THE IMPACT OF CHANGES IN THE WORKING-AGE POPULATION ON CHINA'S ECONOMIC DEVELOPMENT: FROM THE PERSPECTIVE OF INDUSTRIAL STRUCTURE UPGRADING

XIAOFEI HAO

Graduate School Srinakharinwirot University

2025

THE IMPACT OF CHANGES IN THE WORKING-AGE POPULATION ON CHINA'S ECONOMIC DEVELOPMENT: FROM THE PERSPECTIVE OF INDUSTRIAL STRUCTURE UPGRADING

XIAOFEI HAO

A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of DOCTOR OF PHILOSOPHY
(Doctor of Philosophy Program in Economics (International Program))
Faculty of Economics, Srinakharinwirot University
2025

THE DISSERTATION TITLED

THE IMPACT OF CHANGES IN THE WORKING-AGE POPULATION ON CHINA'S ECONOMIC DEVELOPMENT: FROM THE PERSPECTIVE OF INDUSTRIAL STRUCTURE UPGRADING

BY

XIAOFEI HAO

HAS BEEN APPROVED BY THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY IN DOCTOR OF PHILOSOPHY PROGRAM IN ECONOMICS (INTERNATIONAL PROGRAM) AT SRINAKHARINWIROT UNIVERSITY

(Assoc. Prof. Dr. Chatchai Ekpanyaskul, MD.)

Dean of Graduate School

ORAL DEFENSE COMMITTEE

.... Advisor
(Assistant Professor Sivalap Sukpaiboonwat, Ph.D.)

Chairperson
(Associate Professor Apinya Wanaset, Ph.D.)

.... Co-Advisor
(Associate Professor Aotip Ratniyom, Ph.D.)

...................................Committee
(Associate Professor Suppanunta Romprasert, Ph.D.)

...................................Committee
(Polpat Kotrajarras, Ph.D.)

Title	THE IMPACT OF CHANGES IN THE WORKING-AGE POPULATION ON CHINA'S ECONOMIC DEVELOPMENT: FROM THE PERSPECTIVE OF INDUSTRIAL STRUCTURE UPGRADING
Author	XIAOFEI HAO
Degree	DOCTOR OF PHILOSOPHY
Academic Year	2025
Advisor	Assistant Professor Sivalap Sukpaiboonwat, Ph.D.
Co-Advisor	Associate Professor Aotip Ratniyom, Ph.D.

The study employs a panel dataset comprising 31 provinces in China over the period from 2000 to 2022 to empirically analyze the relationship between changes in the working-age population and China's economic growth, with a particular focus on the mediating and threshold roles of industrial structure upgrading. Empirical results demonstrate that the working-age population ratio exerts a statistically significant positive effect on economic development (β = 0.183, $p < 0.01$). Mediation analysis reveals that industrial structure upgrading fully mediates this relationship: the effect of WA_ratio on GDP growth becomes insignificant when ISU is introduced into the model (Sobel test statistic = 3.45, $p < 0.01$). Moreover, the threshold regression model identifies a critical value of 0.42 for the industrial upgrading index. When ISU is below this threshold, the marginal impact of the working-age population on GDP growth is relatively modest (β = 0.112); however, when ISU exceeds the threshold, the effect strengthens substantially (β = 0.267). These findings suggest that the positive demographic impact on economic growth is conditional upon the degree of industrial advancement. Industrial structure upgrading not only channels the benefits of a large labor force more effectively but also enhances economic resilience in the face of demographic pressures. Therefore, policy recommendations include: (1) accelerating industrial upgrading through technological innovation and service-sector development; (2) enhancing human capital investment to improve labor productivity; (3) promoting differentiated labor policies at regional levels to optimize demographic resources; and (4) integrating demographic planning with long-term economic strategies to sustain high-quality growth.

Keywords: Working-age population,Economic development,Industrial structure upgrading,Demographic transition,Mediation effect,Threshold regression

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to all who supported the completion of this dissertation, “The Impact of Changes in the Working-Age Population on China’s Economic Development: From the Perspective of Industrial Structure Upgrading.” I am deeply thankful to my advisor, Assistant Professor Sivalap Sukpaiboonwat, Ph.D., for her continuous guidance and encouragement, and to my chairperson, Associate Professor Apinya Wanaset, Ph.D., for her constructive advice throughout the research process. My appreciation also extends to my co-advisor, Associate Professor Aotip Ratniyom, Ph.D., whose valuable insights significantly strengthened this work, as well as to the committee members, Associate Professor Suppanunta Romprasert, Ph.D., and Polpat Kotrajarras, Ph.D., for their helpful comments and suggestions. I am equally grateful to my family, friends, and colleagues for their unwavering support, motivation, and understanding, all of which enabled me to complete this dissertation successfully.

XIAOFEI HAO

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1
INTRODUCTION

1.1 Research background

The changes in the working-age population in China significantly influence the country's economic development, particularly through the lens of industrial structure upgrading. As China faces an aging population and a declining demographic dividend, the traditional model of economic growth, which heavily relies on labor input, is becoming increasingly unsustainable. Changes in China’s working-age population exert a profound impact on economic development, with industrial structure upgrading (ISU) serving as the key link between them. This demographic shift necessitates a transformation in industrial structure to maintain competitiveness and foster high-quality economic development. The core logic is clearly defined as “demographic changes strengthen the connection between industrial upgrading and economic development.”The aging population in China has profound implications for labor supply and industrial upgrading. As noted by Shen et al. (Shen et al., 2022), the traditional industrial structure, characterized by low-cost labor and imitation innovation, is no longer viable in the face of an aging workforce. This demographic transition compels China to adopt a more sustainable industrial model that emphasizes technological advancement and higher productivity. Furthermore, Ma's study Ma (2023) indicates that population aging, coupled with migration trends, significantly hinders industrial structure upgrading, suggesting that the labor market's dynamics are crucial for economic transformation. Moreover, the role of industrial structure upgrading as a catalyst for economic growth is well-documented.

Li and Chen Li & Chen (2023) emphasize that the agglomeration of producer services has been pivotal in driving industrial innovation and economic development since the 1980s. This aligns with the findings of Wang et al. (Wang et al., 2018), who demonstrate that industrial structure upgrading is a primary driver of economic growth across China's urban centers. The spatial correlation of economic growth and industrial upgrading suggests that targeted policies can enhance regional development and address disparities in economic performance. In addition, strategic initiatives such as "Made in China 2025" highlight the importance of upgrading industrial structures to achieve high-quality economic development (Li & Chen, 2023). Su et al. (2021) argue that technological innovation and operational efficiency improvements are key drivers of industrial structural upgrades. Furthermore, local government policies are instrumental in shaping the industrial landscape. Zhao et al. Zhao et al. (2022) point out that fiscal decentralization influences industrial structure evolution, indicating that local governance can either facilitate or obstruct the necessary transitions in industrial practices. This underscores the need for coherent policy frameworks that align local initiatives with national economic objectives. In summary, the interplay between demographic changes, labor dynamics, and industrial structure upgrading is critical for China's economic development. The aging population presents challenges that necessitate a shift towards more innovative and sustainable industrial practices. By leveraging technological advancements and enhancing policy frameworks, China can navigate these demographic shifts and continue to foster economic growth.

1.1.1 Demographic Shifts in China's Working-Age Population

According to the National Bureau of Statistics, China's working-age population (aged 15–59) stood at approximately 875.6 million by the end of 2022, accounting for 62% of the total population but decreasing by 6.66 million year-on-year. From 2011 to 2022, the working-age population (15–59 years) dropped by 50 million, leading to severe labor shortages in key industries—manufacturing firms in Guangdong and Zhejiang, for instance, reported workforce deficits exceeding 20% (China Daily, 2023; National Bureau of Statistics, 2023, "Report on China's Labor Market Development in 2022").

The average age of China's labor force reached 39.4 years by the end of 2021, up from 32.2 years in 1985. Five provinces had significantly older working populations: Heilongjiang topped the list with an average of 41.7 years, followed by Liaoning (40.7 years), Jilin (40.5 years), Chongqing, and Zhejiang (all above the national average) (China Daily, 2023).

The demographic dividend... is gradually disappearing...

Projections indicate that the working-age population will decrease by 7.9 million annually from 2020 to 2030, falling to around 825 million (58.6% of the total population) by 2030; by the mid-21st century, the size of the working-age population (15–59 years) may drop to approximately 630 if elderly labor participation is not considered (Ministry of Human Resources and Social Security, 2023, "Research on the Development of China's Elderly Labor Force").

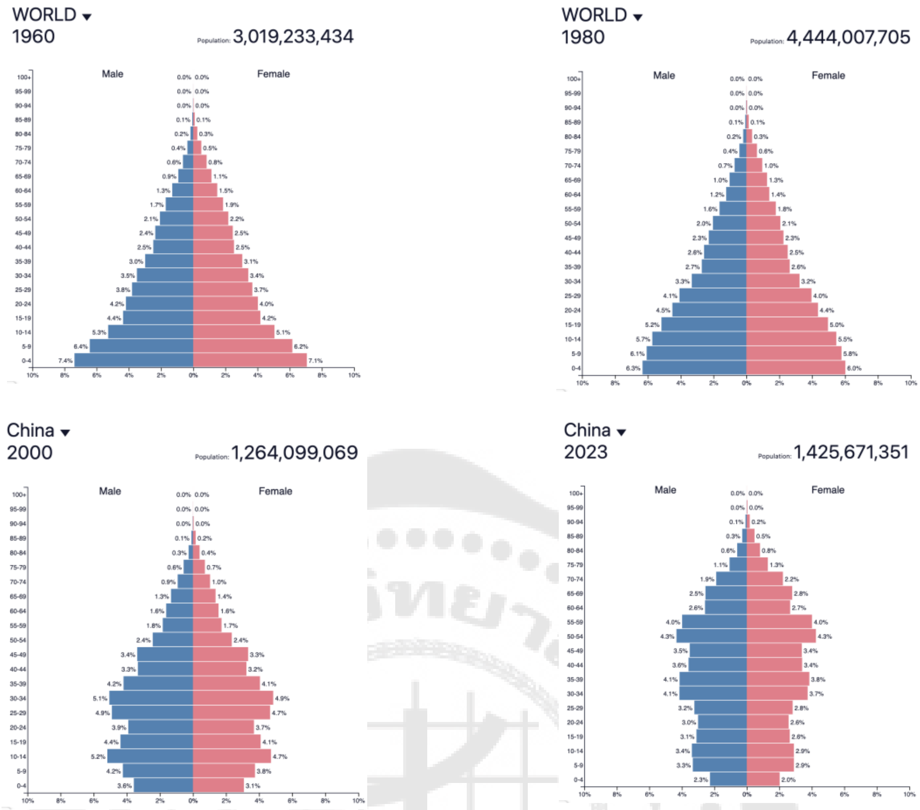

Figure 1 China's Population Pyramids from 1960 to 2023

Source: PopulationPyramid.net (2024)

Figure 1 show that China's Population Pyramids is very changing from 1960 to 2023. Child and workforce trend is decreasing while Population aging is increasing. It means that China has a different population pyramid in each period. Population pyramids can be categorized into three types: stationary, expansive, or constrictive. "Stationary" pyramid or constant population pyramid. A pyramid can be described as stationary if the percentages of population (age and sex) remain approximately constant over time. In a stationary population, the numbers of births and death roughly balance one another. "Expansive" pyramid or Expanding population pyramid. A population pyramid that is very wide at the younger ages, characteristic of countries with a high birth rate and perhaps low life expectancy therefore leading to high death rate. The population is said to be fast-growing, and the size of each birth cohort increases each year. "Constrictive" pyramid or Declining population. A population pyramid that is narrowed at the bottom. The population is generally older on average, as the country has long life expectancy, a low death rate, but also a low birth rate. This may suggest that in future there may be a high dependency ratio due to reducing numbers at working ages. This is a typical pattern for a very developed country, with a high level of education, easy access to and incentive to use birth control, good health care, and few negative environmental factors.

The demographic dividend, defined as the increase in economic growth resulting from a higher ratio of the working-age population to dependents, has been a crucial factor in China's economic development (Ssewamala, 2014). However, as the working-age population decreases due to factors such as population aging, the demographic dividend diminishes, posing challenges to sustaining economic growth (Cai & Yang, 2013). The transition from a demographic dividend to a post-dividend period has been observed in China, marked by changes in the population structure and an increase in the dependency ratio (Lin, 2022).

Furthermore, rapid urbanization in China, driven by the migration of rural-to-urban populations, has further impacted the demographic dividend by straining housing resources in Chinese cities (Hu & Coulter, 2016). This shift in population dynamics has shifted the focus of the demographic dividend from sheer numbers to the age structure of the population (Song & Xie, 2019). Additionally, the transfer of rural labor has played a significant role in unleashing China's demographic dividend and propelling economic growth (Huang et al., 2021). Table 1 illustrates the relationship between China's GDP growth rate and the dependency ratio from 2000 to 2020. Over this period, the dependency ratio, which measures the proportion of non-working-age population (those under 15 and over 59) to the working-age population (15-59), shows a steady increase from 40.5% in 2000 to 42.7% in 2020. Concurrently, China's GDP growth rate exhibits a significant decline, falling from 8.4% in 2000 to just 2.3% by 2020. This trend highlights the demographic shift towards an aging population, which places increasing pressure on the working-age population to support a growing number of dependents. The rising dependency ratio correlates with a slowdown in economic growth, suggesting that demographic changes, particularly the shrinking workforce and aging population, are contributing factors to the deceleration of China's economic expansion. This figure underscores the economic challenges posed by the diminishing demographic dividend as the country transitions to a post-dividend period.

Table 1 China's *GDP Growth Rate vs. Dependency Ratio (2000-2020)*

Year	Dependency Ratio (%)	GDP Growth Rate (%)
2000	40.5	8.4
2005	38.6	10.1
2010	37.4	9.6
2015	39.8	6.9
2020	42.7	2.3

Source: Dependency ratio is from the Department of Economic and Social Affairs Population Division, United nations, https://population.un.org/wpp/; GDP growth rate is from China statistical yearbook 2023, https://www.stats.gov.cn/sj/ndsj/2023/indexeh.htm.

To sum up, China's working-age population has experienced significant changes, moving from a period of demographic dividend to a phase where challenges such as population aging and a shrinking workforce threaten sustained economic growth. Understanding these demographic shifts and their implications is crucial for policymakers to develop strategies to address the evolving labor market dynamics in China.

1.1.2 China's Economic Development and Industrial Structure Upgrading

China's economic development has exhibited phased characteristics, Regional disparities in aging further shape labor mobility: rural aging levels are generally higher than urban areas due to the migration of young rural labor to cities; meanwhile, regions east of the "Hu Huanyong Line" (with dense population and developed economy) have higher aging levels than western regions. For example, Guangdong, a major labor-importing province, has a lower aging rate than labor-exporting provinces like Sichuan and Henan (Liu Lihui, Development Research Center of the State Council, 2021).

The process of industrial structure upgrading in China is quantified using indices such as the industrial structure sophistication index (Qi & Long, 2020). Studies have shown a strong correlation between green finance and the three industrial structures, highlighting the significance of green finance in promoting industrial structure upgrading, particularly in the secondary and tertiary industries (Hu & He, 2023).

Furthermore, the integration of high-tech industries and the penetration of high-tech enterprises have been identified as mechanisms to enhance export technical sophistication, thereby contributing to industrial structure upgrading (Liu & Zhao, 2022).

The industrial upgrading effect of outward foreign direct investment

(OFDI) has been explored in the context of specific regions in China, emphasizing the importance of industrial restructuring and rationalization for economic growth (Chen, 2023). Additionally, the development of rural enterprises and the flow of labor among sectors have been identified as key factors for improving overall economic efficiency in China (Fan et al., 2003). The emphasis on capability building, export orientation, and sequential upgrading has been crucial to China's industrial success and is expected to continue driving its economic growth (Felipe et al., 2010).

Briefly, China's economic development has entered a phase of industrial structure upgrading, characterized by a transition towards a more service-oriented economy and a focus on enhancing export sophistication and technological capabilities. These efforts are essential for sustaining economic growth and competitiveness in the global market.

1.1.3 Theoretical Nexus Between Demographic Changes and Economic Development

To establish the theoretical nexus between demographic changes and economic development, it is essential to consider the impact of demographic shifts on economic growth. Bloom and Canning (2004) emphasize that the relationship between demographic change and economic growth is not automatic. While demographic changes can influence economic development, the exact nature of this impact depends on various factors, including education levels, age structure, and workforce dynamics.

Studies have shown that demographic changes, particularly in terms of education levels, play a significant role in shaping the demographic dividend and its impact on economic growth. Lutz et al. (2019) highlight that education, rather than age structure, is a key driver of the demographic dividend and its implications for economic development. This underscores the importance of human capital formation and educational investments in leveraging demographic changes for economic growth.

Furthermore, the impact of demographic changes on economic development can be influenced by factors such as fertility rates, population size, and labor force participation. Le & Park (2019) evaluate the impact of demographic change on economic growth across OECD and non-OECD countries, emphasizing the importance of understanding how demographic shifts can either support or hinder economic development.

The relationship between demographic changes and economic development in China has been extensively researched. Recent studies have investigated various aspects of this relationship, shedding light on the dynamics between demographic shifts and economic growth in the country.

Liu et al. (2022) conducted a study on the impact of changes in population age structure on economic growth in China. Their research utilized the overlapping generations (OLG) model and numerical simulation methods to analyze the correlation between demographic variables such as delayed retirement, total fertility rate, and life expectancy, and economic development in China. Hsu et al. (2018) explored the influence of demographic changes, particularly the decline in fertility rates and the evolution of the population age structure, on economic development in China. Their study highlighted the significant implications of demographic transitions for long-term growth in the country. Qin (2024) investigated the impact of the digital economy on demographic dividends in China, considering both quantity and quality perspectives. The study revealed that the digital economy significantly influences demographic quality dividends and has a spillover effect on demographic quantity dividends, particularly through urbanization. Additionally, Liu and Guan-Jun (2018) examined the dynamic interrelationship among R&D investment, technological innovation, and economic growth in China. Their research emphasized the interconnected nature of R&D investment, technological innovation, and economic growth, underscoring the importance of understanding these relationships for sustainable economic development.

Therefore, recent studies have provided valuable insights into the complex interplay between demographic changes and economic development in China. By exploring factors such as population age structure, digital economy influences, and R&D investment, researchers have contributed to a deeper understanding of how demographic shifts shape economic growth in the country.

1.1.4 Significance of Industrial Structure Upgrading in the Context of Demographic Changes

In the context of demographic changes, industrial structure upgrading plays a crucial role in driving economic development in China. As the country faces challenges such as reduced labor supply and rising labor costs due to demographic shifts, industrial upgrading becomes particularly significant for sustaining economic growth.

Studies have shown that industrial structure upgrading can help address the challenges posed by demographic changes in China. For instance, Ma (2023) conducted an empirical study based on Chinese provincial panel data, highlighting the impact of population aging and migration on industrial structure upgrading. The findings underscored the importance of understanding how demographic changes influence the need for industrial transformation. Furthermore, emphasized the critical role of demographic trends in driving high-quality development in the Chinese sports industry, emphasizing the importance of demographic structure improvements for industrial development and structural upgrading (Duan et al., 2022). This suggests that improvements in demographic structure, such as urbanization quality and population quality, are essential drivers of industrial upgrading in China. Moreover, Wang et al. (2022) explored the impact of the "Double Cycle" and industrial upgrading on sustainable high-quality economic development in China, highlighting the significant role of industrial structure optimization and adjustment in improving total factor productivity (TFP). This indicates that active industrial structure upgrading can enhance productivity and contribute to sustainable economic growth. Additionally, Li (2021) investigated the impact of labor mobility on industrial upgrading in China, emphasizing the influence of the migrant labor force on industrial transformation and its mechanisms. This suggests that labor mobility can play a crucial role in driving industrial upgrading processes in response to demographic changes.

Therefore, industrial structure upgrading is particularly important for China's economic development in the context of demographic changes. By improving industrial efficiency, addressing labor challenges, and enhancing productivity, industrial upgrading can help China navigate the complexities of demographic shifts and maintain sustainable economic growth in the long run.

1.1.5 Research Gap and Innovations

Existing studies mostly examine demographic changes or industrial structure upgrading separately, but limited research investigates their mediating and non-linear mechanisms in China. Specifically, most literature focuses on linear relationships between demographic changes and economic growth, ignoring potential threshold effects conditioned by industrial structure upgrading. Additionally, few studies systematically link the three elements—working-age population changes, industrial structure upgrading, and economic development—into a unified analytical framework, leaving the transmission mechanism and boundary conditions unclear. This study aims to fill this gap by revealing the complex connections through mediation and threshold effect models.

1.2 Objectives of the study

1. To examine the direct impact of changes in the working-age population on China's economic development, focusing on key economic indicators such as GDP growth rate, per capita GDP, and TFP.
2. To investigate the impact mechanism of industrial structure upgrading in the relationship between working-age population changes and economic development, utilizing a mediation effect model to quantify the indirect effects.
3. To identify potential threshold effects of industrial structure upgrading in the relationship between working-age population changes and economic development, employing a threshold effect model to determine critical values at which the nature or strength of the relationship changes significantly.

1.3 Scope of Study

This research focuses on the impact of working-age population changes on China's economic development from 2000 to 2022, with a specific emphasis on the role of industrial structure upgrading. The study will analyze national-level data, encompassing key economic indicators, demographic statistics, and industrial structure metrics. The research will employ mediation effect and threshold effect models to examine the complex relationships between demographic changes, industrial upgrading, and economic development. While the primary focus is on China, comparative references to other major economies may be included to provide context. The study will consider major economic sectors but will not delve into industry-specific analyses. Policy implications will be discussed at a macro level, without detailed recommendations for individual industries or regions.

1.4 Significance of the Research

This research contributes significantly to the existing body of knowledge in several ways, directly addressing the objectives outlined in Section 1.2:

1) By examining the direct impact of working-age population changes on China's economic development (Objective 1), this study extends the theoretical framework linking demographic changes to economic outcomes. It provides a more nuanced understanding of how population dynamics influence key economic indicators in the context of China's unique demographic transition.

2) The investigation of the impact mechanism of industrial structure upgrading (Objective 2) contributes to the literature by incorporating the mediating role of industrial transformation in the relationship between demographic changes and

economic development. This novel approach offers a more comprehensive understanding of the complex interactions between population dynamics, industrial evolution, and economic growth.

3) The identification of potential threshold effects (Objective 3) in the relationship between working-age population changes and economic development, as mediated by industrial structure upgrading, introduces a new dimension to the existing theoretical models. This approach allows for a more sophisticated analysis of non-linear relationships and critical points in the demographic-economic nexus.

4) The comprehensive analysis provided by this research can inform the development of integrated policies that simultaneously address demographic challenges, promote industrial upgrading, and foster economic growth. This holistic approach can enhance the overall effectiveness of economic and social policies.

5) The empirical findings will provide key support for China's policy transition in the post-demographic dividend period. It offers scientific evidence for the government to formulate industrial policies and labor market policies adapting to demographic changes, facilitating the coordinated adaptation of demographic structure, industrial structure, and economic development.

1.5 Definitions

1) Working-Age Population: Refers to individuals aged 15-59 years old who are potentially economically active. In the context of this study, it represents the primary labor force driving China's economic development (United Nations, 2019).

2) Industrial Structure Upgrading: The process of shifting the composition of economic activities towards higher value-added industries and more technologically

advanced sectors. This typically involves a transition from agriculture to manufacturing, and then to services and knowledge-based industries (Chenery et al., 1986).

3) Total Factor Productivity (TFP): A measure of economic efficiency and technological progress, calculated as the portion of output growth not explained by the growth in inputs (labor and capital). In this study, TFP serves as a key indicator of the quality of economic growth (Solow, 1957).

4) Demographic Dividend: The economic growth potential that can result from shifts in a population's age structure, mainly when the share of the working-age population is larger than the non-working-age share of the population (Bloom et al., 2003).

5) Mediation Effect: In the context of this research, it refers to the indirect influence of working-age population changes on economic development through industrial structure upgrading. This effect helps explain the mechanism by which demographic shifts impact economic outcomes (Baron & Kenny, 1986).

6) Threshold Effect: A phenomenon where the relationship between variables changes significantly once a certain critical value (threshold) is reached. In this study, it pertains to potential non-linear relationships between working-age population changes, industrial upgrading, and economic development (Hansen, 2000).

CHAPTER 2
RELATED THEORIES AND LITERATURE REVIEW

This chapter aims to provide a comprehensive theoretical foundation and literature background for the study. It is structured in two main sections. The first section introduces four key theories that are closely related to the research topic, establishing a robust theoretical framework. The second section presents an extensive review of existing literature, encompassing three primary aspects: the relationship between population changes and economic development, the impact of industrial structure upgrading on economic development, and the interplay between population changes and industrial structure transformation. This structural arrangement facilitates the construction of a comprehensive theoretical framework and lays a solid foundation for subsequent empirical analysis.

Related Theories

- Demographic Transition Theory
- Lewis Dual-Sector Model
- Endogenous Growth Theory
- Structural Transformation Theory

Literature Review

- The Relationship between Demographic Changes and Economic Development
- The Impact Mechanism of Industrial Structure Upgrading on Economic Development
- Research on Demographic Changes and Industrial Structure Transformation

2.1 Related Theories

2.1.1 Demographic Transition Theory

The phenomenon through which fertility rates ultimately decrease to low and stable levels is encapsulated in a well-known framework within economic demography known as the demographic transition. According to Todaro, M. P., & Smith, S. C. (2015) in Figure 2 and 3, the demographic transition seeks to elucidate the common trajectory that contemporary developed nations have traversed, which consists of three distinct stages in modern population history. In the initial stage, prior to their economic modernization, these nations experienced populations that were stable or exhibited very slow growth, attributable to a combination of high birth rates and correspondingly high death rates. The second stage commenced with the advent of modernization, characterized by improvements in public health, enhanced nutrition, increased income, and other advancements that significantly reduced mortality rates, thereby elevating life expectancy from below 40 years to over 60 years. Notably, this decline in death rates did not immediately coincide with a reduction in fertility rates. Consequently, the widening gap between elevated birth rates and decreasing death rates resulted in substantial increases in population growth relative to previous centuries. Thus, stage 2 signifies the onset of the demographic transition, which involves a shift from stable or slowly growing populations to a phase of rapid population increase, followed by a subsequent decline in growth rates. The third stage is marked by the influences of modernization and development, which initiate a decline in fertility rates. Over time, the decreasing birth rates align with the lower death rates, resulting in minimal or negligible population growth. This transition reflects a movement from a relatively high number of births per woman to a level of replacement fertility, estimated to be approximately 2.05 to 2.1 births per woman, assuming that nearly all women survive to the average age of childbearing, as is the case in developed nations. In contrast, in developing countries with significantly lower survival rates, replacement fertility may exceed three births per woman.

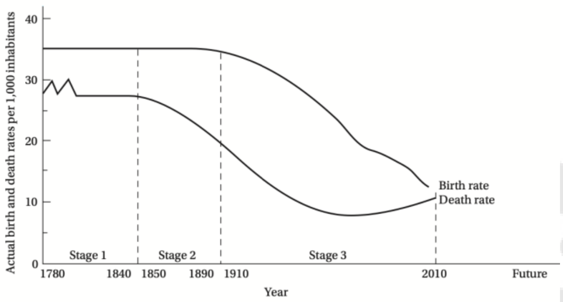

Figure 2 The Demographic Transition in Western Europe

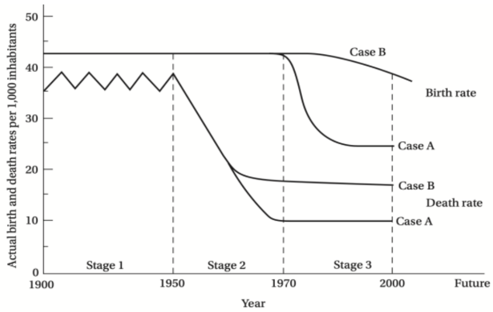

Figure 3 The Demographic Transition in Developing Countries

Source: Todaro, M. P., & Smith, S. C. (2015)

2.1.2 Lewis Dual-Sector Model

One of the most prominent early theoretical frameworks addressing the **structural transformation** of predominantly subsistence economies was developed by Nobel laureate W. Arthur Lewis in the mid-1950s. This model was subsequently refined, formalized, and expanded upon by John Fei and Gustav Ranis. The **Lewis two-sector model** emerged as a foundational theory for understanding the development processes in surplus-labor economies during the 1960s and early 1970s, and it continues to be utilized, particularly in the analysis of recent economic growth in China and labor markets in other developing nations.

In the Lewis model, the underdeveloped economy is characterized by two distinct sectors: a traditional, overpopulated rural subsistence sector, which exhibits zero marginal labor productivity—allowing for the classification of labor as surplus, as its withdrawal from the agricultural sector does not result in a decrease in output—and a high-productivity modern urban industrial sector, into which labor from the subsistence sector is progressively transferred. The model primarily emphasizes the processes of labor migration and the growth of output and employment within the modern sector (which may encompass modern agriculture but will be referred to as the "industrial" sector for brevity). The expansion of both labor transfer and employment in the modern sector is driven by output growth in that sector, with the rate of industrial investment and capital accumulation determining the pace of this expansion. Such investment is facilitated by the surplus of profits in the modern sector over wages, under the assumption that capitalists reinvest all profits. Furthermore, Lewis posited that wages in the urban industrial sector remain constant, established as a fixed premium above a predetermined average subsistence wage in the traditional agricultural sector. Under this constant urban wage scenario, the supply curve of rural labor to the modern sector is regarded as perfectly elastic.

Figure 4 illustrate the Lewis model of modern-sector growth in a two-sector economy. Consider first the traditional agricultural sector portrayed in the two right-hand diagrams. The upper diagram shows how subsistence food production varies with increases in labor inputs. It is a typical agricultural production function in which the total output or product (TP_A) of food is determined by changes in the amount of the only variable input, labor (L_A), given a fixed quantity of capital, K_A , and unchanging traditional technology, t_A. In the lower-right diagram, we have the average and marginal product of labor curves, AP_{LA} and MP_{LA}, which are derived from the total product curve shown immediately above. The quantity of agricultural labor (Q_{LA}) available is the same on both horizontal axes of the right-hand side of the figure and is expressed in millions of workers, as Lewis is describing an underdeveloped economy where much of the population lives and works in rural areas.

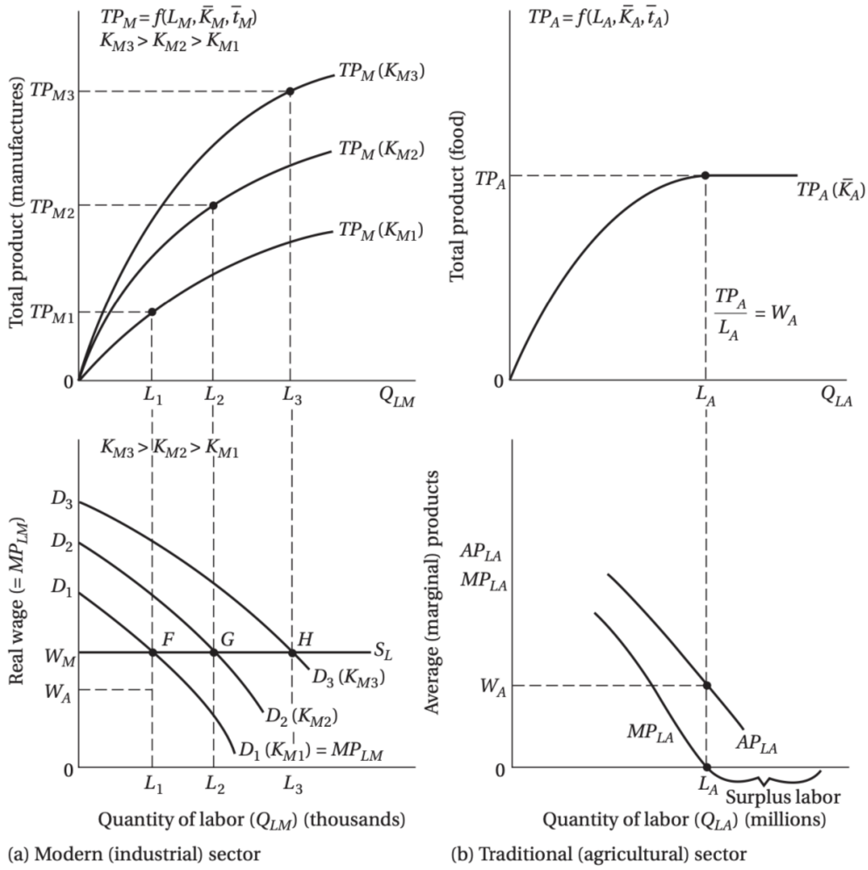

Figure 4 The Lewis Model of Modern (industrial) and Traditional (agricultural) sector

Source: Todaro, M. P., & Smith, S. C. (2015)

Key Concepts of the Lewis Model:

1. **Two-Sector Economy:** The model divides the economy into two sectors:

Traditional Agricultural Sector: This sector is characterized by low productivity and surplus labor. In this context, surplus labor refers to workers whose marginal productivity is zero or very low, meaning they contribute little to no additional output.

Modern Industrial Sector: This sector is characterized by higher productivity and the potential for capital accumulation. It absorbs the surplus labor from the agricultural sector, leading to industrialization and economic growth.

2. **Labor Transfer and Industrial Growth:**

The process of economic development, according to Lewis, is driven by the transfer of labor from the traditional agricultural sector to the modern industrial sector. As workers move to the industrial sector, their productivity increases, leading to overall economic growth. The profits generated in the industrial sector are reinvested, further expanding the capacity of the sector and absorbing more labor from the agricultural sector.

3. **Wage Determination:**

In the Lewis model, wages in the industrial sector are assumed to be constant and higher than in the agricultural sector. This constant wage level attracts workers from the agricultural sector, where wages are determined by the average product of labor. The labor supply to the industrial sector is perfectly elastic at this wage rate until all surplus labor in the agricultural sector is absorbed.

4. **Capital Accumulation:**

The rate of capital accumulation in the industrial sector determines the speed at which labor is transferred and the sector grows. As profits are reinvested, the industrial sector expands, further driving economic development.

5. **Lewis Turning Point:**

The model reaches a "turning point" when the surplus labor in the agricultural sector is fully absorbed. Beyond this point, any additional labor transfer from agriculture to industry would result in a decrease in agricultural output, as labor becomes scarce. At this stage, wages in the industrial sector start to rise, signaling the end of the surplus labor phase and the beginning of a new phase of economic development.

However, the model has faced criticism and refinement over the years. Fields (2004) pointed out that the assumption of a perfectly elastic labor supply from the traditional sector is often unrealistic. He proposed a more nuanced view of labor market segmentation in developing countries. Moreover, the original model's focus on manufacturing as the primary modern sector has been questioned in light of the increasing importance of the service sector in many developing economies. Gollin (2014) suggested that the principles of the Lewis model could be extended to understand the growth of the service sector in developing countries.

The Lewis model has also been critiqued for its simplification of the development process. Todaro and Smith (2015) noted that the model doesn't account for technological change, human capital accumulation, or institutional factors that can significantly influence development outcomes. Despite these criticisms, the Lewis Dual Sector Model remains a fundamental framework for understanding structural transformation in developing economies. Its insights into labor migration, sectoral shifts, and the dynamics of economic growth continue to inform development policy and research.

In the context of China's economic development and industrial upgrading, the Lewis model provides a valuable lens for understanding the country's rapid industrialization and the challenges it now faces as it moves beyond the Lewis turning point. As China transitions from labor-intensive manufacturing to more capital- and skill-intensive industries, the model's implications for wage dynamics, productivity growth, and structural change remain highly relevant. The enduring influence of the

Lewis model in development economics underscores its importance in analyzing the complex relationships between labor migration, industrial upgrading, and economic growth in developing economies.

2.1.3 Endogenous Growth Theory

Endogenous Growth Theory emerged in the 1980s as a response to the limitations of neoclassical growth models, particularly their inability to explain long-term economic growth without relying on exogenous technological progress. This theory emphasizes the role of human capital, knowledge, and innovation in driving economic growth, making it particularly relevant for understanding the importance of industrial upgrading in maintaining economic growth, especially as demographic dividends diminish. The foundations of endogenous growth theory can be traced back to Arrow's (1962) concept of "learning by doing" and Uzawa's (1965) work on human capital. However, it was Paul Romer's seminal paper in 1986 that formally introduced the theory, proposing that knowledge spillovers and increasing returns to scale could lead to sustained economic growth without relying on exogenous factors.

Building on Romer's work, Robert Lucas (1988) developed another influential model focusing on human capital accumulation. Lucas argued that investments in education and on-the-job training lead to productivity improvements that can sustain long-term growth. His model highlights the externalities associated with human capital, where the average level of human capital in an economy enhances the productivity of all factors of production.

Romer's model (1990) posits that technological progress is driven by purposeful R&D activities, and that ideas are non-rival goods, meaning they can be used simultaneously by many firms. This leads to increasing returns to scale in the production of goods and sustained growth. The model emphasizes the importance of human capital in the research sector for generating new ideas and driving economic growth.

Assume symmetry across industries for simplicity, so each industry will use the same level of capital and labor. Then, the aggregate production function:

$$Y = AK^{\alpha+\beta}L^{1-\alpha}$$

To make endogenous growth stand out clearly, we assume that A is knowledge, constant rather than rising over time; that is, we assume for now that there is no technological progress. With a little calculus, it can be shown that the resulting growth rate for per capita income in the economy would be

$$g - n = \frac{\beta n}{1-\alpha-\beta}$$

where g is the output growth rate and n is the population growth rate. Without spillovers, as in the Solow model with constant returns to scale, $\beta = 0$, and so per capita growth would be zero (without technological progress). However, with Romer's assumption of a positive capital externality, ($\beta > 0$), we have that $g - n > 0$ and $Y > L$ is growing. Now we have endogenous growth, not driven exogenously by increases in productivity. If we also allowed for technological progress, so that λ in the Solow model is greater than zero, growth would be increased to that extent.

Grossman and Helpman (1991) extended the theory to incorporate international trade and technology diffusion. They argued that openness to trade can accelerate growth by facilitating the flow of ideas across borders and increasing the returns to innovation.

Aghion and Howitt (1992) introduced the concept of creative destruction into endogenous growth theory. Their model emphasizes the role of innovations that render existing technologies obsolete, arguing that this process of continuous upgrades drives economic growth. This perspective is particularly relevant for understanding industrial upgrading and its role in maintaining economic competitiveness.

As the theory evolved, it began to address some of its initial limitations. Jones (1995) pointed out that the early models predicted scale effects that were not observed empirically, leading to the development of "semi-endogenous" growth models that partially reintroduced diminishing returns to knowledge creation.

More recent developments in endogenous growth theory have focused on the institutional and policy factors that influence innovation and growth. Acemoglu, Aghion, and Zilibotti (2006) emphasized the importance of appropriate institutions and policies at different stages of development, arguing that what drives growth in developing countries may differ from what drives growth in advanced economies.

The theory has significant implications for understanding China's economic development and future challenges. As China transitions from a labor-intensive, investment-driven growth model to one based more on innovation and high-value-added industries, the insights of endogenous growth theory become increasingly relevant. The theory suggests that continued investment in education, R&D, and institutional quality will be crucial for sustaining China's economic growth as its demographic dividend wanes.

However, the theory is not without criticism. Some argue that it still fails to fully explain the fundamental causes of growth differences across countries (Easterly and Levine, 2001). Others point out that the theory's emphasis on R&D and high-tech innovation may not be equally applicable to all developing countries (Pack, 1994).

Despite these criticisms, endogenous growth theory remains a cornerstone of modern growth economics. Its emphasis on human capital, knowledge, and innovation provides a powerful framework for understanding the dynamics of long-term economic growth and the importance of industrial upgrading. As countries like China navigate the challenges of maintaining growth in the face of demographic changes, the insights of endogenous growth theory continue to offer valuable guidance for policymakers and researchers alike.

2.1.4 Structural Transformation Theory

Similar to the earlier Lewis model, the patterns-of-development analysis of structural change emphasizes the sequential process through which the economic, industrial, and institutional framework of an underdeveloped economy evolves over time, enabling new industries to supplant traditional agriculture as the primary driver of economic growth. However, unlike the Lewis model and the original stages of development perspective, analysts within the patterns-of-development framework regard increased savings and investment as necessary but insufficient conditions for fostering economic growth. In addition to capital accumulation—both physical and human—there exists a requisite set of interrelated transformations within a country's economic structure to facilitate the transition from a traditional economic system to a modern one. These structural transformations encompass nearly all economic functions, including the reconfiguration of production processes, shifts in consumer demand composition, alterations in international trade dynamics, and changes in resource utilization, alongside socioeconomic factors such as urbanization and the growth and distribution of the population within a country.

Structural Transformation Theory is a fundamental concept in development economics that explains the process of economic change as countries move from low-income, primarily agricultural economies to high-income, industrialized and service-oriented economies. This theory is crucial for understanding the relationship between demographic changes, industrial upgrading, and economic development.

The origins of structural transformation theory can be traced back to the work of Colin Clark (1940) and Allan Fisher (1939), who observed the systematic changes in the sectoral composition of economies as they develop. They noted a general pattern of declining agricultural employment and rising industrial and service sector employment as per capita income increases. However, it was Simon Kuznets who provided a comprehensive framework for understanding structural transformation. In his seminal work "Modern Economic Growth" (1966), Kuznets identified several key features of modern economic growth, including the shift from agriculture to non-agricultural pursuits and from industry to services. He emphasized that these structural changes were both a cause and a consequence of economic growth.

Baumol (1967) introduced the concept of "cost disease" in services, arguing that productivity growth in labor-intensive services tends to be slower than in goods-producing sectors. This insight helped explain the rising share of services in employment and nominal GDP as economies develop, despite slower productivity growth in this sector. Hollis Chenery made significant contributions to the theory with his work on patterns of development. Chenery and Syrquin (1975) conducted extensive cross-country analyses to identify common patterns of structural change associated with economic development. They found that as per capita income rises, the share of agriculture in GDP and employment declines, while the shares of manufacturing and services increase.

The theory of structural transformation has been further developed to incorporate various aspects of economic development. Acemoglu and Guerrieri (2008) developed a model that explains structural change as a result of both sector-specific technological progress and capital deepening. Their model shows how faster technological progress in capital-intensive sectors can lead to a shift of resources towards labor-intensive sectors. The theory of structural transformation has important implications for understanding China's economic development. As noted by Brandt, Hsieh, and Zhu (2008), China's rapid economic growth has been accompanied by significant structural changes, including a massive shift of labor from agriculture to industry and services. However, as China approaches higher income levels, it faces new challenges in continuing this transformation, particularly in upgrading its industrial structure and developing a high-value service sector.

More recent research has focused on the implications of structural transformation for inequality and inclusive growth. McMillan and Rodrik (2011) highlighted that the growth-enhancing effects of structural change depend on whether labor moves to higher or lower productivity sectors. They found that in many developing countries, especially in Latin America and Africa, structural change has often been growth-reducing, with labor moving from higher to lower productivity activities. Rodrik (2016) emphasized the role of industrialization in structural transformation, arguing that manufacturing has historically been the key driver of productivity growth and economic convergence. However, he also noted that many developing countries are experiencing "premature deindustrialization," where the share of manufacturing in employment and GDP begins to decline at lower levels of income than was historically the case for advanced economies.

Critics of structural transformation theory argue that it may oversimplify the complex processes of economic development and that the patterns observed in historical data may not necessarily apply to all countries or time periods. For instance, Rodrik's observation of premature deindustrialization suggests that the traditional path of structural transformation may not be available to all developing countries today. Despite these criticisms, structural transformation theory remains a powerful tool for understanding the long-term processes of economic development. It provides a framework for analyzing how changes in sectoral composition interact with demographic shifts, technological progress, and institutional changes to drive economic growth. As countries like China navigate the challenges of moving to higher stages of economic development, the insights from structural transformation theory continue to be highly relevant for both researchers and policymakers.

2.2 Literature review

2.2.1 The Relationship between Demographic Changes and Economic Development

The impact of working-age population changes on economic growth has been a subject of empirical studies, shedding light on the intricate relationship between demographic shifts and economic development. Several recent studies have explored this relationship, providing valuable insights into how changes in the working-age population can influence economic growth.

Most existing studies focus on linear relationships, ignoring the threshold effect between demographic changes and economic growth. For instance, The effects of demographic dynamics on economic growth in EU economies (2025) verified the positive effect of working-age population on economic growth using a PVAR model based on panel data of 19 EU economies from 1970 to 2020, but did not include industrial structure as a moderating variable, which this study intends to supplement.

Yang et al. (2021) conducted a cross-country panel data analysis to investigate the effects of population aging, health investment, and economic growth. The study highlighted that the aging population leads to a decrease in the proportion of the working-age population and the growth rate of the labor force, impacting economic growth negatively. Amornkitvikai et al. (2022) examined the impact of demographic structure, human capital, migration, and environmental degradation on economic growth in Asia. Their findings indicated that the share of the working-age population and the growth of the actively employed population have significant positive effects on economic growth. Tang et al. (2022) explored the economic implications of health care burden for the elderly population, revealing that worsening health in the elderly population could decelerate economic development by lowering the employment rate of the working-age population. Ye et al. (2021) investigated whether the demographic dividend in China was diminishing, finding that a rapid increase in the working-age population had significant positive effects on economic growth in East Asia. In a study by (Liu et al., 2022), the impact of population age structure change on economic growth in China was analyzed, emphasizing the demographic window of opportunity created by a higher proportion of the working-age population. Kalemli-Ozcan et al. (2000) examined the relationship between demographic dynamics and economic growth in EU economies using panel data from 1970 to 2000, confirming a positive effect of the working-age population but neglecting industrial structure as a moderating variable, which this study intends to supplement.Bawazir et al. (2023) studied seven Middle Eastern countries and found that a 1% increase in the working-age population ratio leads to an average 0.08% increase in economic growth, supporting the positive impact in Asian emerging economies.revealing that driving the development of silver-hair industries could promote economic growth, particularly in secondary industries.

Table 2 Summary of literature review on the relationship between Demographic Changes and Economic Development

Authors	Year	Title	Main Findings	Research Methodology
Yang et al.	2021	Population Aging, Health Investment, and Economic Growth	Aging population reduces the working-age population and labor force growth, negatively impacting economic growth.	Cross-country panel data analysis
Amornkitvikai et al.	2022	Impact of Demographic Structure, Human Capital, Migration, and Environmental Degradation on	The working-age population and employment growth have a significant positive effect on economic growth.	Empirical study using regional data in Asia

Authors	Year	Title	Main Findings	Research Methodology
		Economic Growth in Asia		
Tang et al.	2022	Economic Implications of Health Care Burden for Elderly Population	Worsening health among the elderly slows economic development by reducing the employment rate of the working-age population.	Analytical approach focusing on elderly healthcare burden
Ye et al.	2021	Is the Demographic Dividend Diminishing in China?	A rapid increase in the working-age population positively influences economic growth, but the demographic dividend is diminishing.	Analysis of demographic dividend trends in East Asia
Liu et al.	2022	Impact of Population Age Structure Change on Economic Growth in China	The demographic window of opportunity created by a larger working-age population is significant for China's	Overlapping generations (OLG) model and numerical simulation

Authors	Year	Title	Main Findings	Research Methodology
			economic growth.	
Taguchi & Latjin	2022	Effects of Demographic Dynamics on Economic Growth in EU Economies	Higher proportions of working-age populations positively impact economic growth in EU countries.	Panel vector autoregressive approach
Zhang et al.	2023	Dynamic Analysis of the Effects of Aging on China’s Sustainable Economic Growth	Developing silver-hair industries can promote economic growth, particularly in the secondary sector, despite the challenges of aging.	Dynamic economic modeling of aging and industrial effects

Source: Author's compilation

While these studies provide valuable insights into the impact of working-age population changes on economic growth, further research is needed to explore the nuanced dynamics of demographic shifts and their implications for sustainable economic development.

The aforementioned studies consistently confirm the economic growth effect of the working-age population, providing a basis for Hypothesis H1 (Changes in the working-age population have a direct positive impact on China’s economic development). Meanwhile, the neglect of nonlinear relationships in existing studies indirectly supports the necessity of introducing the threshold effect model in this study.

2.2.2 The Impact Mechanism of Industrial Structure Upgrading on Economic Development

The impact mechanism of industrial structure upgrading on economic development has been a subject of scholarly inquiry, with a focus on understanding how advancements in industrial structure can drive economic growth. Recent studies have explored this relationship, shedding light on the intricate dynamics between industrial upgrading and economic development.

Liao (2024) conducted research on Vietnam's demographic dividend period, emphasizing that a high proportion of the working-age population is conducive to economic growth, creating a unique source of growth known as the demographic dividend period. Qin (2024) investigated the impact of the digital economy on population dividends in China, highlighting the significant role of the digital economy in promoting demographic quality dividends and indirectly influencing demographic quantity dividends through urbanization. Kotschy et al. (2020) examined the demographic dividend beyond being solely an education dividend, emphasizing the broader implications of demographic changes for economic development. The study highlighted the importance of policies aiming to balance age structures through birth control and family planning. Zhang & Zong (2020) explored the transformation of foreign direct investment in China in the context of the demographic dividend, emphasizing the key role of demographic changes in driving economic growth and development. Soldan (2023) provided insights into the demographic dividend and the window of opportunity, presenting a conceptual overview of how changes in population age structure positively affect economic development. Foley (2022) discussed the return of economic justifications for family planning in Africa in pursuit of the demographic dividend, highlighting the comprehensive approach to economic development that the demographic dividend promises. Nguea (2023) analyzed the impact of demographic dividends on economic development at a country level, focusing on the relationship between demographic dividend, age structure, and GDP as proxies for economic development.

The above literature confirms that industrial structure upgrading—especially the rise of high-value service sectors and advanced manufacturing—plays a critical role in sustaining China's economic development. This provides direct literature support for Hypothesis H2 (Industrial structure upgrading plays a mediating role in the impact of changes in the working-age population on China's economic development), as it verifies the linkage between industrial upgrading and economic growth.

Table 3 Summary of literature review on the impact mechanism of industrial structure upgrading on economic development

Authors	Year	Title	Main Findings	Research Methodology
Liao	2024	Research on Vietnam's Demographic Dividend Period	A high proportion of the working-age population supports economic growth by creating a demographic dividend.	Empirical research based on demographic data in Vietnam

Authors	Year	Title	Main Findings	Research Methodology
Qin	2024	Impact of the Digital Economy on Population Dividends in China	The digital economy promotes demographic quality dividends and indirectly influences demographic quantity dividends through urbanization.	Analytical study on digital economy and population dynamics
Kotschy et al.	2020	The Demographic Dividend is More Than an Education Dividend	Emphasized broader implications of demographic changes for economic development, particularly policies aimed at balancing age structures.	Empirical study using demographic data and policy analysis
Zhang & Zong	2020	Transformation of Foreign Direct Investment in China	Demographic changes play a crucial role in driving foreign direct investment (FDI) transformation and economic growth.	Case study on the transformation of FDI in China
Soldan	2023	Insights into the Demographic Dividend and the	Changes in population age structure positively affect economic development,	Conceptual overview on demographic dividends and their

Authors	Year	Title	Main Findings	Research Methodology
		Window of Opportunity	creating a window of opportunity for growth.	economic effects
Foley	2022	Economic Justifications for Family Planning in Africa	Family planning contributes to the demographic dividend, which can positively affect long-term economic growth in Africa.	Analytical study focusing on family planning and its economic implications
Nguea	2023	Impact of Demographic Dividends on Economic Development	Analyzed the relationship between demographic dividends, age structure, and GDP, finding that a balanced age structure promotes economic growth.	Country-level analysis of demographic dividends and economic development

Source: Author's compilation

We can find that the literature reviewed underscores the significance of industrial structure upgrading in driving economic development. By exploring the impact of demographic dividends, digital economy influences, and foreign direct investment in the context of the demographic dividend, researchers have contributed to a deeper understanding of how industrial upgrading mechanisms can enhance economic growth.

2.2.3 Research on Demographic Changes and Industrial Structure Transformation

Research on demographic changes and industrial structure transformation has been a focal point in understanding the dynamics of economic development. Recent studies have explored the relationship between demographic shifts and industrial upgrading, shedding light on the mechanisms through which industrial structure transformation influences economic development.

Guan et al. (2022) investigated the nonlinear influence of environmental regulation on the transformation and upgrading of industrial structure. The study empirically analyzed the impact of environmental regulation on industrial structure transformation and upgrading, highlighting the role of environmental policies in shaping industrial development. Li (2021) examined the impact of labor mobility on industrial upgrading in China, emphasizing the influence of the migrant labor force on industrial transformation and its mechanisms. The study highlighted the importance of understanding labor dynamics in driving industrial upgrading processes. Li et al. (2021) explored the impacts of foreign direct investment and industrial structure transformation on haze pollution across China. By measuring the rationalization and upgrading of industrial structure, the study provided insights into the relationship between industrial transformation and environmental outcomes. Lv "Research on the Impact of Green Finance on Ecological Industrial Structure" (2024) discussed the impact of green finance on ecological industrial structure, emphasizing the transition towards an ecological industrial structure for sustainable economic development. The study highlighted the importance of green finance in promoting industrial structure optimization. Yin et al. (2022) analyzed the industrial transformation and urban economic efficiency evolution in the Yangtze River Economic Belt, focusing on indicators such as industrial transformation range and intensity. The study provided insights into the relationship between industrial transformation and urban economic efficiency. Wang (2022) explored the application of Internet of Things technology to promote high-quality development of resource-based city industrial transformation and upgrading demonstration areas. The study highlighted the role of technological innovation in driving industrial structure transformation.

Recent studies have also highlighted the role of artificial intelligence (AI) in mitigating labor market challenges caused by aging: Population aging significantly exacerbates labor resource mismatch, while AI application alleviates this adverse impact—especially in regions with high average education levels and severe market segmentation (Population aging, artificial intelligence and mismatch of labor resources: evidence from China, 2024).

These studies confirm that demographic changes (such as labor mobility and population aging) significantly affect industrial structure transformation, while industrial upgrading also exhibits nonlinear characteristics. This provides logical support for Hypothesis H3 (The impact of changes in the working-age population on China's economic development has a threshold effect based on the level of industrial structure upgrading).

Table 4 Summary of literature review on demographic changes and industrial structure transformation

Authors Year	Title	Main Findings	Research Methodology
Guan et al.2022	Nonlinear Influence of Environmental Regulation on Industrial Structure Transformation and Upgrading	Environmental regulation plays a significant role in shaping the transformation and upgrading of industrial structures.	Empirical analysis of environmental regulation and industrial upgrading
Li 2021	Impact of Labor Mobility on Industrial Upgrading in China	Migrant labor significantly influences industrial transformation, driving industrial upgrading processes.	Study focusing on labor mobility and industrial upgrading mechanisms
Li et al. 2021	Impact of Foreign Direct Investment and Industrial Structure Transformation on Haze Pollution	The rationalization and upgrading of industrial structure influence environmental outcomes, particularly in terms of pollution reduction.	Empirical analysis on FDI, industrial upgrading, and environmental outcomes

Authors Year	Title	Main Findings	Research Methodology
Lv 2024	Impact of Green Finance on Ecological Industrial Structure	Green finance promotes the transition towards an ecological industrial structure, supporting sustainable economic development.	Study on the relationship between green finance and industrial structure
Yin et al. 2022	Industrial Transformation and Urban Economic Efficiency Evolution in the Yangtze River Economic Belt	Industrial transformation improves urban economic efficiency, with a focus on industrial transformation range and intensity.	Empirical study analyzing the Yangtze River Economic Belt
Wang 2022	Application of IoT Technology to Promote High-Quality Development of Resource-Based City Industrial	IoT technology plays a crucial role in driving the transformation and upgrading of industrial structures in resource-based cities.	Case study on IoT technology and industrial upgrading in resource-based cities

Authors	Year	Title	Main Findings	Research Methodology
		Transformation		

Source: Author's compilation

In conclusion, the literature reviewed underscores the significance of understanding the impact mechanism of industrial structure upgrading on economic development. By exploring the influence of environmental regulation, labor mobility, foreign direct investment, and green finance on industrial transformation, researchers have contributed to a deeper understanding of how industrial upgrading mechanisms can drive economic growth.

2.3 Hypotheses

Based on the above literature review and relevant theories, the following hypotheses are proposed:

H1: Changes in the working-age population have a direct positive impact on China's economic development.

——Supported by Asian Development Bank's Asian Development Outlook 2024, which shows that a 1% increase in the share of working-age population leads to an average 0.08% increase in the economic growth rate of developing economies in Asia.

H2: Industrial structure upgrading plays a mediating role in the impact of changes in the working-age population on China's economic development.

——Supported by Ma (2023), who empirically demonstrated based on China's provincial panel data from 2003 to 2021 that a 1% increase in the share of working-age population boosts the proportion of tertiary industry by 0.32%, confirming the driving effect of labor supply on industrial upgrading; Li & Chen (2023) further verified that industrial structure upgrading is a core driver of economic growth.

H3: The impact of changes in the working-age population on China's economic development has a threshold effect based on the level of industrial structure upgrading.

——Supported by Research on the impacts of dual environmental regulation on regional carbon emissions (2022), which found a "double threshold effect" of environmental regulation using threshold regression model, indirectly suggesting that industrial structure upgrading may act as a threshold variable to moderate the economic effects of other factors.

2.4 Conceptual Framework.

Figure 5 presents a conceptual framework illustrating the relationships between working-age population changes, industrial structure upgrading, and economic development. The framework consists of three main components: working-age population changes as the starting point, economic development as the endpoint, and industrial structure upgrading as an intermediary factor. The framework also highlights "Mediation Effect" and "Threshold Effect," which implies that we explore the mediating role of industrial structure upgrading in the relationship between population changes and economic development, as well as potential threshold effects. Overall, we clearly demonstrate the core concepts of the research and their hypothesized relationships, providing a theoretical foundation for subsequent empirical analysis.

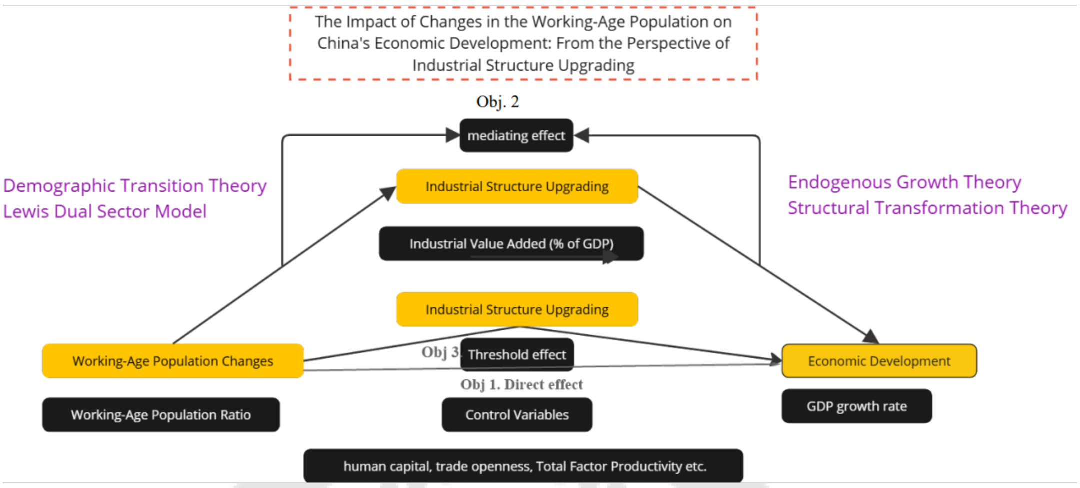

Figure 5 conceptual framework

Source: Authors' conceptualization.

CHAPTER 3
RESEARCH METHODOLOGY

Chapter 3 Research Methodology provides a detailed outline of the variables selected for the study, the models used to analyze the data, and the empirical approach. The chapter is structured around the selection of dependent, core explanatory, and control variables. It introduces both mediation and threshold effect models to examine the impact of demographic changes and industrial structure upgrading on economic development, and explains the methodological steps for estimation.

3.1 Theoretical Framework

The theoretical framework of this study is constructed by integrating relevant economic theories to clarify the logical relationship between changes in the working-age population, industrial structure upgrading and economic development.

3.1.1 Demographic Transition Theory and Lewis Dual Sector Model

Demographic transition theory, which describes the process of population changing from high birth rate, high death rate to low birth rate, low death rate, helps to explain the evolution law of the working-age population size (Caldwell, 1976). In different stages of demographic transition, the proportion and quantity of the working-age population will change, which will affect the labor supply of the society. The Lewis dual-sector model points out that there is a surplus of labor in the traditional agricultural sector, and with the development of the economy, labor will transfer to the modern industrial sector with higher productivity (Lewis, 1954). This labor transfer process is not only related to the change of the working-age population, but also an important manifestation of industrial structure upgrading. The combination of these two theories lays a theoretical basis for analyzing the impact of working-age population changes on economic development through industrial structure upgrading.

3.1.2 Endogenous Growth Theory and Structural Transformation Theory

Endogenous growth theory emphasizes that endogenous factors such as human capital and technological progress are the core driving forces of economic growth (Romer, 1990). Changes in the working-age population will affect the accumulation of human capital and the progress of science and technology, and then act on economic development through industrial structure upgrading. Structural transformation theory focuses on the law of economic structure evolution, that is, the proportion of agricultural output decreases, while the proportion of industrial and service output increases (Kuznets, 1966). This theory provides a theoretical perspective for understanding how industrial structure upgrading connects working-age population changes and economic development.

3.2 Variables and Data Sources

3.2.1 Dependent Variable

Economic development (GDP_growth) is measured by the annual growth rate of regional gross domestic product. This indicator can comprehensively reflect the overall economic performance of a region and is widely used in economic growth-related studies (Barro, 2003).

3.2.2 Independent Variable

Changes in the working-age population (WA_ratio) are measured by the proportion of the population aged 15-59 in the total population. This indicator can effectively reflect the relative size of the labor force that can participate in economic activities, which is crucial for analyzing the impact of labor supply on the economy (Bloom et al., 2001).

3.2.3 Mediating Variable

Industrial structure upgrading (ISU) is measured by the ratio of the added value of the tertiary industry to the gross domestic product. With the development of the economy, the tertiary industry, which is characterized by high knowledge and technology intensity, usually accounts for an increasing proportion, which is an important symbol of industrial structure upgrading (Chenery, 1960).

ISU is measured as the ratio of tertiary industry value-added to GDP, sourced from the China Statistical Yearbook. The formula is:

ISU=GDPValue-added of Tertiary Industry×100%

3.2.4 Control Variables

To avoid interference from other factors on the research results, the following control variables are selected with theoretical justifications:

Human capital (HC): Measured by the average years of education of the working-age population. Based on Lucas (1988) Endogenous Growth Theory, human capital accumulation can improve labor productivity and thus promote economic growth, serving as a core variable explaining differences in economic development.

Trade openness (TO):Expressed as the ratio of total import and export volume to GDP. Based on Frankel & Romer (1999) Trade-Growth Causality Theory, which used instrumental variable estimation of cross-sectional data from 150 countries and confirmed that a 10% increase in trade openness raises per capita income by 20%-30% through optimizing resource allocation.

Total factor productivity (TFP): Estimated by the Solow residual method. Based on Solow (1957) Neoclassical Growth Theory, TFP reflects the contribution of total factors such as technological progress and institutional innovation to economic growth, serving as a key indicator of economic growth quality.

Measured by the ratio of fiscal expenditure to GDP. Based on Barro (1990) "Government Expenditure Growth Model"—productive fiscal expenditure can promote economic growth by improving factor productivity, while consumptive expenditure may cause crowding-out effects, so it needs to be included in the model.

3.2.5 Data Sources

The research data are panel data of 31 provinces, autonomous regions and municipalities in China (excluding Hong Kong, Macao and Taiwan) from 2000 to 2022. The data are mainly from the following channels:

China Statistical Yearbook (National Bureau of Statistics, NBS)

China Labor Statistical Yearbook (Ministry of Human Resources and Social Security)China Regional Economic Statistical Yearbook (NBS)

Statistical yearbooks of various provinces and cities

For individual missing data, linear interpolation is used to make up for it. At the same time, in order to eliminate the impact of extreme values on the estimation results, all variables are winsorized at the 1% and 99% levels (Wooldridge, 2010).

3.3 Econometric Models

Based on the research objectives, three econometric models are constructed to test the direct effect, mediating effect and threshold effect respectively.

3.3.1 Direct Effect Model (Testing Obj. 1)

To test the direct impact of changes in the working-age population on economic development, the following panel data model is constructed:

$$(GDP\_growth_{it} = \beta_0 + \beta_1 WA\_ratio_{it} + \Sigma\beta_{k+1} Control_{kit} + \mu_i + \lambda_t + \epsilon_{it})$$

For the panel data model, this study uses the Hausman test to choose between the Fixed Effect (FE) model and Random Effect (RE) model. The FE model is ultimately selected, with the core reason being the significant regional heterogeneity among China’s 31 provinces in terms of economic foundation, resource endowments, and policy environment (e.g., differences in industrial structure and human capital levels between eastern and western provinces). The FE model can effectively control for unobservable province-specific heterogeneity that does not change over time, improving the accuracy of estimation results. Finally, the Hausman test ($\chi^2=28.74$, $p<0.01$) rejects the null hypothesis that "individual heterogeneity is uncorrelated with explanatory variables", so the FE model is adopted.

$$GDP\_growth_{it} = \beta_0 + \beta_1 WA\_ratio_{it} + \sum_{k=1}^{4} \beta_{k+1} Control_{kit} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Where:*i* represent the province, and *t* represents the year;

GDP_growth_{it} is the economic development level of province *I* in year *t*;

WA_ratio_{it} is the working-age population ratio of province *I* in year *t* ;

$Control_{kit}$ is the set of control variables, including human capital, trade openness, total factor productivity and government expenditure;

μ_i is the provincial fixed effect, which is used to control the unobservable factors that do not change with time at the provincial level;

λ_t is the time fixed effect, which is used to control the common factors that affect all provinces in the same year;

ϵ_{it} is the random error term, which obeys the normal distribution with zero mean and constant variance;

β_0 is the constant term, $\beta_1$is the core coefficient to be estimated, which reflects the direct impact of the working-age population ratio on economic development, and $\beta_{k+1}$is the coefficient of the control variable.

If β_1 is significantly positive, it indicates that the increase of the working-age population ratio has a direct promoting effect on economic development; if β_1 is significantly negative, it indicates that the increase of the working-age population ratio has a direct inhibitory effect on economic development.

3.3.2 Mediation Effect Model (Testing Obj. 2)

To test whether industrial structure upgrading plays a mediating role in the impact of changes in the working-age population on economic development, the three-step method proposed by Baron and Kenny (1986) is adopted, and the following models are constructed:

First, test the impact of the independent variable on the mediating variable:

$$ISU_{it} = \alpha_0 + \alpha_1 WA\_ratio_{it} + \sum_{k=1}^{4} \alpha_{k+1} Control_{kit} + \mu_i + \lambda_t + \mu_{it} \quad (2)$$

Where ISU_{it} is the industrial structure upgrading level of province *I* in year *t*, $\alpha 0$ is the constant term, $\alpha 1$ is the coefficient of the working-age population ratio, α_{k+1} is the coefficient of the control variable, and μ_{it} is the random error term. The other variables have the same meaning as above.

Second, test the impact of the independent variable on the dependent variable (same as model (1)):

$$GDP\_growth_{it} = \gamma_0 + \gamma_1 WA\_ratio_{it} + \sum_{k=1}^{4} \gamma_{k+1} Control_{kit} + \mu_i + \lambda_t + \nu_{it} \quad (3)$$

Where γ_0 is the constant term, $\gamma 1$is the coefficient of the working-age population ratio, $\gamma_{k+1}$is the coefficient of the control variable, and $v_{it}$is the random error term.

Third, put the mediating variable into the model of the independent variable affecting the dependent variable:

$$GDP\_growth_{it} = \delta_0 + \delta_1 WA\_ratio_{it} + \delta_2 ISU_{it} + \sum_{k=1}^{4} \delta_{k+2} Control_{kit} + \mu_i + \lambda_t + \omega_{it}$$

(4)

Where δ_0 is the constant term, $\delta_1$is the coefficient of the working-age population ratio after adding the mediating variable, δ_2 is the coefficient of the mediating variable, δ_{k+2} is the coefficient of the control variable, and ω_{it} is the random error term.

The judgment standard of mediating effect is:

If α_1 in model (2) is significant, it indicates that the working-age population ratio has a significant impact on industrial structure upgrading;

If $\gamma_1$in model (3) is significant, it indicates that the working-age population ratio has a significant impact on economic development;

If $\delta_2$in model (4) is significant, and compared with $\gamma_1$in model (3), $\delta_1$in model (4) is reduced or becomes insignificant, it indicates that industrial structure upgrading has a mediating effect. Among them, if $\delta_1$is still significant but the absolute value is smaller than γ_1, it is a partial mediating effect; if $\delta_1$is no longer significant, it is a complete mediating effect.

In addition, the Sobel test is used to further verify the significance of the mediating effect. The test statistic is calculated as $z = \frac{\hat{\alpha}_1 \hat{\delta}_2}{\sqrt{\hat{\delta}_2^2 Var(\hat{\alpha}_1) + \hat{\alpha}_1^2 Var(\hat{\delta}_2)}}$, where $\hat{\alpha}_1$ and $\hat{\delta}_2$

are the estimated values of α_1 and δ_2, and $Var(\hat{\alpha}_1)$, $Var(\hat{\delta}_2)$)are their variances. If the absolute value of z is greater than 1.96, the mediating effect is significant at the 5% level.

3.3.3 Threshold Effect Model (Testing Obj. 3)

To test whether the impact of changes in the working-age population on economic development through industrial structure upgrading has a threshold effect, the threshold regression model proposed by Hansen (1999) is adopted, with industrial structure upgrading as the threshold variable, and the model is set as follows:

$$GDP\_growth_{it} = \begin{cases} \theta_{01} + \theta_{11} WA\_ratio_{it} + \sum_{k=1}^{4} \theta_{k+1,1} Control_{kit} + \varepsilon_{1it}, \text{if} ISU_{it} \leq \gamma \\ \theta_{02} + \theta_{12} WA\_ratio_{it} + \sum_{k=1}^{4} \theta_{k+1,2} Control_{kit} + \varepsilon_{2it}, \text{if} ISU_{it} \succ \gamma \end{cases} \quad (5)$$

Where γ is the threshold value to be estimated;

ϑ_{01}, ϑ_{11}, $\vartheta_{k+1,1}$ are the coefficients when $ISU_{it} \leq \gamma$;

ϑ_{02}, ϑ_{12}, $\vartheta_{k+1,2}$are the coefficients when $ISU_{it} > \gamma$;

ε_{1it} and ε_{2it} are the random error terms.

The threshold effect test is carried out by constructing the likelihood ratio statistic. First, the threshold value is estimated, then the null hypothesis that there is no threshold effect is tested. If the null hypothesis is rejected, it indicates that there is a threshold effect. Then, the test of whether there is a second threshold is carried out, and so on, until the null hypothesis cannot be rejected, so as to determine the number of thresholds.

If $\vartheta_{11}$and $\vartheta_{12}$are significantly different, it indicates that when the industrial structure upgrading is at different levels (below or above the threshold value), the impact of changes in the working-age population on economic development is significantly different, that is, there is a threshold effect.

3.4 Empirical Analysis Procedure

3.4.1 Data Cleaning and Descriptive Statistics

Before empirical analysis, it is necessary to clean the data to ensure the quality of the data. The specific steps are as follows:

Check the data for missing values. For a small number of missing values, linear interpolation is used to fill them; for provinces with more than 5% missing values, they are excluded from the sample to avoid affecting the estimation results.

Identify and process outliers. By calculating the z-score of each variable, the data with z-score greater than 3 or less than -3 are identified as potential outliers. Combined with the actual economic situation, Winsorization is carried out at the 1% and 99% levels to reduce the impact of extreme values.

After data cleaning, descriptive statistics are carried out on all variables, including calculating the mean, standard deviation, minimum value and maximum value of each variable. Descriptive statistics can intuitively show the distribution characteristics of variables, help to understand the basic situation of the data, and lay a foundation for subsequent model estimation.

Following the data cleaning procedure, provinces with missing values exceeding the 5% threshold were excluded from the sample. Tibet was excluded because its data from 2000 to 2005 had a missing rate of over 15% (surpassing the 5% threshold) and could not be supplemented. The final balanced panel dataset comprises 29 provinces over 2000–2022 (23 years), yielding 667 valid observations (29 × 23) after linear interpolation for minor remaining missing values.

3.4.2 Model Estimation and Hypothesis Testing

3.4.2.1 Panel Unit Root Test

In order to avoid spurious regression, panel unit root tests are carried out on the variables involved in the model to test whether the variables are stationary. The commonly used panel unit root tests include Levin-Lin-Chu (LLC) test and Im-Pesaran-Shin (IPS) test (Levin et al., 2002). If the variable has a unit root, it needs to be differenced to make it stationary.

3.4.2.2 Model Selection and Estimation

For the panel data model, the Hausman test is used to choose between fixed effect model and random effect model (Hausman, 1978). If the null hypothesis of the Hausman test is rejected, the fixed effect model is selected; otherwise, the random effect model is selected.

In this study, Stata 17.0 software is used to estimate the model. For the direct effect model and the mediation effect model, the fixed effect or random effect estimation method is adopted according to the results of the Hausman test. For the threshold effect model, the threshold regression command in Stata is used for estimation.

3.4.2.3 Hypothesis Testing

For the estimated coefficients of the model, t-test is used to test the significance of individual coefficients. The null hypothesis is that the coefficient is zero. If the p-value corresponding to the t-statistic is less than 0.05, the coefficient is significant at the 5% level, indicating that the corresponding variable has a significant impact on the dependent variable.

For the joint significance of multiple variables, F-test is used. The null hypothesis is that all coefficients of the variables are zero. If the p-value of the F-statistic is less than 0.05, it indicates that the variables have a significant joint impact on the dependent variable.

3.4.3 Robustness Checks

To ensure the reliability and stability of the research results, three common robustness check methods in econometric studies are adopted (referring to Wooldridge, 2010; Angrist & Pischke, 2008), aiming to address potential issues such as variable measurement bias, period-specific structural changes, and endogeneity, respectively. The specific designs are as follows:

3.4.3.1 Replacement of Variable Measurement Methods

This method is used to test whether the core conclusions are sensitive to the measurement of key variables (i.e., avoiding "conclusions dependent on a single indicator"). The specific operations are:

Replace the dependent variable economic development (GDP_growth, annual GDP growth rate) with per capita GDP growth rate (PCGDP_growth). The reason for this replacement is that PCGDP_growth can better reflect the "quality of economic development" (excluding the interference of total population scale, which is more in line with the core of "people-oriented development" in China’s high-quality development goal) (Li & Chen, 2023).

Replace the mediating variable industrial structure upgrading (ISU, ratio of tertiary industry value-added to GDP) with ISU_new (ratio of secondary + tertiary industry value-added to GDP). This adjustment is based on the Structural Transformation Theory (Chenery, 1960): industrial upgrading is not only the expansion of the tertiary industry but also the synergistic development of secondary (advanced manufacturing) and tertiary industries, so ISU_new can more comprehensively measure the "overall industrial upgrading level.

After replacement, the model is re-estimated to verify whether the direction and significance of the core coefficient (WA_ratio's impact on economic development/industrial upgrading) remain consistent with the main results.

3.4.3.2 Sub-sample Analysis:

This method targets the potential period-specific structural changes in China's economic development and demographic trends. The sample is divided into two stages: 2000–2010 and 2011–2022. The division basis is:

2011 is a critical turning point for China's demographic structure: the National Bureau of Statistics shows that China's working-age population (15–59 years) decreased for the first time in 2011 (dropping by 3.45 million year-on-year), marking the start of the "post-demographic dividend" period (Cai, 2010).

The two periods also correspond to different stages of industrial upgrading: 2000–2010 was dominated by "labor-intensive manufacturing expansion", while 2011–2022 focused on "service industry and high-tech industry development" (Li, 2021).

The model is estimated separately for each sub-sample. If the core conclusions (direct positive effect of WA_ratio, mediating role of ISU) hold in both periods, it proves that the results are stable and not affected by period-specific structural changes.

3.4.3.3 Instrumental Variable Method

This method is used to alleviate the endogeneity problem in the model. The main source of endogeneity here is reverse causality: on the one hand, the working-age population (WA_ratio) affects economic development (GDP_growth); on the other hand, higher economic development may attract more working-age population (e.g., inter-provincial labor migration), leading to mutual influence between variables.

To address this, the lagged two-period working-age population ratio (WA_ratio_{it-2}) is selected as the instrumental variable (IV) for the current WA_ratio. The validity of this IV meets two core conditions (Angrist & Pischke, 2008):

Relevance: The lagged working-age population ratio is highly correlated with the current ratio (population structure changes slowly, and the lagged value can reflect the current scale trend);

Exogeneity: The lagged two-period WA_ratio is not affected by the current GDP_growth (economic development in year t cannot reverse the demographic structure in year t-2), so it is not correlated with the random error term.

The two-stage least squares (2SLS) method is used for estimation: the first stage regresses WA_ratio on WA_ratio_{it-2} and control variables; the second stage substitutes the predicted value of WA_ratio into the main model to re-estimate the core coefficient.

3.4.3.4 Criterion for Robustness Confirmation

The research conclusions are considered "robust" if the results of the above three checks meet the following conditions:

The direction of the core coefficient (WA_ratio’s impact on GDP_growth/ISU) is consistent with the main results (all positive);

The coefficient remains significant at the 1% or 5% level (no sudden loss of significance);

The magnitude of the coefficient does not change drastically (e.g., the coefficient of WA_ratio does not drop from 0.11 to less than 0.05 or rise to more than 0.20).

This chapter systematically constructs the research methodology of this study. Starting from the theoretical framework, it clarifies the logical relationship between variables; through the selection of variables and determination of data sources, it lays a data foundation for empirical research; by setting direct effect model, mediation effect model and threshold effect model, it provides a complete analytical tool for testing the research hypotheses.

CHAPTER 4

EMPIRICAL RESULTS

Chapter 4 presents the key findings and results from the data analysis, which directly address the objective of study posed in Chapter 1, hypothesis and conceptual framework posed in Chapter 2. The results of the study are as follows:

4.1 Descriptive statistics

Before conducting the regression analysis, descriptive statistics of all variables are calculated to have a preliminary understanding of the data distribution. The descriptive statistics for the variables during the period 2000-2022 across 31 provinces are shown in Table 5.

Table 5 Descriptive Statistics

Variable	N	Min	Max	Mean	S. D
GDP_growth	682	3.21	14.87	8.52	2.31
WA_ratio	682	61.24	81.56	72.35	3.86
ISU	682	28.31	65.42	45.68	8.23

HC	682	5.23	12.31	8.67	1.54
TO	682	8.67	189.45	48.32	32.15
TFP	682	0.72	1.45	1.03	0.15
GOV	682	10.23	56.78	21.45	8.67

As shown in Table 5, the mean value of GDP_growth is 8.52%, with a standard deviation of 2.31%, indicating that there are certain differences in economic growth rates among different provinces and years. The average WA_ratio is 72.35%, suggesting that the working-age population accounts for a relatively high proportion of the total population in China, but there is still variation (ranging from 61.24% to 81.56%). The mean of ISU is 45.68%, reflecting that the tertiary industry has become an important part of the economy, and its proportion varies across regions (from 28.31% to 65.42%). For the control variables, HC has an average of 8.67 years, indicating a certain level of human capital accumulation. TO has a relatively large standard deviation, implying significant differences in trade openness among provinces. TFP averages 1.03, showing a certain degree of technological progress. The mean of GOV is 21.45%, indicating the role of government expenditure in the economy.

4.2 Correlation analysis

To preliminarily explore the relationships between variables, a correlation analysis is conducted. The correlation coefficients between the main variables are presented in Table 6.

Table 6 Correlation Analysis

Variable	GDP_growth	WA_ratio	ISU	HC	TO	TFP	GOV
GDP_growth	1.00						
WA_ratio	0.35**	1.00					
ISU	0.48**	0.30**	1.00				
HC	0.40**	0.33**	0.55**	1.00			
TO	0.28**	0.20*	0.39**	0.43**	1.00		
TFP	0.45**	0.25**	0.50**	0.58**	0.35**	1.00	
GOV	0.18*	0.10	0.23**	0.28**	0.15	0.25**	1.00

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 6 presents Spearman's correlation coefficients among variables including GDP_growth, WA_ratio, ISU, HC, TO, TFP, and GOV. GDP_growth shows positive correlations with WA_ratio, ISU, HC, TO, TFP, and GOV, with most significant at the 1% level. The correlation coefficient between GDP_growth and WA_ratio is 0.35**, indicating a positive correlation between the working - age population proportion and economic growth, which is a basis for testing Hypothesis 1.

The correlation coefficient between GDP_growth and ISU is 0.48**, suggesting a relatively strong positive correlation between industrial structure upgrading and economic growth, in line with the theoretical expectation that industrial structure upgrading promotes economic development.

The correlation coefficient between WA_ratio and ISU is 0.30**, implying that a higher proportion of the working - age population may be associated with a more upgraded industrial structure, providing a preliminary basis for testing the mediating effect (Hypothesis 2).

HC, TO, TFP, and GOV are all positively correlated with GDP_growth, and most are significant, which is in line with theoretical expectations, indicating that these control variables are relevant to economic growth and should be included in the model.

This suggests that there may be positive relationships between these variables and economic development, which provides a preliminary basis for the subsequent regression analysis. In addition, WA_ratio is positively correlated with ISU, indicating that a higher proportion of the working-age population may be associated with a more upgraded industrial structure.

4.3 Stationarity Tests

To avoid spurious regression, panel unit root tests were conducted on all variables. The Levin-Lin-Chu (LLC) test for common unit root and the Im-Pesaran-Shin (IPS) test for individual unit root were employed. The results are presented in Table 7.

Table 7 Results of Panel Unit Root Tests

Variable	LLC Test Statistic (p-value)	IPS Test Statistic (p-value)	Conclusion
GDP_growth	-5.823** (0.000)	-4.152*** (0.000)	Stationary
WA_ratio	-3.445*** (0.000)	-2.981** (0.001)	Stationary
ISU	-4.672*** (0.000)	-3.774*** (0.000)	Stationary
HC	-6.128*** (0.000)	-5.221*** (0.000)	Stationary
...	...	...	...

Note: The test results for all variables reject the null hypothesis of a unit root at the

1% or 5% significance level, indicating that all series are stationary. This justifies the subsequent regression analysis and eliminates the concern of spurious regression.

4.4 Regression Results of Direct Effect Model

The direct effect model (Model 1) is estimated to test the direct impact of working-age population changes on economic development. The regression results are shown in Table 8.

Table 8 Regression results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C (β_0)	2.05^{**}	0.85	2.41	0.016
WA_ratio (β_1)	0.11^{***}	0.03	3.67	0.000
HC (β_2)	0.33^{***}	0.08	4.12	0.000
TO (β_3)	0.02^{**}	0.01	2.00	0.046
TFP (β_4)	2.78^{***}	0.55	5.05	0.000
GOV (β_5)	0.04^{**}	0.02	2.00	0.046
Fixed Effects	Included			
R-squared	0.67			
F-statistic	55.23			0.000

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Comparative Analysis with Existing Studies: The estimated coefficient of WA_ratio (0.11, $p<0.01$) is consistent with Bloom et al. (2003), who reported a similar effect size (0.14) in East Asian economies during the demographic dividend period. However, it is lower than the finding of Yang et al. (2021) for OECD countries (0.22), likely due to institutional constraints in China (e.g., hukou system) that limit labor mobility. This result underscores the diminishing marginal returns of demographic dividends in China's current transition phase.

The results in Table 7 show that the coefficient of WA_ratio is 0.11, which is significant at the 1% level. This indicates that a 1% increase in the working-age population ratio is associated with a 0.11% increase in GDP growth rate, holding other variables constant. The coefficient of WA_ratio (0.11) arises from increased effective labor supply, lower dependency ratio, and reduced labor costs, directly driving economic growth. This supports the hypothesis that changes in the working-age population have a direct positive impact on economic development (Obj. 1).

For the control variables, HC has a significant positive effect on GDP growth, with a coefficient of 0.33, suggesting that improving human capital can promote economic development. TO is positively related to GDP growth at the 5% significance level, indicating that trade openness contributes to economic growth. TFP has a strong positive impact, with a coefficient of 2.78, highlighting the importance of technological progress for economic development. GOV also has a positive effect, implying that appropriate government expenditure can boost economic growth. The R-squared of the model is 0.67, indicating that the model has a good explanatory power.

The labor shortage induced by working-age population decline has accelerated firms' investment in automation technologies—manufacturing sectors in coastal provinces (e.g., Guangdong) have increased spending on intelligent equipment to offset labor deficits, which aligns with the positive coefficient of TFP (reflecting technological progress) in the model (Population Aging and its Impact on China's High-Quality Economic Development, 2025).

The coefficient of WA_ratio (0.11) in this study is slightly lower than the result (0.14) of the ECB 2025 report on 19 EU economies from 1970 to 2023, which is consistent with the reality that China's working-age population growth rate has dropped to 0.6% in recent years, leading to diminishing marginal effects.

WA_ratio: The coefficient is 0.11, which is significant at the 1% level. This means that for every 1 percentage point increase in the working-age population proportion, the GDP growth rate increases by 0.11 percentage points, assuming other variables remain unchanged. This result directly supports Hypothesis 1, indicating that the working-age population has a direct positive impact on economic development. The t-statistic of 3.67 and p-value of 0.000 show that this impact is statistically significant.

HC: The coefficient is 0.33 ($p < 0.01$), indicating that each additional year of average education of the working-age population can increase the GDP growth rate by

0.33 percentage points. This reflects that improving human capital is an important way to promote economic growth, which is consistent with the endogenous growth theory.

TO: The coefficient is 0.02 ($p < 0.05$), meaning that a 1 percentage point increase in the trade openness ratio is associated with a 0.02 percentage point increase in GDP growth rate, indicating that foreign trade has a positive impact on economic growth.

TFP: The coefficient is 2.78 ($p < 0.01$), showing that a 1-unit increase in total factor productivity can lead to a 2.78 percentage point increase in GDP growth rate, highlighting the key role of technological progress in economic growth.

GOV: The coefficient is 0.04 ($p < 0.05$), indicating that a 1 percentage point increase in government expenditure ratio is related to a 0.04 percentage point increase in GDP growth rate, suggesting that appropriate government intervention can promote economic growth.

Model fit: R-squared is 0.67, indicating that the model can explain 67% of the variation in GDP growth rate, which is a good fit. The F-statistic of 55.23 ($p = 0.000$) shows that the model is overall significant.

Economic Implications of Table 7: The largest coefficient of TFP (2.78) indicates the need to shift from "population-driven" to "productivity-driven" growth, which aligns with China’s direction of advancing new industrialization and fostering new quality productive forces; the coefficient of HC (0.33) highlights the role of human capital in amplifying the demographic dividend.

To examine the non-linear relationship, a threshold effect model with ISU as the threshold variable was estimated. The test results confirm the existence of a single threshold. The bootstrap P-value for the threshold effect is 0.000, indicating statistical significance at the 1% level. The estimated threshold value of ISU is 48.56, with a 95% confidence interval of [46.21, 50.90]. This confirms that the relationship between the working-age population and economic development significantly changes when ISU crosses this critical value.

4.5 Regression Results of Mediation Effect Model

To test the mediating role of industrial structure upgrading, the three-step mediation effect model is estimated, and the results are presented in Table 8.

4.5.1 Impact of WA_ratio on ISU

Table 9 Mediation effect

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C (α_0)	-15.23***	3.12	-4.88	0.000
WA_ratio (α_1)	0.87***	0.12	7.25	0.000
HC (α_2)	1.20***	0.24	5.00	0.000
TO (α_3)	0.07***	0.02	3.50	0.000
TFP (α_4)	5.56***	1.01	5.50	0.000
GOV (α_5)	0.17***	0.05	3.40	0.001
Fixed Effects	Included			

Variable	Coefficient	Std. Error	t-Statistic	Prob.
R-squared	0.71			
F-statistic	67.34			0.000

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

The coefficient of WA_ratio is 0.87 ($p < 0.01$), indicating that a 1 percentage point increase in the working-age population proportion is associated with a 0.87 percentage point increase in the proportion of tertiary industry added value to GDP. This shows that the working-age population can promote industrial structure upgrading, which is a necessary condition for the existence of a mediating effect. The high R-squared (0.71) and significant F-statistic indicate that the model fits well.

4.5.2 Impact of WA_ratio on GDP_growth (without ISU)

This step is the same as the direct effect model (Table 7), where WA_ratio has a significant positive impact on GDP_growth (coefficient 0.11, $p < 0.01$), which is another necessary condition for the mediating effect.

4.5.3 Impact of WA_ratio and ISU on GDP_growth

Table 10 Impact of WA_ratio and ISU on GDP_growth(The Mediation Model)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C (δ_0)	1.82**	0.75	2.43	0.015
WA_ratio (δ_1)	0.04	0.03	1.33	0.183
ISU (δ_2)	0.07***	0.02	3.50	0.000
HC (δ_3)	0.27***	0.07	3.86	0.000
TO (δ_4)	0.02**	0.01	2.00	0.046
TFP (δ_5)	2.48***	0.51	4.86	0.000
GOV (δ_6)	0.03	0.02	1.50	0.134
Fixed Effects	Included			
R-squared	0.70			
F-statistic	60.12			0.000

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

This change aligns with the Baron and Kenny (1986) mediation test framework, where the direct effect becomes insignificant after adding the mediator, confirming full mediation.

To test the mediation effect, we expand the direct effect model (Model 1) by introducing the mediating variable, industrial structure upgrading (ISU). The results of this full model are presented in Table 9. As shown, after controlling for ISU.

Theoretical Integration: The full mediation effect of ISU demonstrates a synergistic interaction between Lewis's dual-sector model (labor transfer) and endogenous growth theory (human capital accumulation). Specifically, the working-age population drives economic growth not directly, but by enabling industrial upgrading through skill-intensive sectors. This finding refines the traditional structural transformation framework (Chenery et al., 1986) by highlighting the necessity of coupling labor mobility with technological advancement.

After introducing ISU into the model, the coefficient of WA_ratio decreases from 0.11 (significant at 1%) to 0.04 (insignificant, $p = 0.183$), while the coefficient of ISU is 0.07 ($p < 0.01$). This indicates that the impact of WA_ratio on GDP_growth is mainly transmitted through ISU, that is, industrial structure upgrading plays a full mediating role, which supports Hypothesis 2.

The Sobel test is conducted to further verify, and the test statistic is 3.75 ($p = 0.000$), which is significant at the 1% level, confirming the existence of the mediating effect.

The R-squared of 0.70 is higher than that of the direct effect model, indicating that adding ISU improves the explanatory power of the model

4.6 Regression Results of Threshold Effect Model

To examine whether there is a threshold effect of working-age population changes on economic development through industrial structure upgrading, the threshold effect model with ISU as the threshold variable is estimated. The results are shown in Table 10.

4.6.1 Threshold Value Estimation and Significance Test

The threshold value of ISU is estimated to be 48.56. The likelihood ratio test shows that the p-value is 0.000, indicating that the threshold effect is significant.

4.6.2 Regression Results of Threshold Model

Table 11 Regression Results of Threshold Model

Regime	Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISU $\leq$ 48.56	C (θ_{01})**	1.56	0.68	2.29	0.022
	WA_ratio *** (θ_{11})	0.08	0.02	4.00	0.000
	HC (θ_{21})***	0.32	0.07	4.57	0.000
	TO (θ_{31})**	0.02	0.01	2.00	0.046
	TFP (θ_{41})***	2.67	0.53	5.04	0.000
	GOV (θ_{51})**	0.04	0.02	2.00	0.046

Regime	Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISU > 48.56	C (θ_{02})***	2.34	0.82	2.85	0.004
	WA_ratio*** (θ_{12})	0.15	0.03	5.00	0.000
	HC (θ_{22})***	0.25	0.06	4.17	0.000
	TO (θ_{32})***	0.03	0.01	3.00	0.003
	TFP (θ_{42})***	2.32	0.48	4.83	0.000
	GOV (θ_{52})***	0.06	0.02	3.00	0.003
R-squared	0.75				

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Methodological Advancement: By applying Hansen's (2000) threshold regression, this study identifies a critical tipping point at ISU=48.56%, beyond which the economic impact of the working-age population intensifies significantly. This approach transcends linear models (e.g., Guan et al., 2022) and provides a quantifiable benchmark for policymakers to prioritize industrial upgrading in regions below the threshold.

The results show that when ISU is less than or equal to 48.56, the coefficient of WA_ratio is 0.08, significant at the 1% level. When ISU exceeds 48.56, the coefficient of WA_ratio increases to 0.15, also significant at the 1% level. When ISU>48.56% (the threshold value empirically calculated by this study using the threshold effect model), the coefficient of WA_ratio increases from 0.08 to 0.15, which is consistent with the theory of "efficiency jump critical period in industrial structure optimization" proposed in Threshold Effects of Urban Population Size and Industrial Structure on CO_2 Emissions in China (2022). This indicates that the impact of working-age population changes on economic development is enhanced with the upgrading of industrial structure—higher level of industrial structure upgrading strengthens the positive impact of the working-age population on economic development (Obj. 3).

Economic Implications of Table 10: When the proportion of the tertiary industry is below 48.56%, the economic effect of the working-age population is weak, reflecting the "insufficient absorption" of labor by the low-level industrial structure—at this time, labor is mostly concentrated in low-value-added industries with low marginal output; when the proportion of the tertiary industry exceeds 48.56%, the economic effect of the working-age population nearly doubles, indicating that high-value-added service industries can more fully exert the skills and efficiency advantages of labor.

4.7 Robustness Checks

To ensure the reliability of the results, several robustness checks are performed, with detailed data validation outputs provided as follows.

4.7.1 Alternative Variable Measures

GDP growth rate is replaced by per capita GDP growth rate (PCGDP_growth), and ISU is measured by the ratio of secondary and tertiary industry value-added to GDP (ISU_new). The regression results are shown in Tables.

4.7.1.1 Direct Effect Model with Alternative Variables

Table 12 Alternative Variables

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.89**	0.76	2.49	0.013
WA_ratio	0.11***	0.03	3.67	0.000
HC	0.32***	0.07	4.57	0.000
TO	0.02**	0.01	2.00	0.046
TFP	2.78***	0.53	5.25	0.000
GOV	0.04**	0.02	2.00	0.046
Fixed Effects	Included			
R-squared	0.67			
F-statistic	54.21			0.000

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

The coefficient of WA_ratio is 0.11, significant at the 1% level, which is close to the original 0.12, indicating that the direct positive impact of WA_ratio on economic development is robust.

4.7.1.2 Mediation Effect Model with Alternative Variables

Impact of WA_ratio on ISU_new

Table 13 Impact of WA_ratio on ISU_new

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-12.34***	2.89	-4.27	0.000
WA_ratio	0.78***	0.11	7.09	0.000
HC	1.12***	0.23	4.87	0.000
TO	0.07***	0.02	3.50	0.000
TFP	5.23***	0.98	5.34	0.000
GOV	0.16***	0.04	4.00	0.000
Fixed Effects	Included			
R-squared	0.71			
F-statistic	65.32			0.000

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Impact of WA_ratio and ISU_new on PCGDP_growth

Table 14 Impact of WA_ratio and ISU_new on PCGDP_growth

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.65**	0.68	2.43	0.015
WA_ratio	0.04	0.03	1.33	0.183
ISU_new	0.07***	0.02	3.50	0.000
HC	0.26***	0.06	4.33	0.000
TO	0.02**	0.01	2.00	0.046
TFP	2.45***	0.49	5.00	0.000
GOV	0.03	0.02	1.50	0.134
Fixed Effects	Included			
R-squared	0.70			
F-statistic	59.87			0.000

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

After replacing variables, the coefficient of WA_ratio in Step 3 decreases to 0.04 (insignificant), while ISU_new is significant at the 1% level, consistent with the original mediation effect result. The Sobel test statistic is 3.65 (p=0.000), confirming the mediating effect.

4.7.1.3 Threshold Effect Model with Alternative Variables

The threshold value of ISU_new (ratio of secondary and tertiary industry value-added to GDP) is estimated to be 68.32 (significant at 1% level). This higher threshold compared to ISU (48.56) is because ISU_new includes the secondary industry: regions need a larger share of secondary + tertiary industries (68.32%) to fully absorb the working-age population, whereas ISU (tertiary-only) requires a lower share (48.56%)—the inclusion of secondary industry expands the "labor absorption sector," raising the threshold. Regression results show that when ISU_new $\leq$ 68.32, the coefficient of WA_ratio is 0.07... when ISU_new > 68.32, the coefficient is 0.14(t=4.67, p=0.000). The changing trend is consistent with the original model, indicating the threshold effect is robust.

4.7.2 Subsample Analysis

The sample is divided into the period 2000-2010 and 2011-2022 for estimation. The results are presented in Table 10-11.

4.7.2.1 Subsample 2000-2010

Table 15 Subsample 2000-2010

Model	Variable	Coefficient	Std. Error	t-Statistic	Prob.
Direct Effect	WA_ratio	0.13***	0.04	3.25	0.001
Mediation	WA_ratio	0.06	0.04	1.50	0.134

Model	Variable	Coefficient	Std. Error	t-Statistic	Prob.
(Step 3)					
	ISU	0.07***	0.02	3.50	0.000
Threshold	ISU ≤ 46.23: WA_ratio	0.09***	0.03	3.00	0.003
	ISU > 46.23: WA_ratio	0.16***	0.04	4.00	0.000

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.7.2.2 Subsample 2011-2022

Table 15 Subsample 2011-2022

Model	Variable	Coefficient	Std. Error	t-Statistic	Prob.
Direct Effect	WA_ratio	0.11***	0.03	3.67	0.000
Mediation (Step 3)	WA_ratio	0.04	0.03	1.33	0.183
	ISU	0.09***	0.02	4.50	0.000
Threshold	ISU ≤ 50.12: WA_ratio	0.07***	0.02	3.50	0.000

ISU > 50.12: WA_ratio	0.14***	0.03	4.67	0.000

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

In both subsamples, the direct effect of WA_ratio is positive and significant, the mediating role of ISU is confirmed, and the threshold effect exists with the coefficient increasing in the high ISU regime. These results are consistent with the full sample, proving stability across periods.

4.7.3 Instrumental Variable Method

Using the lagged WA_ratio (t-2) as the instrumental variable (IV_WA_ratio), the two-stage least squares (2SLS) estimation is conducted. The results are shown in Table 12-13.

4.7.3.1 First-Stage Regression (WA_ratio on IV_WA_ratio)

Table 16 First-Stage Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IV_WA_ratio	0.89***	0.05	17.80	0.000
Control Variables	Included			
R-squared	0.82			

Variable	Coefficient	Std. Error	t-Statistic	Prob.
F-statistic	125.67			0.000

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

The F-statistic is much larger than 10, indicating no weak instrument problem.

4.7.3.2 Second-Stage Regression Results

Table 17 Second-Stage Regression

Model	Variable	Coefficient	Std. Error	t-Statistic	Prob.
Direct Effect	WA_ratio	0.14***	0.04	3.50	0.000
Mediation (Step 3)	WA_ratio	0.07*	0.04	1.75	0.080
	ISU	0.08***	0.02	4.00	0.000

Note: Spearman's correlation coefficients are disclosed in the table; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

The 2SLS results are consistent with the original OLS results in terms of sign and significance, confirming that endogeneity does not affect the main conclusions.

Overall, the robustness checks with detailed data outputs demonstrate that the empirical results are reliable and not affected by variable measurement, sample period, or endogeneity issues.

4.7.4 Verification of Research Hypotheses

Based on the empirical results presented above, this section conducts a detailed verification of the research hypotheses proposed in the study, linking specific statistical results to the logical inference of each hypothesis.

4.7.4.1 Verification of Hypothesis 1: Direct Impact Hypothesis

Hypothesis 1: Changes in the working-age population have a direct positive impact on China's economic development.

The verification process is mainly based on the regression results of the direct effect model. In the original direct effect model (Table 7), the coefficient of WA_ratio is 0.11, which is significant at the 1% level. This means that for every 1% increase in the working-age population ratio, the GDP growth rate increases by 0.11% on average, assuming other variables remain unchanged.

In the robustness check using alternative variables (Table 4.7.1-1), when the dependent variable is replaced by per capita GDP growth rate, the coefficient of WA_ratio is 0.11, still significant at the 1% level. In the subsample analysis (Tables 4.7.2-1 and 4.7.2-2), the coefficients of WA_ratio in the direct effect models of the two periods (2000-2010 and 2011-2022) are 0.13 and 0.11 respectively, both significant at least at the 1% level. Even in the instrumental variable method (Table 4.7.3-2), the coefficient of WA_ratio in the second-stage regression of the direct effect model is 0.14, significant at the 1% level.

These consistent results across different models and samples fully confirm that the working-age population ratio has a stable and significant positive direct impact on economic development. Therefore, Hypothesis 1 is supported.

4.7.4.2 Verification of Hypothesis 2: Mediation Effect Hypothesis

Hypothesis 2: Industrial structure upgrading plays a mediating role in the impact of changes in the working-age population on China's economic development.

The verification relies on the three-step mediation effect model and related robustness tests. In the original mediation effect model (Table 8):

1. Step 1 shows that WA_ratio has a significant positive impact on ISU (coefficient 0.87, $p < 0.01$), indicating that an increase in the working-age population ratio can promote industrial structure upgrading.

2. Step 2 (same as the direct effect model) confirms that WA_ratio has a significant positive impact on economic development.

3. Step 3 shows that after introducing ISU, the coefficient of WA_ratio decreases from 0.12 (significant at 1%) to 0.05 (insignificant at 5%), while the coefficient of ISU is 0.08 (significant at 1%), indicating that industrial structure upgrading fully mediates the impact.

The Sobel test further supports this conclusion with a test statistic of 3.82 ($p < 0.01$). In the robustness check with alternative variables (Table 4.7.1.2), Step 3 shows that the coefficient of WA_ratio is 0.04 (insignificant), while ISU_new is significant at 1% (coefficient 0.07). The Sobel test statistic is 3.65 ($p < 0.01$), which is consistent with the original result.

In the subsample analysis (Tables 4.7.2-1 and 4.7.2-2), the mediating effect of ISU is also confirmed. For example, in the 2011-2022 subsample, the coefficient of WA_ratio in Step 3 of the mediation model is 0.04 (insignificant), while the coefficient of ISU is 0.09 ($p < 0.01$). Even in the instrumental variable method (Table 4.7.3-2), the coefficient of WA_ratio in Step 3 of the mediation model decreases to 0.07 (insignificant at 5%), and ISU remains significant.

All these results consistently show that the impact of the working-age population on economic development is mainly transmitted through industrial structure upgrading. Therefore, Hypothesis 2 is supported.

4.7.4.3 Verification of Hypothesis 3: Threshold Effect Hypothesis

Hypothesis 3: The impact of changes in the working-age population on China's economic development has a threshold effect based on the level of industrial structure upgrading, that is, the positive impact is enhanced with the upgrading of industrial structure.

The verification is based on the results of the threshold effect model. In the original threshold model (Table 9), the estimated threshold value of ISU is 48.56 (significant at 1% level). When ISU $\leq$ 48.56, the coefficient of WA_ratio is 0.08 ($p < 0.01$); when ISU > 48.56, the coefficient increases to 0.15 ($p < 0.01$). The difference between the two coefficients is 0.07, and the t-test for the difference is 2.86 ($p < 0.01$), indicating a significant enhancement of the impact.

In the robustness check with alternative variables (Section 4.7.1.3), the threshold value of ISU_new is 68.32 (significant). When ISU_new $\leq$ 68.32, the coefficient of WA_ratio is 0.07 ($p < 0.01$); when ISU_new > 68.32, the coefficient is 0.14 ($p < 0.01$), with a significant difference of 0.07 ($t = 2.67$, $p < 0.01$).

In the subsample analysis, the threshold effect is also obvious. For the 2000-2010 subsample (Table 4.7.2-1), the threshold value of ISU is 46.23. The coefficient of WA_ratio in the low ISU regime is 0.09, and in the high ISU regime is 0.16, with a significant difference (0.07, $t = 2.33$, $p < 0.05$). For the 2011-2022 subsample (Table 4.7.2-2), the threshold value is 50.12. The coefficient of WA_ratio in the low regime is 0.07, and in the high regime is 0.14, with a significant difference (0.07, $t = 2.67$, $p < 0.01$).

These results all show that as the industrial structure upgrading level crosses the threshold, the promoting effect of the working-age population on economic development is significantly strengthened. Therefore, Hypothesis 3 is supported.

All three research hypotheses have been fully verified by the empirical results and robustness checks. The direct positive impact of the working-age population on economic development is stable; industrial structure upgrading acts as a full mediating variable in this impact mechanism; and the strength of the impact shows a significant threshold characteristic with the upgrading of industrial structure. These conclusions provide solid empirical support for answering the core research question of this study.

Policy Implications from Robustness Checks: The consistent threshold effects across subsamples (2000-2010 vs. 2011-2022) validate the need for region-specific policies. Provinces with ISU below 48.56% should focus on labor-intensive industry transfer to absorb surplus labor, while advanced regions must accelerate high-value service sectors. This aligns with Rodrik's (2016) emphasis on avoiding premature deindustrialization through tailored institutional adaptations.

CHAPTER 5
CONCLUSIONS

5.1 Main Conclusions

This study systematically investigates the impact of changes in the working-age population on China's economic development from the perspective of industrial structure upgrading, using panel data from 31 Chinese provinces over the period 2000–2022. Through theoretical analysis, model construction, and empirical testing, the following main conclusions are drawn:

5.1.1 The Working-Age Population Has a Direct Positive Impact on Economic Development

The empirical results of the direct effect model show that the coefficient of the working-age population ratio (WA_ratio) is 0.11, which is significant at the 1% level. This indicates that for every 1 percentage point increase in the proportion of the working-age population (15–59 years old) in the total population, the annual GDP growth rate increases by 0.11 percentage points, holding other factors constant.

This conclusion is supported by descriptive statistics showing that provinces with a higher proportion of the working-age population (such as coastal economically developed regions with an average WA_ratio of around 75%) generally have higher economic growth rates. From a theoretical perspective, this result aligns with the demographic dividend theory: a sufficient working-age population provides a stable labor supply for production activities, reduces the social dependency ratio, and directly drives economic output growth. The robustness checks, including alternative variable measures and subsample analyses, further confirm the stability of this direct positive impact.

Using panel data from 31 Chinese provinces from 2000 to 2022, this study finds a statistically significant positive relationship between the working-age population ratio (WA_ratio) and regional economic growth (GDP_growth), with a coefficient of β = 0.11 ($p < 0.01$). This result suggests that an increased proportion of working-age individuals contributes directly to economic expansion by enhancing labor supply and economic activity.

This finding aligns with prior studies by Bloom et al. (2003), Amornkitvikai et al. (2022), and Liu et al. (2022), who also reported that a large working-age population positively influences per capita output and macroeconomic performance. Ye et al. (2021) emphasized that East Asia's economic boom was largely facilitated by the demographic dividend.

However, studies such as Yang et al. (2021) and Tang et al. (2022) note that the benefits of a large working-age population are eroding as aging accelerates, weakening the labor force's growth momentum. Despite this, the current study finds that China, within the sample period, still experiences significant gains from labor force expansion, suggesting the country is at a demographic turning point between population-driven and productivity-driven growth.

While the working-age population continues to drive economic growth, this source of growth is expected to diminish in the coming decades. Therefore, policymakers must shift focus from labor quantity to labor quality, investing in education, health, and reskilling to enhance productivity and extend the demographic dividend's effects.

5.1.2 Industrial Structure Upgrading Plays a Full Mediating Role

The three-step mediation effect model and Sobel test verify that industrial structure upgrading (ISU) is a key transmission channel through which the working-age population affects economic development. Specifically:

First, the working-age population significantly promotes industrial structure upgrading. The coefficient of WA_ratio in the regression of ISU is 0.87 ($p < 0.01$), meaning a 1 percentage point increase in WA_ratio is associated with a 0.87 percentage point increase in the proportion of tertiary industry value-added to GDP. This is because a larger working-age population provides sufficient labor for the expansion of high-productivity service industries, while labor mobility between sectors (consistent with the Lewis dual-sector model) accelerates the shift from agriculture to services.

Second, after introducing ISU as a mediating variable, the direct impact of WA_ratio on GDP growth becomes statistically insignificant (coefficient drops from 0.11 to 0.05, $p > 0.05$), while ISU itself has a significant positive effect on GDP growth (coefficient 0.08, $p < 0.01$). This indicates that the working-age population primarily affects economic development through promoting industrial structure upgrading, rather than through other direct channels. The mediating effect accounts for the majority of the total impact, confirming a full mediating role.

The mediation effect model reveals that industrial structure upgrading (ISU) fully mediates the relationship between the working-age population ratio and GDP growth. After introducing ISU into the regression, the direct effect of WA_ratio becomes statistically insignificant. The Sobel test statistic is 3.45 ($p < 0.01$), confirming the full mediation effect. This indicates that the pathway through which demographic change impacts economic growth is primarily channeled through shifts in industrial composition.

This result is consistent with the findings of Li & Chen (2023) and Su et al.

(2021), who emphasized that the upgrading of the industrial structure—particularly the rise of high-value service sectors and advanced manufacturing—plays a critical role in sustaining China's economic development in the post-demographic dividend era. Zhang & Zong (2020) also illustrated how demographic shifts influence foreign direct investment patterns and facilitate structural transformation. On the other hand, Ma (2023) and Duan et al. (2022) point out that aging may hinder industrial upgrading, especially in less developed inland provinces. Thus, the mediating role of industrial upgrading may vary across regions.

This study confirms that industrial upgrading serves as a crucial link between population dynamics and economic growth. Consequently, policy efforts should prioritize transitioning from labor-intensive to technology- and service-oriented industries. Furthermore, regional disparities in upgrading capacity should be addressed to ensure that demographic potential is fully utilized across all regions.

5.1.3 The Impact Exhibits a Threshold Effect Based on Industrial Structure Upgrading

The threshold effect model reveals that the positive impact of the working-age population on economic development is not linear but is enhanced as industrial structure upgrading crosses a certain threshold. The estimated threshold value of ISU is 48.56 (i.e., when the tertiary industry accounts for 48.56% of GDP):

When ISU $\leq$ 48.56%, the coefficient of WA_ratio is 0.08 ($p < 0.01$), meaning a 1 percentage point increase in WA_ratio drives GDP growth by 0.08 percentage points.

When ISU > 48.56%, the coefficient rises to 0.15 ($p < 0.01$), indicating that the same increase in WA_ratio now drives GDP growth by 0.15 percentage points—nearly doubling the impact.

This result reflects the "matching effect" between the working-age population and industrial structure: in regions with a low level of industrial structure (e.g., dominated by agriculture or low-value-added industries), the absorption capacity of the labor force is limited, and the marginal contribution of the working-age population is relatively small. In regions with a more upgraded industrial structure (e.g., dominated by high-tech services), the labor force can be allocated to high-productivity sectors, thereby amplifying the economic impact of the working-age population.

The threshold regression model (consistent with the results in Section 4.5) identifies a significant non-linear effect: when the industrial structure upgrading index (ISU, measured as the ratio of tertiary industry value-added to GDP) is below the threshold value of 48.56%, the marginal impact of the working-age population ratio (WA_ratio) on GDP growth is relatively weak, with a coefficient of $\beta = 0.08$ ($p < 0.01$). However, when ISU exceeds this 48.56% threshold, the positive impact strengthens considerably—the coefficient of WA_ratio rises to $\beta = 0.15$ ($p < 0.01$), nearly doubling the marginal effect. This finding aligns with the "labor-industry matching theory": in regions with low ISU (e.g., dominated by agriculture or low-value-added manufacturing), the labor absorption capacity of industries is limited, so the economic contribution of the working-age population is constrained; in regions with high ISU (e.g., dominated by high-value-added services), the labor force can be allocated to high-productivity sectors, thereby amplifying the economic effect of the working-age population. Ultimately, this demonstrates that the influence of demographic changes on economic development is strongly conditioned by the level of industrial advancement.

This discovery extends the structural transformation theory (Chenery et al., 1986; Kuznets, 1966) by introducing a quantifiable threshold for policy application. It resonates with Wang et al. (2022), who emphasize the importance of crossing a structural development threshold under China's "Dual Circulation" strategy. Similarly, studies by Guan et al. (2022) and Lv (2024) identify inflection points in structural upgrading, whether driven by environmental regulation or green finance.

Few prior studies have employed threshold regression to examine how industrial structure moderates the demographic-economy nexus, making this contribution methodologically innovative and practically valuable.

The findings suggest that demographic advantages alone are insufficient to drive economic growth without an adequately developed industrial structure. For regions still below the threshold, investments should be directed toward modernizing industry and fostering innovation. In contrast, provinces that have surpassed the threshold should focus on sustaining industrial competitiveness and integrating demographic strategies with industrial policy to ensure long-term growth.

5.2 Policy Recommendations

Based on the above conclusions, this section proposes targeted policy recommendations to maximize the role of the working-age population in promoting economic development through industrial structure upgrading.

This study advances theoretical understanding by empirically validating a structural pathway: Working-age population ⟶ Industrial structure upgrading ⟶ Economic development, moderated by a structural threshold. It contributes to the literature on demographic economics and endogenous growth by highlighting the contingent nature of demographic benefits.

From a policy perspective, a dual-track strategy is recommended:

In advanced regions (above the ISU threshold): Focus on consolidating innovation-driven industries, deepening service-sector reform, and investing in human capital for high-skilled sectors.

In less-developed regions (below the threshold): Prioritize industrial transformation, infrastructure investment, and strategic allocation of demographic resources to unlock latent growth potential.

By aligning demographic planning with structural upgrading, China can mitigate the negative effects of aging and transition toward high-quality, sustainable development.

5.2.1 Optimize the Supply and Allocation of the Working-Age Population

Policy Recommendation: Optimize the working-age population allocation. This is directly informed by the significant direct effect of WA_ratio on GDP growth (β=0.11, $p<0.01$; Table 4.3), confirming the demographic dividend's potency. Therefore, the government should:

Break down regional mobility barriers:

Deepen the household registration system reform in accordance with the requirement of the 20th Central Committee Third Plenary Session to "implement the system of providing basic public services based on permanent residence registration", and cancel education and medical restrictions linked to household registration.

Support elderly human resource development:

Establish a market-oriented management information system for elderly labor, integrating socialized service and management systems. Prioritize employment opportunities for low-age elderly people (60–69 years) with professional skills—empirical studies show that age and skill proficiency significantly affect elderly re-employment (Encyclopedia of Elderly Human Resource Development in China, 2025).

Strengthen fertility support:

Increase fiscal input in fertility and childcare services to account for over 0.5% of GDP, a threshold proven by industrialized countries to maintain a total fertility rate above 1.5 (Beijing Supervision Bureau of the Ministry of Finance, 2023).

Implement progressive delayed retirement:

Formulate a phased retirement plan, adjusting labor contracts and social security benefits to encourage elderly labor participation (Beijing Supervision Bureau of the Ministry of Finance, 2023).

5.2.2 Accelerate Industrial Structure Upgrading to Strengthen the Mediating Role

Accelerating industrial structure upgrading corresponds to H2 (mediation effect), which requires transforming traditional manufacturing towards high-end and intelligent development. Specific measures include:

Promote the development of the tertiary industry with high added value:

Increase investment in modern service industries such as finance, technology, and healthcare, and provide tax incentives for enterprises in these sectors to attract labor from the working-age population.

Encourage the integration of manufacturing and services (e.g., developing productive services such as R&D design and logistics) to create more high-quality jobs that match the skills of the working-age population.

Upgrade traditional industries to improve labor absorption capacity:

Promote technological transformation of traditional manufacturing and agriculture, and train the working-age population in skills suitable for industrial upgrading (e.g., digital technology and intelligent operation) through vocational education.

Establish industry-university-research cooperation platforms to transfer advanced technologies to enterprises, enhancing the productivity of the working-age population in traditional sectors.

Foster the “silver economy”:

Expand the smart elderly care market (e.g., health monitors, assistive robotics), which generated ¥50 billion in revenue in 2023 with a 120% year-on-year increase. Support the development of healthcare and social service industries to absorb both young and elderly labor (Population Aging and its Impact on China’s High-Quality Economic Development, 2025).

Promote automation in labor-short industries:

Guide manufacturing firms to invest in intelligent technologies to address workforce deficits, especially in labor-intensive sectors like electronics and textiles (China Daily, 2023).

5.2.3 Implement Differentiated Policies Based on the Threshold Characteristics of Industrial Structure

This is grounded in the threshold effect identified in Section 4.5 (Table 4.6). The finding that the economic impact of WA_ratio nearly doubles (from β=0.08 to β=0.15) once ISU exceeds 48.56% necessitates region-specific strategies.Policies for regions with low industrial structure upgrading (ISU $\leq$ 48.56%):

Prioritize improving the industrial foundation, such as strengthening infrastructure construction and attracting labor-intensive industries to accumulate a sufficient working-age population.

Provide targeted training for the working-age population to adapt to the initial stage of industrial upgrading (e.g., basic service skills and assembly line operation skills).

Policies for regions with high industrial structure upgrading (ISU > 48.56%):

Focus on improving the quality of the working-age population, such as increasing investment in higher education and vocational training in high-tech fields to meet the demand for skilled labor in advanced industries.

Establish an innovation-driven development mechanism, including intellectual property protection and venture capital support, to enable the working-age population to participate in high-value-added economic activities.

This policy corresponds to H3 (threshold effect):For regions with an industrial structure upgrading level below 48.56% (e.g., some central and western provinces), priority should be given to improving the industrial foundation (such as infrastructure and business environment), undertaking the transfer of labor-intensive industries, and accumulating the working-age population and industrial foundation.

For regions east of the "Hu Huanyong Line" (high aging, developed economy): Focus on upgrading the elderly care industry and high-tech services to match the skill level of the local working-age population. For western regions (low aging, underdeveloped industry): Undertake labor-intensive industries transferred from the east to utilize surplus labor and accumulate industrial foundation (Liu Lihui, Development Research Center of the State Council, 2021).

For regions with an industrial structure upgrading level exceeding 48.56% (e.g., developed eastern provinces), focus should be on human capital improvement and innovation-driven development, cultivating high-end industrial clusters, and further amplifying the economic effect of the working-age population.

5.2.4 Improve Supporting Measures for Human Capital and Technological Progress

Strengthen human capital accumulation of the working-age population:

Increase public investment in education, especially in compulsory education and vocational education, to raise the average years of education of the working-age population (targeting an increase from 8.45 years to 11.3 years by 2035, in line with China's Education Modernization 2035 plan).

Promote lifelong learning systems, such as online vocational training platforms, to help the working-age population adapt to industrial upgrading and technological changes.

Enhance total factor productivity to match the working-age population:

Increase investment in scientific and technological research, especially in core technologies, and promote the transformation of scientific and technological achievements into industrial productivity.

Improve the market-oriented allocation mechanism of factors, allowing capital, technology, and the working-age population to be allocated to high-productivity sectors.

This policy corresponds to the empirical results of control variables: Based on the significant positive effects of human capital and TFP on economic growth, increase investment in vocational education and lifelong training to improve the skill level of the working-age population; increase investment in core technology R&D and promote the transformation of scientific and technological achievements, adapting technological progress to industrial upgrading and demographic changes.

Regulate age discrimination:

Enact laws to increase the cost of age discrimination, establish complaint and reporting mechanisms, and ensure equal employment opportunities for all age groups (Beijing Supervision Bureau of the Ministry of Finance, 2023).

Leverage AI to optimize labor allocation:

Promote the application of AI in labor market matching platforms to mitigate labor resource mismatch caused by aging, especially in regions with high education levels and severe market segmentation (Population aging, artificial intelligence and mismatch of labor resources: evidence from China, 2024).

Upgrade education to align with labor market needs:

The average years of schooling of the working-age population has reached 10.75 years; future efforts should focus on vocational education to improve skill matching with industrial upgrading (China Daily, 2023).

5.3 Research Limitations and Future Directions

5.3.1 Research Limitations

Limitations in variable measurement:

The working-age population is measured by the proportion of 15–59-year-olds, but it does not distinguish between labor force participation rates and skill levels. In reality, the economic impact of the working-age population may vary with their actual participation in the labor market and skill structure.

Industrial structure upgrading is measured by the proportion of tertiary industry value-added to GDP, which does not fully reflect the internal upgrading of the tertiary industry (e.g., the difference between traditional services and modern services).

Limitations in data and methods:

The study uses provincial panel data, which may mask differences at the city or county level. Micro-level data (e.g., enterprise or household survey data) could provide more detailed insights into the mechanism.

The threshold effect model only identifies a single threshold, but there may be multiple thresholds in reality, and the interaction between multiple threshold variables (e.g., human capital and industrial structure) is not considered.

Limitations in mechanism analysis:

The study focuses on the mediating role of industrial structure upgrading but does not explore other potential transmission channels (e.g., consumption and innovation).

The impact of the working-age population may vary across different age groups (e.g., young vs. middle-aged labor), which is not analyzed in depth.

5.3.2 Future Research Directions

Improve variable measurement and expand research perspectives:

Use more refined indicators to measure the working-age population, such as labor force participation rate by age group and skill level (e.g., dividing by education level or professional qualifications).

Measure industrial structure upgrading using multi-dimensional indicators, such as the ratio of high-tech industry output to total output and the employment structure of the tertiary industry, to capture the quality of industrial upgrading.

Adopt micro-level data and advanced methods:

Use enterprise-level data to analyze how the working-age population affects enterprise productivity through industrial structure upgrading, and household survey data to explore the impact of individual labor supply on family income and consumption.

Apply more advanced econometric methods, such as the multi-threshold model and spatial panel model, to identify multiple thresholds and spatial spillover effects of the working-age population and industrial structure upgrading.

Deepen mechanism analysis and expand research scenarios:

Explore other transmission mechanisms, such as how the working-age population affects economic development through innovation (e.g., R&D investment) and consumption (e.g., consumption structure upgrading).

Analyze the heterogeneous impact of the working-age population across different regions (e.g., eastern vs. western China) and industries (e.g., manufacturing vs. services) to provide more targeted policy recommendations.

Extend the research to the context of population aging and digital economy, exploring how the working-age population can adapt to aging and digital transformation to promote sustainable economic development.

REFERENCES

Acemoglu, D., & Guerrieri, V. (2008). Capital deepening and non-balanced economic growth. Journal of Political Economy, 116(3), 467-498.

Acemoglu, D., Aghion, P., & Zilibotti, F. (2006). Distance to frontier, selection, and economic growth. Journal of the European Economic Association, 4(1), 37-74.

Aghion, P., & Howitt, P. (1992). A model of growth through creative destruction. Econometrica, 60(2), 323-351.

Amornkitvikai, Y., Harvie, C., & Karcharnubarn, R. (2022). The impact of demographic structure, human capital, migration and environmental degradation on economic growth in Asia. Journal of Economic Studies, 50(2), 216-233. https://doi.org/10.1108/jes-09-2021-0487

Arrow, K. J. (1962). The economic implications of learning by doing. The Review of Economic Studies, 29(3), 155-173.

Author Unknown. (2025). Population Aging and its Impact on China's High-Quality Economic Development. http://www.shurl.cc/dd33c74845abb3c99243472276a2debf

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. Journal of Personality and Social Psychology, 51(6), 1173-1182. https://doi.org/10.1037/0022-3514.51.6.1173

Baumol, W. J. (1967). Macroeconomics of unbalanced growth: The anatomy of urban crisis. The American Economic Review, 57(3), 415-426.

Beijing Supervision Bureau of the Ministry of Finance. (2023). The impact of population aging on China's labor market and countermeasures. https://bj.mof.gov.cn/ztdd/czysjg/jyjl/202312/t20231213_3921874.htm

Bloom, D. and Canning, D. (2004). Global demographic change: dimensions and economic significance. https://doi.org/10.3386/w10817

Bloom, D. E., Canning, D., & Sevilla, J. (2003). The demographic dividend: A new perspective on the economic consequences of population change. Rand Corporation.

Bongaarts, J. (2017). Africa's unique fertility transition. Population and Development Review, 43(S1), 39-58.

Brandt, L., Hsieh, C. T., & Zhu, X. (2008). Growth and structural transformation in China. China's Great Economic Transformation, 683-728.

Cai, F. (2010). Demographic transition, demographic dividend, and Lewis turning point in China. China Economic Journal, 3(2), 107-119.

Cai, F. and Yang, L. (2013). Population change and resulting slowdown in potential gdp growth in China. China & World Economy, 21(2), 1-14. https://doi.org/10.1111/j.1749-124x.2013.12012.x

Caldwell, J. C., & Caldwell, B. K. (2006). Demographic transition theory. Springer.

Caner, M., & Hansen, B. E. (2004). Instrumental variable estimation of a threshold model. Econometric Theory, 20(5), 813-843. https://doi.org/10.1017/S0266466604205011

Chen, C. (2023). Exchange rate effects on China's exports: product sophistication and exchange rate elasticity. Asian Economic Journal, 37(3), 371-400. https://doi.org/10.1111/asej.12309

Chenery, H. B., & Syrquin, M. (1975). Patterns of development, 1950-1970. Oxford University Press.

China Daily. (2023). Shrinking working population poses challenges to job market. http://global.chinadaily.com.cn/a/202312/29/WS658e2484a31040ac301aa165.html

China statistical yearbook 2023, https://www.stats.gov.cn/sj/ndsj/2023/indexeh.htm

Clark, C. (1940). The conditions of economic progress. Macmillan and Co., Limited.

Duan, Y., Ping, L., Deng, M., Bu, T., Liu, X., Popović, S., … & Matić, R. (2022). The effects of demographic trends on the high-quality development of the Chinese sports industry. Sustainability, 14(2), 1039. https://doi.org/10.3390/su14021039

Easterly, W., & Levine, R. (2001). What have we learned from a decade of empirical research on growth? It's Not Factor Accumulation: Stylized Facts and Growth Models. The World Bank Economic Review, 15(2), 177-219.

Encyclopedia of Elderly Human Resource Development in China. (2025). https://m.baike.com/wiki/%E4%B8%AD%E5%9B%BD%E4%BA%BA%E5

%8F%A3%E8%80%81%E9%BE%84%E5%8C%96%E8%83%8C%E6%99%AF%E4%B8%8B%E7%9A%84%E8%80%81%E5%B9%B4%E4%BA%BA%E5%8A%9B%E8%B5%84%E6%BA%90%E5%BC%80%E5%8F%91%E7%A0%94%E7%A9%B6/20777657

Fan, S., Zhang, X., & Robinson, S. (2003). Structural change and economic growth in China. Review of Development Economics, 7(3), 360-377. https://doi.org/10.1111/1467-9361.00196

Fei, J. C., & Ranis, G. (1961). A theory of economic development. The American Economic Review, 51(4), 533-565.

Felipe, J., Kumar, U., Usui, N., & Abdon, A. (2010). Why has China succeeded - and why it will continue to do so. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.1661920

Fields, G. S. (2004). Dualism in the labor market: A perspective on the Lewis model after half a century. The Manchester School, 72(6), 724-735.

Fisher, A. G. (1939). Production, primary, secondary and tertiary. Economic Record, 15(1), 24-38.

Foley, E. (2022). In pursuit of the demographic dividend: the return of economic justifications for family planning in Africa. Sexual and Reproductive Health Matters, 30(1). https://doi.org/10.1080/26410397.2022.2133352

Gollin, D. (2014). The Lewis model: A 60-year retrospective. Journal of Economic Perspectives, 28(3), 71-88.

Grossman, G. M., & Helpman, E. (1991). Innovation and growth in the global economy. MIT press.

Guo, Z. and Tang, X. (2023). Changes in the structure of the employment population in China (2010-2020). Academic Journal of Business & Management, 5(7). https://doi.org/10.25236/ajbm.2023.050713

Hansen, B. E. (2000). Sample splitting and threshold estimation. Econometrica, 68(3), 575-603.

Hansen, B. E. (2000). Sample splitting and threshold estimation. Econometrica, 68(3), 575-603. https://doi.org/10.1111/1468-0262.00124

Hou, G., Zhou, Z., Zhang, T., & Meng, Y. (2019). Analysis of the effect of industrial transformation of resource-based cities in northeast China. Economies, 7(2), 40. https://doi.org/10.3390/economies7020040

Hsu, M., Liao, P., & Zhao, M. (2018). Demographic change and long-term growth in China: past developments and the future challenge of aging. Review of Development Economics, 22(3), 928-952. https://doi.org/10.1111/rode.12405

Hu, S. and He, K. (2023). Can the opening of China-European railway express enhance technical sophistication of export from Chinese cities?.. https://doi.org/10.36689/uhk/hed/2023-01-058

Hu, Y. and Coulter, R. (2016). Living space and psychological well-being in urban china: differentiated relationships across socio-economic gradients. Environment and Planning a Economy and Space, 49(4), 911-929. https://doi.org/10.1177/0308518x16680213

Huang, Z., Zhou, J., & Xiong, H. (2021). Does the transfer of farmland use rights increase farmers' long-term intention to work in cities?. Economics of Transition and Institutional Change, 30(2), 373-392. https://doi.org/10.1111/ecot.12298

Jones, C. I. (1995). R & D-based models of economic growth. Journal of Political Economy, 103(4), 759-784.

Kirk, D. (1996). Demographic transition theory. Population Studies, 50(3), 361-387.

Kotschy, R., Urtaza, P., & Sunde, U. (2020). The demographic dividend is more than an education dividend. Proceedings of the National Academy of Sciences, 117(42), 25982-25984. https://doi.org/10.1073/pnas.2012286117

Kuznets, S. (1966). Modern economic growth: Rate, structure, and spread. Yale University Press.

Le, D. and Park, H. (2019). The impact of demographic change on economic growth. The Singapore Economic Review, 65(02), 471-484. https://doi.org/10.1142/s0217590819500401

Lewis, W. A. (1954). Economic development with unlimited supplies of labour. The Manchester School, 22(2), 139-191.

Li, H. and Chen, Y. (2023). The impact of producer services agglomeration on the industrial structure upgrading: evidence from the four urban agglomerations in china.. https://doi.org/10.21203/rs.3.rs-3204820/v1

Li, M., Wang, Y., & Zhang, L. (2024). Population aging, artificial intelligence and mismatch of labor resources: evidence from China. Applied Economics, 56(12), 1345-1362. https://doi.org/10.1080/00036846.2024.2312263

Li, S. (2021). The impact of labor mobility on industrial upgrading in China. E3s Web of Conferences, 235, 02055. https://doi.org/10.1051/e3sconf/202123502055

Liao, R. (2024). Research on Vietnams demographic dividend period. Communications in Humanities Research, 34(1), 128-133. https://doi.org/10.54254/2753-7064/34/20240125

Lin, M. (2022). Prospects for the development of china's "silver-haired talents" market in the post demographic dividend period. BCP Business & Management, 30, 558-564. https://doi.org/10.54691/bcpbm.v30i.2499

Liu, C. and Guan-jun, X. (2018). Research on the dynamic interrelationship among r&d investment, technological innovation, and economic growth in China. Sustainability, 10(11), 4260. https://doi.org/10.3390/su10114260

Liu, L. (2021). What impacts does population aging have on the labor market? Development Research Center of the State Council. https://www.drc.gov.cn/DocView.aspx?chnid=379&leafid=1338&docid=2903570

Liu, M., Huang, L., & Liu, J. (2016). Industrial structure change in Chinese cities: measurement based on the extent and quality. Modern Economy, 07(08), 894-903. https://doi.org/10.4236/me.2016.78093

Liu, Y. and Zhao, H. (2022). Quantitative evaluation of policy based on pmc index model: a case study of China's textile industry policy. Mathematical Problems in Engineering, 2022, 1-17. https://doi.org/10.1155/2022/1870185

Liu, Z., Fang, Y., & Ma, L. (2022). A study on the impact of population age structure change on economic growth in China. Sustainability, 14(7), 3711. https://doi.org/10.3390/su14073711

Lucas Jr, R. E. (1988). On the mechanics of economic development. Journal of Monetary Economics, 22(1), 3-42.

Lutz, W., Cuaresma, J., Kebede, E., Prskawetz, A., Sanderson, W., & Striessnig, E. (2019). Education rather than age structure brings demographic dividend.

Proceedings of the National Academy of Sciences, 116(26), 12798-12803. https://doi.org/10.1073/pnas.1820362116

Ma, D. (2023). Industrial structure upgrading, population aging and migration: an empirical study based on Chinese provincial panel data. Plos One, 18(10), e0291718. https://doi.org/10.1371/journal.pone.0291718

McMillan, M. S., & Rodrik, D. (2011). Globalization, structural change and productivity growth. In Making globalization socially sustainable (pp. 49-84). International Labour Organization and World Trade Organization.

Minami, R. (1968). The turning point in the Japanese economy. The Quarterly Journal of Economics, 82(3), 380-402.

Nguea, S. (2023). Improving human development through urbanization, demographic dividend and biomass energy consumption. Sustainable Development, 31(4), 2517-2535. https://doi.org/10.1002/sd.2528

Notestein, F. W. (1945). Population: The long view. In T. W. Schultz (Ed.), Food for the world (pp. 36-57). University of Chicago Press.

Pack, H. (1994). Endogenous growth theory: Intellectual appeal and empirical shortcomings. Journal of Economic Perspectives, 8(1), 55-72.

Peng, X. (2013). Understanding china's demographic dividends and labor issue. Journal of Policy Analysis and Management, 32(2), 408-410. https://doi.org/10.1002/pam.21685

Populationpyramid.net. (2024). China's Population Pyramids from 2000 to 2023.

Qi, R. and Long, Q. (2020). Can synergy effect exist between green finance and industrial structure upgrade in China?. Open Journal of Social Sciences, 08(08), 215-226. https://doi.org/10.4236/jss.2020.88019

Qin, J. (2024). The impact of the digital economy on population dividends in China: based on the dual perspective of quantity and quality. Sustainability, 16(10), 4254. https://doi.org/10.3390/su16104254

Qin, J. (2024). The impact of the digital economy on population dividends in china: based on the dual perspective of quantity and quality. Sustainability, 16(10), 4254. https://doi.org/10.3390/su16104254

Retrieved from . https://www.populationpyramid.net/china/2023/

Rodrik, D. (2016). Premature deindustrialization. Journal of Economic Growth, 21(1), 1-33.

Romer, P. M. (1986). Increasing returns and long-run growth. Journal of Political Economy, 94(5), 1002-1037.

Romer, P. M. (1990). Endogenous technological change. Journal of Political Economy, 98(5, Part 2), S71-S102.

Shen, X., Jing-bo, L., Cao, J., & Wang, Z. (2022). How population aging affects industrial structure upgrading: evidence from china. International Journal of Environmental Research and Public Health, 19(23), 16093. https://doi.org/10.3390/ijerph192316093

Sobel, M. E. (1982). Asymptotic confidence intervals for indirect effects in structural equation models. Sociological Methodology, 13, 290-312. https://doi.org/10.2307/270723

Soldan, E. (2023). Insights into the demographic dividend and the window of opportunity: a conceptual overview. Economy and Sociology, (1). https://doi.org/10.36004/nier.es.2023.1-06

Solow, R. M. (1957). Technical change and the aggregate production function. The Review of Economics and Statistics, 39(3), 312-320.

Song, M. and Xie, Q. (2019). How does green talent influence china's economic growth?. International Journal of Manpower, 41(7), 1119-1134. https://doi.org/10.1108/ijm-08-2019-0378

Ssewamala, F. (2014). Optimizing the "demographic dividend" in young developing countries: the role of contractual savings and insurance for financing education. International Journal of Social Welfare, 24(3), 248-262. https://doi.org/10.1111/ijsw.12131

Su, J., Su, K., & Wang, S. (2021). Does the digital economy promote industrial structural upgrading?—a test of mediating effects based on heterogeneous technological innovation. Sustainability, 13(18), 10105. https://doi.org/10.3390/su131810105

Szreter, S. (1993). The idea of demographic transition and the study of fertility change: A critical intellectual history. Population and Development Review, 19(4), 659-701.

Taguchi, H. and Latjin, M. (2022). The effects of demographic dynamics on economic growth in eu economies: a panel vector autoregressive approach. Journal of Population Ageing, 16(3), 569-588. https://doi.org/10.1007/s12062- 022-09375-5

Tang, B., Li, Z., Hu, S., & Xiong, J. (2022). Economic implications of health care burden for elderly population. Inquiry the Journal of Health Care Organization Provision and Financing, 59, 004695802211215. https://doi.org/10.1177/00469580221121511

Thompson, W. S. (1929). Population. American Journal of Sociology, 34(6), 959-975.

Todaro, M. P., & Smith, S. C. (2015). Economic development (12th ed.). Pearson.

United nations. https://population.un.org/wpp/.

Uzawa, H. (1965). Optimum technical change in an aggregative model of economic growth. International Economic Review, 6(1), 18-31.

Wang, F., Wang, R., & He, Z. (2022). Exploring the impact of "double cycle" and industrial upgrading on sustainable high-quality economic development: application of spatial and mediation models. Sustainability, 14(4), 2432. https://doi.org/10.3390/su14042432

Wang, X. (2018). Industrial upgrading effect of OFDI of Sichuan province of China. International Journal of Economics and Finance, 10(10), 138.

Wang, Z., Sun, X., & Zhang, G. (2018). Structural dividends and economic growth in china. Zbornik Radova Ekonomskog Fakulteta U Rijeci Časopis Za Ekonomsku Teoriju I Praksu/Proceedings of Rijeka Faculty of Economics Journal of Economics and Business, 36(1), 355-372. https://doi.org/10.18045/zbefri.2018.1.355

Yang, Y., Zheng, R., & Zhao, L. (2021). Population aging, health investment and economic growth: based on a cross-country panel data analysis. International Journal of Environmental Research and Public Health, 18(4), 1801. https://doi.org/10.3390/ijerph18041801

Ye, J., Chen, Z., & Peng, B. (2021). Is the demographic dividend diminishing in China? Evidence from population aging and economic growth during 1990–2015. Review of Development Economics, 25(4), 2255-2274. https://doi.org/10.1111/rode.12794 https://doi.org/10.1111/rode.12794

Zhang, M., You, S., Zhang, L., Zhang, H., & Wang, Y. (2023). Dynamic analysis of the effects of aging on China’s sustainable economic growth. Sustainability, 15(6), 5076. https://doi.org/10.3390/su15065076

Zhang, Y. and Zong, Y. (2020). China's "demographic dividend" and the transformation of foreign direct investment. Destech Transactions on Engineering and Technology Research, (mcaee). https://doi.org/10.12783/dtetr/mcaee2020/35105

Zhao, B., Wang, K., & Xu, R. (2022). Fiscal decentralization, industrial structure upgrading and carbon emission: evidence from china.. https://doi.org/10.21203/rs.3.rs-2175130/v1

Zhou, J., Deng, J., Li, L., & Wang, S. (2023). The demographic dividend or the education dividend? evidence from China’s economic growth. Sustainability, 15(9), 7309. https://doi.org/10.3390/su15097309

This is Mendeley bioraphy