initial capital estimates).

6.5 Policy Implications

First, evidence-based recommendations. Given that research has found the interactive effects of FDI and technology spillovers to be most pronounced in Central and Western regions, it is recommended to pilot a targeted FDI-R&D centre linkage programme in these regions, offering tax incentives to foreign-invested enterprises that establish R&D centres and collaborate with local universities or businesses. Encourage foreign-invested enterprises to establish R&D centres, enhance the convenience of R&D activities for foreign-invested enterprises, and actively attract overseas talent, guiding their investments toward advanced manufacturing, emerging industries, and green and low-carbon sectors. Foreign-invested R&D centres can better leverage the role of foreign investment in allocating global innovation resources and effectively harness the interactive effects between foreign investment and technology spillovers, thereby driving local industrial upgrading and economic growth.

Domestic enterprises can establish joint laboratories with foreign-invested enterprises, especially in Central hub cities such as Hefei, Wuhan, and Zhengzhou, to pilot foreign-invested technology transfer platforms, requiring participating enterprises to match local supply chain enterprises. Efforts should be made to increase investment in scientific and technological research and development and cooperation with foreign-invested enterprises, enhance independent innovation capabilities on the basis of digesting and absorbing foreign technologies, and improve the technological content and international competitiveness of products. The number of joint R&D projects each year and the proportion of domestic enterprises' patents citing foreign technologies should be gradually increased.

It should be noted that local enterprises should not blindly, repetitively, or low-quality attract investment. Instead, they should introduce foreign capital with strong industrial relevance based on local characteristics and comparative advantages, thereby forming a radiating and driving effect on upstream and downstream industries, producing industrial agglomeration effects, and promoting the extension of industrial chains and economic growth.

Second, recommendations based on national development goals. Based on the regional differences in technology spillover identified in the study, formulate differentiated foreign investment attraction policies, with the Eastern region focusing on R&D-oriented FDI and the Central and Western regions focusing on technology-applicable FDI. Optimise the structure of foreign investment, on the one hand restricting the inflow of speculative foreign investment and on the other hand strengthening industrial guidance for foreign investment.

Aligning with international high-standard trade and economic rules, continuously improving laws and regulations, protecting intellectual property rights, and further optimising the business environment and institutional framework. Institutional innovation can reduce transaction costs and institutional risks for enterprises, thereby providing foreign-invested enterprises with fair and open market access conditions and a business environment, which is conducive to promoting high-level opening-up and integrating into a higher-level international economic circulation. Continuously improving market access standards, reducing the negative list for foreign investment access, and attracting more foreign investment. Foreign-invested enterprises in areas outside the negative list are managed in accordance with the principle of equal treatment for domestic and foreign investments and enjoy national treatment.

With the continuous increase in per capita income and the upgrading of consumption capacity, the potential of China's huge domestic market is becoming apparent. The low-cost comparative advantage based on primary factors such as natural resources and labour is gradually being lost. The gradual formation of China's huge domestic market, industrial support capabilities, and talent dividends will become new advantages in attracting foreign investment.

Thirdly, based on the OECD's exploratory suggestions. Referring to the OECD's regional coordination principles, explore the establishment of cross-regional infrastructure co-construction and sharing mechanisms and technology spillover compensation mechanisms. Focus on improving transportation and digital connectivity within the Yangtze River Delta, Beijing-Tianjin-Hebei, and Guangdong-Hong Kong-Macao Greater Bay Area radiation zones. Pilot the innovation visa system and extend the scope of

technology spillover through the enclave economy model, providing additional rewards for foreign investment projects that generate significant positive spillover effects.

Specifically, the Eastern region focuses on attracting technology-intensive and knowledge-intensive foreign investment and foreign trade, leveraging the leading, and technology spillover effects of developed regions such as Beijing, Shanghai, and Guangzhou, and transferring foreign investment projects with diminishing marginal returns to Central and Western regions. It fully utilises the resource endowments of central and western regions to implement fly-in economy strategies, thereby enhancing the synergistic growth of regional economies. The central region should leverage its late-mover advantage, fully utilise government expenditure to improve infrastructure, and play a crucial role as a transportation hub linking the Eastern and Western regions. It should actively accept industrial transfers from the eastern region, attract foreign investment in high-end manufacturing and productive services, and leverage both domestic and international technology spillover effects. The Western region should develop green energy industries based on local conditions, while leveraging tax incentives, the recruitment of high-end talent, and cross-regional cooperation projects to fully utilise its border geographical advantages. This will attract more foreign investment and effectively utilise technological spillover effects to promote balanced economic growth between China's coastal and inland regions.

6.6 Recommendations for Future Studies

In order to make up for the limitations of existing research and reveal the impact of FDI and technology spillover on China's economic growth in a more comprehensive and dynamic way, future research can consider the following aspects:

First, cross-country comparative research. Cross-country panel studies could replicate the spatial and interactive modelling framework to examine the generalisability of results across emerging economies with similar dual-track development models. For example, countries such as Brazil, Russia, India and South Africa in the BRICS countries, as well as Malaysia, Singapore, and Vietnam in the Association of Southeast Asian Nations.

Second, intra-regional studies. In view of the three major regions of China's introduction of foreign investment, technology spillover and economic level of difference, future research can be one of the regions in-depth study, especially on the domain of certain provinces to analyse the characteristics and provide replicable and popularised experience. For example, Anhui Province in the Central region has tapped into the advantages of late-stage innovation.

Third, dynamically analyse the heterogeneity of technology spillovers at the micro level. Future studies could use firm-level data to validate the mechanism of spillovers and interaction effects identified at the macro-regional level. Meanwhile, microdata can also be classified by industry to observe the commonalities and characteristics of technology spillovers across different industries.

Fourth, methodological improvements. It is recommended that subsequent studies consider using exogenous shocks such as changes in foreign investment access policies to construct instrumental variables. Additionally, alternative spatial weight matrices and spatial panel estimators (e.g., SAR, SEM) can be employed to test the robustness of the spatial dependence findings. In terms of parameter settings, the system tests the sensitivity of capital depreciation rates and initial capital estimation methods and introduces the

proportion of technology introduction expenditure as a dynamic adjustment factor, providing methodological innovation for accurately quantifying technology spillover effects in the Chinese context.

While this study addresses critical econometric challenges such as endogeneity, heteroskedasticity, autocorrelation, multicollinearity, and stationarity; the use of the Augmented Mean Group (AMG) estimator, developed by Eberhardt and Teal (2010), which allows for heterogeneous slope coefficients and controls for cross-sectional dependence and unobserved common factors, along with the Spatial Lag Model (SLM), as discussed by LeSage and Pace (2009), that accounts for spatial dependence and spillover effects, provides a robust foundation for analysis.

However, future research could benefit from explicitly reporting a comprehensive diagnostic framework, including unit root and cointegration tests (Pesaran, 2007), multicollinearity diagnostics (O'Brien, 2007), and checks for endogeneity and heteroskedasticity (Wooldridge, 2010). Moreover, incorporating extended robustness checks such as alternative spatial weight matrices (Elhorst, 2014), different lag specifications, and sub-sample analyses would enhance empirical validity and facilitate replication.

Future studies may also consider alternative spatial models such as the Spatial Durbin Model (SDM), the Spatial Error Model (SEM), or the General Nesting Spatial Model (GNSM) to further test the stability and consistency of the results (LeSage & Pace, 2009; Elhorst, 2014). Expanding the analysis to include cross-country or regional comparisons would enable the assessment of institutional and policy heterogeneity in influencing FDI and technology spillover effects (Keller, 2004; Jordaan, 2008).

Additionally, the integration of structural break tests (Bai & Perron, 2003) or regime-switching models (Hamilton, 1989) could capture shifts in spatial dynamics arising from major economic transitions. With the increasing availability of high-frequency and granular data, incorporating machine learning techniques within the spatial econometric framework offers a promising avenue for uncovering non-linear relationships and improving forecasting accuracy (Varian, 2014). Lastly, embedding spatial models into policy simulation tools such as dynamic spatial CGE models could provide deeper insights into the spatially differentiated impact of FDI and technology diffusion, thereby enhancing the policy relevance of the research (Robinson et al., 2010; Thissen et al., 2013).

6.7 A Remark

China has been on a path of actively exploring economic growth suited to its national conditions and has become the largest economy in the developing world through the joint efforts of its people, making important contributions to the sustainable growth of the world economy and the building of a community of human destiny. This chapter summarises the whole text. First, it summarises the findings that technology spillover and its interaction with foreign direct investment have positively contributed to China's economic growth, and that there are positive spatial spillovers of economic growth in different regions. Second, the chapter summarises the contributions to body of knowledge and stakeholders. Technological progress as an internal driving force has gradually become a distinctive symbol of China's economic growth. The government should carry out localised institutional innovation according to the comparative advantages of different regions, foreign enterprises should take the initiative to adjust their investment strategies in China and share the dividends of China's economic growth, and local Chinese enterprises should improve their ability to digest, absorb, and transform technology into independent

innovation. Then, the policy implications of this chapter state that China firmly supports and advocates investment liberalisation, continuously explores institutional innovation to attract high-quality foreign investment, and deepens regional synergistic cooperation to gradually form new comparative advantages. In addition, the study limitations such as the results lack of generalisability, the limitation of the three regional divisions, and the lack of technology spillover mechanisms at the micro level. Finally, future research will focus on cross-country comparative studies, intra-regional studies, and dynamic analysis of heterogeneity in micro-level technology spillovers.

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APPENDICES

Table 1: Full Sample for Direct and Indirect Model (CCEMG)

Variable	Constant		Constant and Trend	
	Direct	Indirect	Direct	Indirect
lrfdi	0.0020	0.0137	0.0075	-0.0021
lrdcap	0.1058**	0.1202	0.1544***	0.1076
lrfdi_lrdcap	-	0.0241	-	0.0201
lto	0.0018	-0.0085	-0.0011	-0.0104
lrgs	0.0401**	0.0278	0.0221	0.0147
lpop	0.0478	0.0961	0.0697	0.1644

Note: ***, ** and * represents significance at the 1%, 5% and 10% significance levels, respectively

Table 2: Direct and Indirect Model by Region (CCEMG)

Region	Model		lrfdi	lrdcap	lrfdi_lrdcap	lto	lrsgs	lpop
Eastern	Constant	Direct	0.0167	0.3082 ***	-	0.0035	0.0449 **	0.1476
		Indirect	0.0454	0.3577	-0.0495	-0.0089	0.0546 **	0.1113
	Constant and Trend	Direct	0.0199 ***	0.3357 ***	-	0.0091	0.0457 ***	0.3031 ***
		Indirect	0.2318	0.5281 **	-0.2215	-0.0012	0.0534 ***	-0.0734
Central	Constant	Direct	-0.0005	-0.0083	-	-0.0081	-0.0175	0.2985
		Indirect	-0.0405	-0.1143	0.0344	0.0036	-0.0085 *	0.3869 *
	Constant and Trend	Direct	-0.0004	0.0208	-	-0.0051	-0.0205	0.2634
		Indirect	-0.0474	-0.1191	0.0452	0.0082	-0.0304	0.4056 *
Western	Constant	Direct	-0.0084 **	0.0835	-	-0.0098 **	0.0382	1.0244 **
		Indirect	-0.0114	0.0737	0.0150	0.0003	0.0098	0.5869
	Constant and Trend	Direct	-0.0104 *	0.1131	-	-0.0047	0.0198	0.8910 **
		Indirect	-0.0088	0.0681	0.0076	-0.0004	-0.0095	1.0271 **

Note: ***, ** and * represents significance at the 1%, 5% and 10% significance levels, respectively

