Digitalization and Management Innovation III
A.J. Tallón-Ballesteros (Ed.)

doi:10.3233/FAIA250026

A Review of Research on the Impact of Ageing on the Digital Economy and Its Countermeasures

Jianyang Liu [a] and Lifeng Song [a,1]
[a] *Beijing Wuzi University, China*

Abstract. With global demographic changes, population ageing has become one of the most important social phenomena of the 21st century, with far-reaching implications for China and the global economic system. This article comprehensively analyses the impact of population ageing on macroeconomics, regional economy and microeconomics, and discusses effective policy response strategies. The article first analyses the current situation and trend of population ageing, then discusses its impact on digital macroeconomics, digital regional economy and digital microeconomics, and finally makes macroeconomic and social security policy recommendations to cope with ageing. The findings of this study underscore the necessity for collective action by governments, businesses, social organisations and individuals alike in order to effectively address the challenges associated with an ageing population. Further research is required to enhance comprehension of the impacts of ageing, particularly in the context of the accelerated development of the digital economy. Additionally, investigation into the effective utilisation of technology to optimise the quality of life and social participation of older individuals is a subject that merits comprehensive examination. This paper advocates for collective action by all societal sectors to construct a comprehensive strategic framework for adapting to an ageing society, with the objective of ensuring sustained and robust economic growth and comprehensive and harmonious social advancement.

Keywords. Population ageing; digital economy impact; economic growth; social security; technological innovation; policy recommendations

1. Introduction

In the context of the significant global demographic shifts that have occurred in the twenty-first century, the phenomenon of ageing has emerged as a particularly salient social issue. The issue of ageing has become a significant concern for governments and sociologists due to the ongoing decline in fertility rates, the increasing longevity of life expectancy, and the entry of large-scale populations into old age. As projected by the United Nations, the global population of individuals aged 60 and above will reach 2.2 billion by 2050, representing 22% of the total population. In Europe, this proportion will reach 34%. Developing regions, such as Asia and Latin America, will also be confronted with the unprecedented challenge of an ageing population.

[1]Corresponding Author: Lifeng Song, Email: songlifeng@bwu.edu.cn.

In China, the world's most populous country, the issue of an ageing population is particularly salient. Since China entered an ageing society in 2000, the proportion of elderly people in the country has continued to rise. It is projected that the number of elderly individuals in China will reach 480 million by 2050, representing approximately a quarter of the global elderly population. This demographic shift presents a number of challenges to the family structure, social security system and distribution of healthcare resources. Furthermore, it has the potential to impact the sustained and healthy development of the digital economy. In this context, an in-depth study of the impact of ageing on the digital economy and its countermeasures is of great theoretical and practical significance for achieving sustainable economic and social development.

The existing literature on the economic impact of ageing focuses on the following aspects: firstly, the impact of ageing on the labor market. As the proportion of the population of working age declines, the issue of an insufficient labor supply becomes increasingly salient. This may give rise to higher labor costs and lower productivity, which in turn may affect economic growth. A second area of focus is the impact of an ageing population on consumption and savings. The process of ageing may result in alterations to the consumption structure, with the consumption requirements of the elderly differing from those of the young. This may consequently influence the advancement of related industries. Furthermore, the process of ageing may also exert an influence on investment and capital accumulation, as a consequence of its impact on the savings rate.

The objective of this paper is to put forth a series of proposed countermeasure suggestions, based on a comprehensive analysis of the impact of aging on the digital economy. In terms of methodology, this paper will adopt a systematic literature review approach to examine the existing research literature on the impact of aging on the digital economy, both domestically and internationally. This analysis will be contextualized within the specific circumstances of China. This paper's research content is comprised of three principal elements. Initially, the current situation and trend of population ageing in China will be analyzed. Subsequently, the impact of ageing on digital macroeconomics, digital regional economy and digital microeconomics will be explored. Finally, macroeconomic policy and social security policy suggestions will be put forward to cope with ageing.

The paper makes two distinct contributions to the existing body of literature. Firstly, it conducts an extensive review of the multifaceted ways in which an aging population influences the digital economy, a perspective that has been underexplored in prior research. The analysis delves into the intricate dynamics between aging and key components of the digital economy, such as labor market shifts, evolving consumer behaviors, and the pace of technological innovation. This comprehensive examination reveals the profound economic implications of demographic aging, paving the way for more strategic and effective policy interventions. Secondly, this research presents a set of policy recommendations specifically calibrated to China's aging scenario. These recommendations are designed to harness the digital economy as a lever for addressing the challenges posed by an aging demographic, with a focus on enhancing digital literacy among the elderly, fostering a culture of digital entrepreneurship, and catalyzing the digital transformation of traditional sectors to generate inclusive employment opportunities. By offering these targeted suggestions, this study seeks to inform policy discourse and strategic planning in China's pursuit of digital economic growth amidst an aging population.

The theoretical foundation of this paper is primarily based on the principles of population economics, development economics and social security theory. Population economics provides a theoretical framework for analyzing the impact of demographic changes on the economy. Development economics, on the other hand, focuses on structural changes and policy choices in the process of economic development. Finally, social security theory provides theoretical support for analyzing the impact of ageing on the social security system and proposing reforms. The study is of great practical significance about China's response to population ageing. As the process of ageing accelerates, the question of how to balance the social security needs of the elderly population with the sustainability of economic development through policy adjustments represents a significant challenge for China. The research presented in this paper can serve not only to provide a theoretical basis for the formulation of relevant policies by the government, but also to offer a new perspective for academics engaged in the study of the ageing issue.

2. Related works

The burgeoning digital economy and the concurrent rise of an aging population have set the stage for a complex interplay of demographic and economic factors. This section reviews the literature that addresses the impact of aging on the digital economy and explores potential strategies to mitigate any adverse effects[1].

2.1 The Aging Population and Digital Economy Dynamic

The study by Guo and Xiao (2024) [2]delves into the impact of an aging labor force on the employment transformation of migrant workers amidst the burgeoning digital economy in China. Utilizing data from the China Family Panel Studies (CFPS) from 2012 to 2020, they employ multiple Logit regression models to assess the influence of an aging workforce on the transition of migrant workers from traditional to new economy sectors. Their research indicates that while an aging labor force significantly inhibits this employment transformation, the digital economy acts as a catalyst, promoting the shift and alleviating the negative impacts of an aging workforce. This finding underscores the potential of the digital economy as a strategic tool in addressing the challenges brought about by demographic aging.

2.2 Corporate Strategies in Response to Aging

Wang and Zhao (2024)[3] contribute to the discourse by examining the effects of population aging on corporate digital transformation strategies. Through an empirical investigation based on population census data from various provinces in China, they reveal that aging directly hinders financial support and decision-making for digital initiatives. Furthermore, they explore the indirect effects of aging through financial strategies and management perspectives. The study suggests that non-state-owned and small to medium-sized enterprises are more significantly impacted by aging, highlighting the need for tailored strategies to support these vulnerable sectors in the face of demographic changes.

2.3 Policy Implications and Strategic Insights

The synthesis of these studies offers valuable insights for policymakers and corporate strategists. The work of Guo and Xiao (2024)[2] suggests that leveraging the digital economy can be a proactive approach to counteract the employment challenges posed by an aging population. Similarly, Wang and Zhao (2024)[3] emphasize the necessity for enterprises to adapt their digital transformation strategies to accommodate the realities of an aging demographic, particularly for non-state-owned and SMEs that may lack the resources to navigate these changes independently

In conclusion, the existing literature highlights the necessity for a multifaceted approach to address the impact of an aging population on the digital economy. Strategies must consider both the broader economic implications and the specific challenges faced by different sectors and enterprise sizes. By doing so, it is possible to harness the potential of the digital economy to foster inclusive growth and mitigate the adverse effects of an aging workforce.

3. Methods

This literature review aims to assess the impact of an aging population on the digital economy and to explore strategic countermeasures within the Chinese context. The methodology is divided into two focused approaches corresponding to the two parts of the study.

This study employs the bibliometric methodology with the assistance of the Chinese database China Knowledge Network (CNKI). The following keywords were utilized: "silver-hair economy," "aging + medical expenses," "aging + regional development," "aging + finance," "aging + microeconomics," "aging + digital economy," and "aging + macroeconomics." The keywords were then taken as follows, with the time range from 1 January 2018 to 31 December 2023, and with the exclusion of news, conferences and other invalid literature. The CSSCI core journals were selected as the search target, resulting in the screening out of 387 pieces of related core literature. The main focus of the study was then a literature review and summary of this literature.

3.1 Impact Analysis

A systematic literature search was conducted using PubMed, IEEE Xplore, ScienceDirect, and Google Scholar with keywords such as "aging population," "digital economy," and "economic impact." The search was restricted to English-language articles published between 2010 and 2024. Articles were included if they provided empirical or theoretical analysis on the economic effects of an aging population on digital sectors. Non-empirical and off-topic studies were excluded. Data extraction focused on the key findings and methodologies, with a qualitative synthesis to identify the predominant themes and impacts.

3.2 Countermeasures Analysis

The second phase of the review centered on literature discussing strategies and policies to mitigate the impacts identified in Part 1. The search strategy was consistent with Part

1, with additional keywords like "strategies," "policies," and "countermeasures." Inclusion criteria favored articles offering actionable solutions or policy insights. Data were extracted to thematic categories such as policy interventions and technological adaptations, aiming to compile a set of strategic responses to the challenges of an aging population in the digital economy.

4. Results & Discussion

4.1 The impact of the ageing population on the digital economy and the challenges this presents.

As a global challenge of the twenty-first century, the impact of population ageing on the economic system is complex and multidimensional. The phenomenon exerts an influence on economic growth at the macro level, affecting labor markets, consumption patterns, savings and investment behavior. Furthermore, it influences regional economic structures, industrial upgrading and urbanization processes at the mesa level. Furthermore, at the micro level, changes in the age structure of the population are also influencing household decision-making, corporate behavior and individual consumption patterns. From a macroeconomic standpoint, population ageing presents a challenge to economic growth potential, as it leads to a reduction in both labor force participation and productivity. Concurrently, it may also result in alterations to consumption patterns, influencing savings rates and investment behavior, which in turn have far-reaching implications for macroeconomic stability and growth. At the mesa level, the impact of population ageing on regional economies is manifested in several ways. Firstly, there are constraints on economic density, employment density and energy supply levels. Secondly, there are effects on population contraction and economic dynamism. At the micro level, economic decisions made by households and businesses, including asset allocation, entrepreneurial behavior and savings rates, are also significantly influenced by ageing trends[4].

The objective of this paper is to provide a comprehensive analysis of the impact of population ageing on the macro, mesa and micro levels of the economic system, and to explore effective policy response strategies. By undertaking an exhaustive examination of the influence of an ageing population on economic growth, industrial structure, urbanization and social welfare, the paper will put forward a comprehensive strategy to advance high-quality economic development. This strategy will seek to offset the adverse effects of an ageing population while capitalizing on its potential positive effects[5].

4.1.1 This paper examines the impact of population ageing on the macro digital economy.

The phenomenon of population ageing represents a global trend with significant macroeconomic implications. Firstly, the process of ageing has a direct impact on the potential for economic growth, reducing both the participation rates of the labor force and the overall productivity of that labor[6]. Furthermore, this impact displays heterogeneity across regions, indicating the necessity for policymakers to adopt a more nuanced approach to regional considerations[7]. Furthermore, the process of ageing may also engender some positive changes about the growth of the digital economy. For instance, the ageing of the population may facilitate the development of green technology

and the substitution of capital, particularly in the environmental and technological spheres, thereby creating new avenues for economic growth. However, the macro-digital economy is also affected by the side effects of ageing to a greater extent. Firstly, it may result in a reduction in per capita consumption and diminished returns on capital, which in turn affects savings rates, industrial upgrading and productivity[8]. Furthermore, the process of ageing may result in a reduction in consumer demand and an increase in labor costs, which in turn have implications for tax policy. Furthermore, from a monetary policy perspective, the process of ageing presents a challenge to the objectives and effectiveness of monetary policy, with the potential to affect the economy by influencing fertility rates and income levels of the older population. Furthermore, the process of ageing exerts both spillover and crowding-out effects on foreign direct investment (FDI)[9], which generally inhibits FDI inflows.

As illustrated in the China Statistical Yearbook, the urban workers' pension insurance dependency ratio (defined as the ratio of the number of insured workers to the number of insured retirees) serves as a case in point. In 2007, the dependency ratio of China's urban workers' pension insurance was 3.07, indicating that for every 3.07 enterprise workers contributing to urban workers' pension insurance in 2007, there was one retired worker receiving pension. From 2007 to 2011, the dependency ratio exhibited a notable decline, dropping from 3.07 in 2007 to 2.017 in 2011. Similarly, from 2007 to 2009, the dependency ratio demonstrated a considerable reduction, dropping from 3.07 in 2007 to 2.53 in 2019, indicative of a general downward trend.

The ratio of income to expenditure of China's urban pension insurance fund provides an illustrative example of the observed declining trend from 2007 to 2022. Despite a brief period of recovery, the ratio of income to expenditure has continued to decline on an annual basis. From 2007 to 2020, the ratio of income to expenditure exhibited a decline, from 1.31 in 2007 to a low of 0.86 in 2020, representing a total decline of 0.45. In 2020, there was already a situation in which income was insufficient to cover expenditure. Subsequently, between 2020 and 2022, the ratio experienced a brief increase, reaching 1.07. Furthermore, the ratio of income to expenditure of the urban workers' pension insurance fund has remained at approximately 1 over the past four years. Given the prevailing trend of decline, it is anticipated that the ratio will continue to fall below 1 in the future, leading to an increased prevalence of insufficient income to cover expenditures.

Second, in the context of science, technology and innovation, there is a complex relationship between ageing and science, technology and innovation. Ageing can affect technological progress through mechanisms such as weakening the physical and mental capacities of workers, affecting the accumulation of human capital and threatening the innovative activities of enterprises. In particular, changes in the age structure of the population lead to a reduction in the labor force and force companies to recruit older workers. As the age of employees increases, their ability to learn and innovate continues to decline, resulting in a lack of innovation in the implementation of innovation projects (Liang et al. 2014)[10].Meyer (2007)[11] found that firms with a high number of older employees usually have a harder time adopting new technologies than firms with a high number of younger employees. People's motivation to innovate changes with age (Bosek et al., 2005; Kanfer and Ackerman, 2004)[12,13], and as people get older, they realise that even learning will not bring much benefit in the future, and due to the time lag in generating benefits from new innovation-related technologies, older people may not be able to wait to enjoy its benefits (Friedberg, 2003).As people get older, they realize that even learning will not bring much benefit in the future, and due to the time lag in

generating benefits from new innovation-related technologies, older people may not be able to wait to enjoy its benefits (Friedberg, 2003)[14].

Ultimately, the key determinant of long-term economic development potential is total human resources, rather than total population. Even under relatively pessimistic population growth expectations, China's total human resources will continue to grow until 2040 and remain stable from 2040 to 2050. This indicates that the potential growth rate of China's economy in the next 30 years could be substantial.

Finally, ageing also has a negative impact on health care; in particular, the gradual deepening of demographic ageing can lead to a rapid increase in health care costs, contributing to an excessive financial burden on the national health sector. And why does population ageing lead to a significant increase in health expenditure? One key reason is that health expenditure rises significantly with age. Not only do older people have a higher incidence of disease than younger age groups, but they also suffer from diseases of longer duration, which directly leads to a significant increase in demand for health care and thus drives up the overall cost of health care.

The Special Report on the Sixth National Health Service Statistical Survey (Second Series), prepared by the Statistical Information Centre of the National Health and Welfare Commission, used data from the two national health service surveys in 2013 and 2018 to analyze the self-reported economic burden of chronic diseases among the elderly aged 60 and above. According to the analysis in this report, the economic burden of chronic diseases among the surveyed elderly population in 2018 was 610 million yuan, or 8,813.3 yuan per capita, which is a significant increase compared with the economic burden of chronic diseases among the surveyed elderly population in 2013, which was 2,481.8 yuan per capita. If the scope of the study is extended to the whole country, based on the 249 million elderly people aged 60 and above at the end of 2018, the national economic burden of chronic diseases among the elderly population will be 2.2 trillion yuan, while in 2013, based on the 212 million elderly people, the national economic burden of chronic diseases among the elderly population will be 0.5 trillion yuan.

In addition, according to data released by the National Committee on Ageing of China, without taking into account changes in the hospitalization rate, it is projected that the outpatient and inpatient medical and health care costs for the elderly in China will reach 130,987,000,000,000,000 yuan in 2050; taking into account changes in the hospitalization rate, it is projected that the outpatient and inpatient medical and health care costs for the elderly will reach 155,283,000,000,000,000 yuan in 2050.

In conclusion, the macroeconomic consequences of an ageing population are complex and interrelated, encompassing a range of domains including economic growth, monetary policy, labor productivity, foreign direct investment, science and technology innovation, and healthcare costs. The studies offer a variety of perspectives and comprehensive analyses of the impact of ageing on the economy, thereby facilitating a more nuanced understanding of the challenges posed by ageing. In evaluating the impact of ageing on the economy, it is essential for policymakers to consider the direct effects of ageing and its indirect effects through other factors, such as the urbanization rate and total human resources. This necessitates the adoption of appropriate policy design to mitigate the negative impacts of ageing while capitalizing on its potential positive effects.

4.1.2 This study examines the impact of population ageing on the regional digital economy.

In China, the process of population aging is gradually becoming an important factor affecting the development of regional digital economies. Relevant studies have demonstrated that 34 prefecture-level cities in Northeast China have entered a period of rapid aging, which has a significant impact on the level of local economic density, employment density, and energy supply. The inhibitory effect of aging on regional digital economic growth is evident, but the specific manifestations of this effect vary across different regions.

Firstly, the impact of population aging on the digital economy in towns and villages varies. One study, for instance, found that the aging risk in 31 provinces in China exhibited disparate spatial distributions and evolutionary trends when the PSR model and the weighted TOPSIS method were employed for analysis [5]. The use of panel data and threshold regression models in studies has revealed that when a certain level of urbanization is reached, the process of ageing can in fact facilitate industrial upgrading. Conversely, the process may be hindered. The specific reason for this may be since regions with a high level of urbanization have a high level of digital transformation, which helps to promote the development of the digital economy in towns and cities, especially in the service sector. This can effectively offset the economic pressure caused by ageing.

At the rural level, the adverse effects of population ageing are especially pronounced about the advancement of the digital economy. The low penetration of information technology in rural areas creates greater barriers for older population groups in the use of digital technology. This not only limits their ability to access information and services, but also impedes the pace of rural digital economy development. For instance, obstacles impede the dissemination of e-commerce, telemedicine, and smart agriculture, among other domains. These impediments could potentially enhance the quality of life for older individuals and augment the efficiency of agricultural production. Furthermore, the aging of the population in rural areas can also result in a deficit of individuals with digital skills, as younger generations tend to migrate from these areas, leaving a dearth of local talent with modern information technology. This further constrains the implementation of digital tools and innovation.

From an industrial standpoint, the impact of an ageing population on digital transformation varies across different sectors. From the perspective of the manufacturing industry, the ageing of the population has been observed to drive capital accumulation and productivity growth. This is due to a reduction in the labor supply, which in turn prompts enterprises to rely more on automation technology and intelligent equipment. Concurrently, to address labor shortages, enterprises have augmented their investment in human capital and facilitated technological innovation, thereby propelling the transformation and modernization of the manufacturing industry. Nevertheless, in the eastern developed regions, the process of ageing has resulted in a discernible negative impact on the digital transformation of the service industry [15]. The service industry is characterized by a high degree of dependency on human capital, particularly in sectors that necessitate direct interpersonal interaction, such as retail, catering and personal care services. As the proportion of the population in the older age bracket increases, the structure of the labor market undergoes a series of shifts, with a reduction in the number of younger workers leading to a decline in the quality-of-service provision and a weakening of the incentives for service innovation.

According to the 45th Statistical Report on China's Internet Development Status released by the China Internet Network Information Centre, as of March 2020, older internet users over 60 in China accounted for 6.7% of the total number of internet users, and the penetration rate of older internet users was 23.7%, less than a third of that of younger internet users (73.0%) (estimated based on China's total population and its composition at the end of 2019). Similarly, one in two people in China use mobile phones to access the Internet, but only one in five older people use mobile Internet.

In terms of use, the proportion of elderly people using search engines, installing APPs and using WeChat is significantly lower than that of young people, due to the existence of digital skills deficits. Among them, the proportion of elderly people using search engines is 4.4%, less than 1/6 of non-elderly internet users (27.4%); the number of mobile phone APPs per capita of elderly people is 37, only 44.0% of that of young internet users aged 20-29 (84 mobile phone APPs per capita); the proportion of elderly people using WeChat is 26.2%, less than 1/6 of that of non-elderly users .It can be inferred that the aging population is hindering the popularity of the IT industry.

In conclusion, the process of population ageing exerts a complex and multidimensional influence on the advancement of China's regional digital economy. The phenomenon of deep ageing is particularly pronounced in the Northeast, which is facing significant challenges in terms of economic density, employment and energy supply. In comparison between urban and rural areas, the negative impact of ageing is to some extent offset in urban areas due to higher levels of urbanization and digital transformation, as well as the promotion of services and other sectors. Nevertheless, rural areas are characterized by low levels of IT penetration and difficulties encountered by the elderly in utilizing digital technologies. This has resulted in a notable impediment to the advancement of the digital economy, particularly in the domains of e-commerce, telemedicine and smart agriculture. From an industrial perspective, the impact of ageing on the manufacturing industry is primarily evidenced by the promotion of automation and intelligent processes, which has prompted enterprises to increase their reliance on technology, thereby enhancing productivity and capital accumulation. However, in the service sector, particularly in the developed eastern regions, the structural shifts in the labor force due to ageing have undermined the quality of service and innovation capacity, which has a detrimental impact on the digital transformation of the service sector.

4.1.3 This paper examines the impact of population ageing on the micro-digital economy

As a significant socio-economic phenomenon of the 21st century, the influence of population ageing on the economy has progressively permeated from the macro to the micro level. The rapid development of information technology and the deepening of digital transformation have resulted in the emergence of the digital economy as a new engine for economic growth. However, population ageing is also bringing a series of unprecedented challenges and opportunities. In this context, an investigation into the impact of population ageing on the micro-digital economy is significant for understanding the current economic development trend and for formulating relevant policies to adapt to and guide this change. The objective of this paper is to analyses the impact of population ageing on the micro-digital economy.

From the perspective of business innovation, the process of ageing has had a significant impact on labor-intensive industries, as well as exerting a profound influence on the development of high-technology firms and certain service industries. As the

proportion of the population over the age of 65 increases, the overall number of business entries in cities demonstrates a downward trend. This is primarily attributable to a reduction in the labor supply, a decline in human capital levels and changes in local market demand. The tightening of the labor market is compelling firms to reassess their long-term strategic planning, particularly regarding the recruitment of new personnel and the upgrading of technology. Furthermore, population ageing may also impact the innovative capacity and technological progress of firms by altering their age structure. As individuals age, their cognitive and innovative abilities may decline, which not only affects the internal innovation climate of firms but may also result in slow responses to rapidly changing market environments (7). From the standpoint of household economic behavior, the deepening of population ageing will have a profound impact on household consumption patterns and lifestyles, thereby indirectly contributing to an increase in household carbon emissions. A growing elderly population is frequently accompanied by shifts in consumption patterns, including an increased demand for services such as healthcare, leisure, and recreation. These changes may contribute to an overall rise in household energy consumption and carbon footprint.

First, from the perspective of household economic behavior, population ageing will have an impact on household financial allocation. According to the family life cycle theory, the life cycle of a family can be divided into three periods, namely young, middle-aged and old, and in different periods, the financial needs, wealth accumulation and consumption characteristics of family members are different. Therefore, at the level of financial asset allocation, the vast majority of the elderly will choose savings products with faster liquidity or lower risk savings products and financial assets in order to ensure the adequacy of their own funds for their old age and will be resistant to financial assets with higher risk and lower liquidity. In addition, when the family structure changes or family members become older, there is a significant change in individual and family attitudes to risk in financial management. For households with an older population or a relatively high proportion of older household members, attitudes towards financial assets tend to be more aversive, and such households are willing to choose lower-risk and more liquid financial assets when allocating financial assets. According to the 2017 and 2019 China Household Finance Survey (CHFS), the level of equity allocation accounts for a relatively low level of risky financial asset allocation among the financial assets of China's empty nester households. Financial asset management products, a low-risk financial asset, accounted for as much as 51 percent.

Concurrently, the process of ageing can also exert a detrimental influence on the level of entrepreneurial activity within the household. This is since the ageing process can result in a reduction in the number of social activities that are undertaken by the household, as well as a lowering of the risk tolerance that is exhibited by the individuals within that household. As the population ages, there is a corresponding decline in the degree of risk appetite, which affects not only investment decisions but may also lead to conservative investment behavior and asset allocation. This, in turn, affects the overall rate of return in the capital market. Furthermore, population ageing may prompt households to favor more robust financial asset allocation to protect their basic quality of life and cope with future uncertainty. This, in turn, reduces the overall investment risk appetite of residents and increases the margin of safety of household finances [16]. These changes collectively comprise a complex pattern of economic behavior in an ageing society, with significant implications for macroeconomic and social welfare.

Second, population ageing will have a significant negative impact on the development of small and medium-sized enterprises (SMEs). Compared to large

enterprises, SMEs lack advantages in financing, core technology and scale, and will find it more difficult to cope with the structural labor shortages and the increase in labor costs brought about by demographic change, which will squeeze SMEs' profit margins and create difficulties for their survival. More specifically, demographic changes affect the sustainable development of SMEs mainly from the perspective of labor supply, labour costs, labor productivity, innovation capacity and consumption. Firstly, from the perspective of labor supply, ageing will lead to a decline in the growth rate of the total working population and a decrease in the labor force participation rate, which will lead to labor shortages in SMEs. Second, from the perspective of labor costs, with the deepening of aging, China's labor market will experience a shortage of labor supply and structural contradiction in employment, and labor costs will continue to rise, which will add to the burden of SMEs. Third, from the perspective of labor productivity. Third, from the perspective of labor productivity, since labour productivity increases with age, peaks in the 40-50 age group, and begins to decline after 50, with the deepening of the ageing process, older workers will be in a state of decline in terms of physical fitness, learning ability and intellectual level; moreover, it may be difficult for older workers to adapt to new skills in their occupations, which will lead to a decline in labor productivity. Fourth, from the perspective of innovation ability, the deepening of ageing directly leads to a decline in the proportion of people with strong innovation ability in society, making it difficult for small and medium-sized enterprises (SMEs) to recruit innovative talents, thus hindering the improvement of their innovation ability and lowering their innovation performance. Fifth, from the perspective of consumer demand, deepening ageing will lead to negative growth in the total population, which in turn will lead to a reduction in the number of consumers and a shrinking of the consumer market.

In conclusion, the process of population ageing has had a significant effect on the micro-digital economy. On the one hand, the process of ageing has resulted in significant disruptions across a range of industries, including labor-intensive sectors, high-technology fields and service-oriented businesses. These developments have led to a reduction in the available labor force and a decline in the level of human capital, prompting firms to rethink their long-term strategic planning, particularly in relation to talent acquisition and technological advancement. Concurrently, as the proportion of the ageing population increases, the innovation dynamism and rate of technological advancement of firms may decline, as the cognitive and innovation abilities of older employees are relatively limited. This, in turn, affects the competitiveness of firms in the fast-changing market environment. Furthermore, population ageing also affects household economic behavior, leading to changes in consumption patterns. These include an increased demand for healthcare and leisure and recreation services, which may result in an overall increase in household energy consumption and carbon footprint. Furthermore, the ageing of the population has been observed to result in a reduction in the frequency of social activities within households, as well as a lowering of the risk tolerance of household members. This has the effect of discouraging entrepreneurial activities within the household. The rising proportion of older people has been found to result in a greater inclination towards conservative investment strategies, with a more robust allocation of financial assets being chosen to ensure quality of life and to prepare for future uncertainties. This conservative behavior has been found to indirectly affect the overall rate of return in the capital market.

Consequently, population ageing not only imposes novel requirements on business operations and technological innovation at the micro level, but also affects economic decision-making at the household level. Collectively, these changes constitute a complex

pattern of economic behavior in an ageing society, with far-reaching and profound implications for the development of the micro-digital economy in terms of economic and social welfare.

4.2 The objective is to propose countermeasures and recommendations to address the challenges posed by an aging society to the digital economy

The advent of an aging population in China has precipitated a pressing need for profound adjustments to the country's legal system, educational model, and economic structure. In the context of the current digital economy, the utilization of digital technology to address the challenges posed by an ageing population has become a pressing concern. From a legal standpoint, a series of laws and regulations must be formulated and improved to safeguard the legitimate rights and interests of the elderly, while balancing intergenerational equity to ensure social stability and harmony. In the field of education, there is a need to adapt to this demographic change and enhance the social participation and lifelong learning opportunities of the elderly through the reform of the education system, with the aim of enhancing their social capital and personal well-being. From an economic standpoint, the aging of the population exerts a considerable influence on the labor market, consumption patterns and economic growth. In addition, it necessitates the implementation of corresponding adjustments in economic policy and industrial structure to advance sustainable economic development and enhance the quality of life for older individuals. This paper will examine how the challenges posed by population ageing can be addressed through the development of a digital economy from the legal, educational and economic levels. It will propose strategies that are both aligned with the current societal needs and adaptable for the future, with the aim of establishing a robust foundation for the long-term stability and development of Chinese society.

4.2.1 It is recommended that countermeasures be implemented at the legal level.

In addressing the challenges posed by China's rapidly ageing population, it is imperative to implement robust legal countermeasures at the macro level. It has been emphasized that there is a need to strengthen infrastructure, institutions and resources to enhance the quality of health services for the elderly in rural areas. Furthermore, the strategy of focusing on the quality of the population and replacing 'quantity' with 'quality' has been proposed as a means of achieving a high quality of life for the population [17]. From the perspective of legal protection for socialized old age, it is crucial to elucidate the interrelationship between the rights and responsibilities of the family, society, enterprises and the state in legislation.

In terms of the implementation of the positive ageing strategy in the context of labor law, some scholars have put forth the proposition that the extant labor law system requires enhancement and optimization to ensure the effective protection of the employment rights of the elderly. Furthermore, they have suggested that the delayed retirement system should be improved for workers before reaching the age of majority, and that labor rights and interests should be strengthened for workers after reaching the age of majority. Furthermore, the necessity of the state's obligations in the rule of law for the elderly has been debated. It is proposed that the state should expedite the construction of the legal system for the elderly, with the objective of safeguarding the rights and interests of the elderly group.

To address the challenges inherent in the legislative framework for elderly education, it is essential to establish a fundamental framework for the legal system governing elderly education. This framework should emphasize the value concept of legislation and facilitate the improvement of the legal system. For instance, the legal response to elderly drivers can be examined from the standpoint of traffic jurisprudence with a view to safeguarding their driving safety.

Take Japan's approach to ageing as an example. As early as 1970, the number of people aged 65 and over in Japan reached 7.39 million, accounting for 7.1% of the total population, marking the country's entry into an ageing society. China, on the other hand, only entered an ageing society in 2000, so Japan has more experience in coping with an ageing population in the East Asian region. Moreover, the process and the main causes of population ageing in Japan have a lot in common with China. Therefore, learning from Japan's experience in dealing with population ageing at the legislative level has some reference value for China's current response to ageing.

Specifically, in the 1970s, the Japanese government proposed the construction of a 'Japanese-style welfare society' and began to pay attention to home-based welfare measures, introducing a variety of laws closely related to people's lives; in 1973, a system of paying medical fees for the elderly was introduced, and medical care for the elderly was made free, also known as the 'Year of Welfare'. In the 1980s, Japan began to reduce social security costs in line with fiscal austerity, emphasizing 'individual vitality and the spirit of self-help', but this was widely criticized by society. During this period, the reform of the medical care system for the elderly abolished the free system and replaced it with a system in which the elderly were required to pay part of their medical expenses. In 1990, with Japan's ageing population and growing concern for the elderly, relevant legislation was expanded and enriched. In 1990, the Welfare for the Elderly Act and other laws were revised, and a law was added to promote home-based welfare services and the construction of home-based welfare services and facilities, with city, town and village governments assuming primary responsibility for the provision of home-based welfare services. In 1990, the Law on the Welfare of the Elderly and other laws were amended to include the promotion of home-based welfare services, the provision of home-based welfare services and the construction of facilities mainly at the city, town and village levels, and the obligation of cities, towns, villages and prefectures to formulate health and welfare programmers for the elderly.

The visiting care system for the elderly was introduced in 1992. This was followed in 1997 by the Nursing Care Insurance Act, which introduced a social insurance approach to the provision of nursing care for the elderly. In the 21st century, due to the slow growth of the Japanese economy, some of the laws had to be revised to reduce the proportion of public payments, and the Nursing Care Insurance Law was revised after 2005 to emphasize the role of prevention and to adjust the fees for home care and care in nursing facilities. At the same time, the Law on Employment Stability for the Elderly was amended to promote the extension of the retirement age for the elderly (from 1 January 2010 to 31 December 2011), in line with the policy of raising the retirement age.

In conclusion, the macro-legal dimension of China's countermeasures against ageing necessitates the establishment of a comprehensive and multifaceted legal framework encompassing a vast array of domains, including health services, old-age security, labor law, education legislation, and numerous others. This necessitates that legislators not only concentrate on present social requirements but also anticipate prospective developments and establish legal policies that are both aligned with the present situation and adaptable to future alterations. By implementing these comprehensive measures, it

is possible to construct a more inclusive and sustainable society, effectively addressing the challenges posed by ageing and establishing a robust foundation for China's long-term development and social stabile.

4.2.2 It is recommended that countermeasures be implemented at the educational level

Considering the significant challenge posed by population ageing, the field of education assumes a pivotal role. Education is not only a means of promoting the well-being of older persons; it is also a key factor in the advancement of society. The enhancement of the quality of life and social participation of older people can be achieved through the implementation of educational initiatives, which can also serve to strengthen their employability and social networks, thereby promoting active ageing. In response to the decline in student numbers and the uneven distribution of resources faced by China's higher education system, some scholars have proposed the construction of a collaborative education system and the establishment of a lifelong learning platform for older persons. This would enable the adaptation to demographic changes through educational innovations, while simultaneously stimulating the learning potential and creativity of older people.

From the perspective of human resources, enhancing employment services and legal protection for the elderly can optimize the utilization of the elderly group's potential. Furthermore, education policies should be closely integrated with the job market to facilitate continuous learning and re-employment opportunities for the elderly. The development of gerontological education in China draws on the experience of gerontological education in Japan, offering valuable insights into the challenges of an ageing population. It also provides a new perspective on the construction of the discipline of gerontological education. Furthermore, studies analyzing the vocational skills training system for the elderly and the research hotspots of gerontological education from an international perspective have also been conducted, providing innovative ideas for the construction of a harmonious ageing society.

The integration of geriatric education and neuroscience proposes novel mechanisms, directions and technologies for geriatric education, thereby providing scientific support for the strategy of active ageing. It is emphasized that geriatric education should prospectively establish a foundation for future research, with the objective of tapping into the positive plasticity potential of the aging brain and actively expanding the intrinsic and extrinsic value of geriatric education. From the perspective of population change in counties, factors such as the increase in urbanization and the proportion of higher education graduates have created opportunities for the high-quality development of county populations. This indicates that education plays an important role in promoting the economic and social development of counties, and that education can act as a bridge connecting the elderly and society, particularly in the context of an ageing population.

In conclusion, the educational dimension of the response to ageing requires a multidimensional, interdisciplinary and comprehensive strategy. This encompasses, but is not limited to, the elevation of the educational attainment of older individuals, the augmentation of their social involvement and employability, the establishment of a lifelong learning system, and the promotion of the integration of education with employment, health and social services. Through these measures, the potential of education in addressing the challenges of ageing can be fully actualized, thus providing more expansive and inclusive learning opportunities for older individuals, thereby contributing to the comprehensive and harmonious development of society.

4.2.3 Proposals for economic countermeasures

In the economic sphere, the process of ageing presents a duality of challenges and opportunities. It is therefore imperative that effective economic policies are developed to mitigate the impact of ageing. The effects of ageing have a significant impact on the labor market, including an increase in labor costs and a potential decline in labor productivity. However, technological advances can compensate for labor shortages and can also facilitate a transition towards a more technology-intensive economic growth model.

About industrial restructuring, the emergence of the silver-hair economy, comprising products and services tailored to the needs of the elderly, has emerged as a new source of economic growth. Concurrently, it is imperative to reform the retirement system, enhance the scope and sufficiency of pension insurance, and safeguard the economic stability of the elderly. The establishment of a comprehensive pension service system is an effective means of enhancing the quality of life for the elderly. Investment in education is a crucial strategy for upgrading human capital, thereby improving the employability and quality of life of the elderly and mitigating the adverse effects of ageing on the economy. In particular, the challenges associated with ageing can be effectively addressed by optimizing the development trajectory of the silver hair industry.

In terms of economic development, it is also recommended that the relevant policies be improved to adjust the fertility policy, optimize the industrial structure and improve the social security system. From the perspective of fiscal sustainability, we investigate the impact of population ageing on the high-quality development of the economy. We propose that the population policy should be adjusted and optimized to improve the quality of the workforce and activate the consumption potential of the ageing population. Furthermore, it is notable that our study identified population ageing and population mobility as significant drivers of local government debt growth. This finding has implications for the development of evidence-based debt management strategies at the local level. Given the importance of demographic factors in shaping fiscal expenditures, it is essential to consider these factors in the formulation of debt management policies and to adjust the structure of fiscal expenditures according to demographic characteristics.

In conclusion, the effects of an ageing population on China's economy are complex and varied. However, the challenges posed by an ageing population can be effectively addressed and sustainable economic development can be achieved through economic-level countermeasures. These include technological innovation, industrial restructuring, social security reforms, the construction of health and pension service systems, investment in education, and the application of the digital economy. These studies not only provide theoretical analyses of the economic impacts of ageing, but also offer specific policy recommendations, thereby providing valuable references for policymakers.

5. **Conclusions**

In the context of globalization, population aging has become a universal phenomenon with significant implications for economic and social structures. This paper presents a comprehensive analysis of the effects of aging on several macroeconomic areas, including economic growth, the labor market, consumption patterns, savings, and

investment. It reveals the dual impact of aging on sustainable economic and social development. In response to China's distinctive population aging challenges, this paper puts forth a series of countermeasure recommendations, including but not limited to technological innovation, industrial structure optimization, enhancement of the social security system, construction of a health and pension service system, and increase of investment in education. The objective of these recommendations is to mitigate the challenges associated with an aging population through the implementation of innovative policy measures and social programs, while simultaneously capitalizing on the opportunities presented by this demographic shift for economic growth.

The conclusions of this paper underscore the necessity for a unified response from governments, enterprises, social organizations, and individual citizens in addressing the challenges of aging. It is imperative that policymakers implement forward-thinking policies to adapt to demographic shifts. Enterprises must prioritize technological innovation to enhance productivity while addressing the unique needs of older individuals. Social organizations should facilitate enhanced social participation and quality of life for older people. Individual citizens must cultivate lifelong learning skills and adaptability to social change.

Further research is required to enhance comprehension of the impact of aging, particularly in the context of the accelerated development of the digital economy. Additionally, there is a need for in-depth investigation into the effective utilization of technology to enhance the quality of life and social participation of older individuals. Furthermore, the acceleration of the aging process necessitates the implementation of stress testing and reforms to the social security system. In conclusion, this paper advocates for unified action across all societal sectors to construct a comprehensive strategic framework for adapting to an aging society. This framework must ensure sustained and healthy economic development and comprehensive and harmonious social progress. It is hoped that these efforts will result in the transformation of the challenges of aging into a driving force for social progress and innovation.

Acknowledgments

This paper is funded by a grant from the Research Center for Xi Jinping Thought on Socialism with Chinese Characteristics in the New Era, Beijing, China, for the project "Research on Enhancing the Risk-Resistant Capability and Security Level of Industrial Supply Chains"(Project No. 23LLGLA021).

References

[1] ZHOU J, YE X. Aging population and digital inclusive finance, a natural experiment from China. PLOS ONE. 2023;18(11): e0287292.

[2] GUO L, XIAO F. Digital economy, aging of the labor force, and employment transformation of migrant workers: Evidence from China. Economic Analysis and Policy. 2024; 84: 787-807. DOI:10.1016/j.eap.2024.09.032.

[3] WANG P. Impact of population aging on corporate digital transformation strategies: An empirical investigation based on population census data from various provinces in China. Finance Research Letters, 2024 Sept; 67, Part A: 105838

[4] PRETTNER K. Population aging and endogenous economic growth. Journal of Population Economics, 2013, 26(2): 811-834. DOI:10.1007/s00148-012-0441-9.

[5] HARPER S, LEESON G. Introducing the Journal of Population Ageing. Journal of Population Ageing, 2008; 1(1): 1-5. DOI:10.1007/s12062-009-9012-6.
[6] BLOOM D E, CANNING D, FINK G. Implications of population ageing for economic growth. Oxford Review of Economic Policy. 2010; 26(4): 583-612. DOI:10.1093/oxrep/grq038.
[7] BRAUN R A, IKEDA D, JOINES D H. THE SAVING RATE IN JAPAN: WHY IT HAS FALLEN AND WHY IT WILL REMAIN LOW*. International Economic Review. 2009; 50(1): 291-321. DOI:10.1111/j.1468-2354.2008.00531.x.
[8] SHEINER L. The Determinants of the Macroeconomic Implications of Aging. American Economic Review. 2014; 104(5): 218-223. DOI:10.1257/aer.104.5.218.
[9] RIEDL A. Location factors of FDI and the growing services economy[1]: Evidence for transition countries. Economics of Transition. 2010; 18(4): 741-761. DOI:10.1111/j.1468-0351.2010.00391.x.
[10] LIANG J, WANG H, LAZEAR E P. Demographics and Entrepreneurship. JOURNAL OF POLITICAL ECONOMY. 2018; 126: S140-S196. DOI:10.1086/698750.
[11] MEYER J. Older Workers and the Adoption of New Technologies. SSRN Electronic Journal, 2007[2024-11-05]. DOI:10.2139/ssrn.1010288.
[12] BOSEK M, GRZEGORZEWSKI B, KOWALCZYK A, LUBIŃSKI I. Degradation of postural control system as a consequence of Parkinson's disease and ageing. Neuroscience Letters. 2005 Mar; 376(3): 215-220. DOI:10.1016/j.neulet.2004.11.056.
[13] KANFER R, ACKERMAN P L. Aging, Adult Development, and Work Motivation. The Academy of Management Review. 2004; 29(3): 440. DOI:10.2307/20159053.
[14] FRIEDBERG L. The Impact of Technological Change on Older Workers: Evidence from Data on Computer Use. Industrial and Labor Relations Review. 2003; 56(3): 511-529.
[15] MAREŠOVÁ P, MOHELSKÁ H, KUČA K. Economics Aspects of Ageing Population. Procedia Economics and Finance. 2015; 23: 534-538. DOI:10.1016/S2212-5671(15)00492-X.
[16] COILE C, MILLIGAN K. How Household Portfolios Evolve After Retirement: The Effect of Aging And Health Shocks. Review of Income and Wealth. 2009; 55(2): 226-248. DOI:10.1111/j.1475-4991.2009.00320.x.
[17] EHRENHARD M, KIJL B, NIEUWENHUIS L. Market adoption barriers of multi-stakeholder technology: Smart homes for the aging population. Technological Forecasting and Social Change. 2014; 89: 306-315. DOI:10.1016/j.techfore.2014.08.002.