Study on the Impact of Population Aging on the Technical Complexity of China's Export Products——Based on 630 Provincial Panel Data from 2000 to 2020

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Abstract: China's economy is facing the dual challenges of the accelerating aging process and the transformation of China's export trade structure. Based on 630 provincial panel data from 2000 to 2020, this paper uses a fixed-effect model to study the impact of population aging on the technical complexity of export products. The results show that the aging of the population significantly affects the technical complexity of export, and the ratio of the elderly population positively impacts the technical complexity of export products. In the study of regional heterogeneity, it is found that there is a significant positive relationship between population aging and export technology complexity in the eastern, central, and western regions. In addition, through the intermediary effect, this paper concludes that population aging indirectly promotes the improvement of export technology complexity through the impact mechanism of R&D, investment, education expenditure, urbanization process, and consumption level.

1. Introduction

The year 2021 marks the twentieth anniversary of China's accession to the WTO. China has become the world's largest country in goods trade, the world's second-largest commodity consumption market, and the actual use of foreign investment exceeded a trillion. China's opening-up has entered a new stage, with continued improvement in the import and export trade structure, increasing export competitiveness, and continuous global expansion of manufacturing and high-tech industries. Foreign trade is the key hub of the smooth international and domestic circulation. To achieve the transformation and upgrading of "Made in China" to " Made with Wisdom", we should not only "bring technology in", but also "take technology out." Since China entered the aging society in 2000, population aging has been continuously deepened. According to the data of the seventh census in 2020, the proportion of the elderly population in 12 provinces exceeds 14%. The deepening population aging makes the price of labor in China increase, the comparative advantage of the labor force gradually decreases, and the "demographic dividend" gradually disappears. However, China's population structure has also undergone significant changes. Professional skilled talents and highly educated and high-level talents are constantly increasing, and the accumulation of human capital and the level of labor technology are continually improving, showing the demographic characteristics of "aging, highly skilled and highly educated," which promotes China's technology to go out.

"The 14th Five-Year Plan" is an important window for China to cope with the aging population, and a critical period for the high-quality development of foreign trade. How to break through the labor cost constraint and export growth bottleneck caused by the aging population, and realize the transformation of industrial structure from labor-intensive industries to technology-intensive industries. How to improve the structure and quality of export trade and realize the leap of China's economy from high-speed growth to high-quality development based on the great domestic cycle, give full play to the endowment advantages of human capital and technological innovation, and make use of both international and domestic markets and resources. To this end, this paper selects the provincial panel data of China from 2000 to 2020, uses the technical complexity of export products to measure the technological structure of export trade in each province of China, and conducts an empirical analysis of population aging and technical complexity of export products by constructing an econometric model to provide a new perspective for the study of China's population structure and high level of export trade "going out".

2. Literature Review

2.1 Population Aging and Technical Complexity of Export Products

The most commonly used index to measure the technical composition of a country's export products is the technical complexity of export products. This paper uses the formula of Hausmann (2007) [1]to calculate the technical complexity of export products. Zheng Zhanpeng and Wang Yangdong (2017) [2]used China's provincial panel data. They found that in the process of international technology spillover, human capital promotes the technical complexity of China's export products. Dai kuizao (2018) [3], based on the panel data of high-tech industries from 1995 to 2015, believed that the development of the technology market has a significant impact on the technical complexity of export products. Wang Siyu and Zheng Lekai (2019) [4] believed that the global value supply chain contributes to improving the technical complexity of export products through cost effect, division of labor effect, and technology spillover effect. Qi Junyan and Xiang Ganlin (2020) [5]studied the impact of the level of financial openness of different policies on the technological complexity of manufacturing export products, among which the opening of foreign capital access plays the largest role.

A country's industrial structure and comparative export advantage are endogenous, which depends on the abundance of its labor force and capital. With the acceleration of population aging, the transformation of labor production factors has a profound impact on a country's trade and export structure. Wang Youxin and Zhao Yajing (2016) [6] studied the effect of population structure change on comparative export advantage by constructing the OLG model. They concluded that the improvement of human capital is conducive to upgrading export quality in aging countries. Gao Yue, Li Ronglin (2018) [7]proved by an econometric model that the impact of population aging on the technical complexity of export products presented an "inverted U-shape." Song Guohao and Xu Jiexiang (2018) [8]based on transnational panel data, through static and dynamic panel analysis and concluded that population aging affects the technical complexity of export products from consumer demand, labor supply, and human capital.

2.2 Literature Review

Compared with the research of existing scholars, the marginal contribution of this paper is as follows: Firstly, this paper makes an empirical analysis based on China's provincial panel data from 2000 to 2020, so as to provide Chinese experience for exploring the internal relationship between population aging and the technological complexity of export products; Secondly, the fixed-effect model is used to explore the internal impact of population aging on the technical complexity of export products, and the robustness test is used to verify the regression data; Thirdly, the provinces are divided into three economic zones. Through grouping regression analysis, this paper explores the regional differences of population aging on the complexity of China's export technology, expands and analyzes the impact of population aging on the regional heterogeneity of export trade, and makes up for some deficiencies in the existing literature; Finally, using the intermediary effect model, this paper deeply analyzes the transmission mechanism of the impact of population aging on the technical complexity of export products, so as to provide relevant mathematical support for improving the transformation and upgrading of export trade in the new era.

3. Research Design

3.1 Model Construction

This paper selects the panel model through F Test, LM Test, and Hausman Test (Table 1). F test rejects the original hypothesis that the mixed effect is better than the fixed effect at the significance level of 1%; LM Test rejected the original hypothesis that the mixed effect was better than the random effect at the level of 1%; Hausman Test rejected the original hypothesis that the random effect was better than the fixed effect at the level of 1%.

Therefore, the fixed-effects panel regression model is selected for the subsequent empirical study. The fixed-effects panel regression model is as follows.

$$y_{i,t} = \sum_{k=2}^{k} \beta_k x_{i,t} + \lambda_i + \varepsilon_{i,t} \tag{1}$$

Table 1. Effectiveness Test Results

Test type	Original hypothesis	Test value	Model selection
F Test	Mixed effects are better than fixed effects	F(29,595) =10.08, p=0.000	Fixed-effects model
LM Test	Mixed effects are better than random effects	$x^2(1)$=137.99, p=0.000	Random effects model
Hausman Test	Random effects are better than fixed effects	$x^2(6)$=153.94, p=0.000	Fixed effects model

The most commonly used indicator to measure the technical composition of a region's export products is the technical complexity of export products. In this paper, based on the modification of Hausmann's (2007) product export complexity measure, we take the provincial-level export data and gross per capita product instead of the relevant national-level data, and measure the technical complexity of export products in two steps according to Lall's classification.

In summary, this paper constructs a fixed-effects panel OLS model as follows.

$$lnexpy_{i,t} = \beta_0 + \beta_1 Adro_{i,t} + \beta_2 Sr_{i,t} + \beta_3 Fdi_{i,t} + \beta_4 Trade_{i,t} + \beta_5 Rrd_{i,t} + u_i + \lambda_i + \varepsilon_{i,t} \tag{2}$$

where the subscript t denotes province, i denotes year and is the regression coefficient, u_i and λ_i represent individual fixed effect and time fixed effect respectively; $\varepsilon_{i,t}$denotes random error terms; $lnexpy_{i,t}$is the explanatory variable, denoting the technical complexity of export products; $Adro_{i,t}$ is the core explanatory variable, denoting the elderly population ratio. The following control variables are also added: $Sr_{i,t}$is industrial structure upgrading, $Fdi_{i,t}$ is foreign direct investment, $Trade_{i,t}$ is foreign trade dependence, and $Rrd_{i,t}$ is human capital.

3.1 Variable Selection and Data Sources

3.2.1. Variable Selection

Dependent variables: Technical complexity of exported products. This paper uses Haussman's (2007) method to measure the technical complexity of China's inter-provincial export products. In the empirical model, in order to reduce the heteroscedasticity and differences among the data, this paper adopts the logarithmic method.the paper is logarithmic in order to reduce heteroskedasticity and differences between data. Export values by industry are derived from the China Industrial Economic Statistical Yearbook. GDP per capita is obtained from the China Statistical Yearbook, and it is converted into the actual GDP based on the year 2000.

Independent variables: Elderly population ratio. The elderly population ratio refers to the proportion of the population aged 65 and above in the total population. This paper uses the elderly population ratio to measure the degree of population aging (Gao, Yue, and Li, Ronglin, 2018; Xiong Yonglian et al., 2018).

In addition to the above variables, this paper selects four indicators based on previous studies, namely industrial structure upgrading, foreign direct investment, foreign trade dependence, and human capital, as control variables to alleviate the endogeneity caused by the omission of variables.

3.2.2. Data sources

This paper uses Chinese provincial panel data from 2000 to 2020 to study the relationship between the technical complexity of export products and the elderly population ratio. To ensure the completeness of the data, the Tibet Autonomous Region is excluded from this paper, and panel data for a total of 30 provinces are obtained. Table 2 shows the descriptive statistics of all variables.

Table 2. Descriptive Statistics

Var	Obs	Mean	Sd	Min	Max
lnExpy	630	10.2151	0.5080	8.9300	11.1100
Adro	630	0.1286	0.0366	0.0433	0.2548
Avti	630	0.4485	0.0919	0.2960	0.8390
Fdi	630	0.0390	0.0612	0.0000	0.3791
Trade	630	0.3083	0.3658	0.0076	1.7113
Rrd	630	0.0031	0.0045	0.0004	0.0327

4. Empirical Analysis

This section analyzes the fixed-effects panel regression model established. Firstly, it explores the impact of population to elderly ratio on the technical complexity of export products in each region at the overall level. Then it is divided into three regions: the east, the middle and the west, and the relationship between the two regions is further discussed. The results of the panel regression analysis are as follows.

4.1 National Inter-Provincial Level Regression

The elderly population ratio is taken as the core independent variable, and then control variables such as industrial structure upgrading, foreign direct investment, foreign trade dependence, and human capital are gradually introduced, and the fixed effects regression results are listed in Table 3.

Table 3. Full Sample Fixed Effects Regression Results

Variable	(1)	(2)	(3)	(4)	(5)
Adro	19.53^{***} (0.83)	15.26^{***} (1.07)	14.96^{***} (1.08)	14.31^{***} (1.10)	12.78^{***} (1.01)
Sr		2.13^{***} (0.36)	2.08^{***} (0.36)	2.51^{***} (0.39)	1.69^{***} (0.36)
Fdi			-1.10^{**} (0.54)	-1.23^{**} (0.54)	-1.06^{**} (0.49)
Trade				0.35^{***} (0.13)	0.78^{***} (0.12)
Rrd					157.78^{***} (14.34)
Constant	8.36^{***} (0.08)	7.81^{***} (0.12)	7.90^{***} (0.13)	7.67^{***} (0.15)	7.56^{***} (0.14)
N	630	630	630	630	630
R^2	0.481	0.510	0.514	0.520	0.601

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Firstly, while retaining the elderly population ratio as the core independent variable, with the introduction of control variables one by one, the elderly population ratio maintains a positive effect on the technical complexity of exported products all the time and it has passed the significance test of p-value at the 1% level. It can be seen that the elderly population ratio can significantly contribute to the technical complexity of exported products. With the growth of age, the experience will gradually accumulated through "learning by doing", proposed by Arrow, which is the learning effect. With the continuous accumulation of experience and knowledge, people's technical abilities will be gradually improved. The increase of the proportion of the elderly will increase the proportion of the skilled labor force, which is conducive to the improvement of the complexity of export technology. In addition, the elderly can also promote the advancement of young people's technical level and ability through mentoring. In this way, aging will also positively impact the improvement of export technology complexity. Secondly, industrial structure provincial level, foreign trade dependence, and human capital as control variables pass the significance test at a 1% level, consistent with the results of previous studies on the factors influencing the technical complexity of export products. Foreign direct investment has a significant negative effect on the technical complexity of export products. This maybe due to the increase in aging, the decline in labor supply and the rise in labor cost, the increasing ratio of capital to labor, and the more rapid growth in labor cost compared with the return on capital. With the gradual decline of the demographic dividend and the unbalanced development of the domestic financial market, it is challenging to allocate financial resources effectively, which reduces the ease of financing for enterprises and makes their costs increase and investment returns decrease. Eventually, the enthusiasm and possibility of foreign enterprises to invest are significantly reduced, and the inflow of foreign direct investment is also reduced. Scholars Chen Jiyong, Jiang Yanping, and Wang Baoshuang (2017) also demonstrate through empirical analysis that the elderly population ratio has a significant inhibitory effect on the inflow of foreign direct investment.

4.2 Regional heterogeneity test

In order to further study whether the impact of aging on the technical composition of export products is different in regions with varying levels of development, we divided 30 provinces into eastern coastal areas, central and western regions according to regional distribution, and made regional heterogeneity test. The results are shown in Table 4.

Table 4. Regional Heterogeneity Regression Results

Variable	East	Central	West
Adro	4.51*** (1.56)	12.42*** (1.88)	17.66*** (1.68)
Sr	4.84*** (0.56)	-0.89 (0.55)	0.32 (0.54)
Fdi	-2.47* (1.34)	-0.29 (0.49)	6.65*** (2.47)
Trade	0.77*** (0.13)	2.33*** (0.70)	-0.20 (0.41)
Rrd	82.95*** (16.35)	531.31*** (62.28)	334.73*** (38.03)
Constant	6.73*** (0.26)	8.23*** (0.18)	7.64*** (0.19)
N	252	189	189
R^2	0.585	0.757	0.796

$^{*} p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$

By comparing the empirical results at the eastern, central and western levels, it can be found that there is a positive correlation between the elderly population ratio and the technical complexity of export products at different regional levels. It has passed the significance test of P value at the level of 1%, which fully verifies the hypothesis that population aging is conducive to improving the technical complexity of export products. For horizontal comparison, this paper uses the practice of Lian Yujun and Liao Junping (2017) for reference to carry out the seemingly unrelated test. The empirical P values obtained are listed in Table 5. Obviously, the empirical P values of the three groups are all less than 0.01, indicating significant differences among the three subsamples in the East, Middle and West. Therefore, it can be found that among the influence coefficients of the elderly population ratio on the technical complexity of export products, the western region is the largest, and the eastern region is the smallest. This may be because the development of the west region is relatively backward compared to the east region. A large number of young labor force go out to work, resulting in the imbalance of population structure and the aggravation of aging.

Table 5. Test results of coefficient difference between groups

Project	**Empirical p value**
Eastern vs central	0.0001
East vs West	0.0000
Central vs Western	0.0000

4.3 Robustness Test

In order to ensure the reliability of the regression results, this paper uses the elderly dependency ratio (the ratio of the number of non-working age population to the number of working-age population) to replace the elderly population ratio for the robustness test. The results show that the elderly dependency ratio has passed the significance test of P value at the level of 1%, which can significantly promote the technical complexity of export commodities. The robustness test results are highly consistent with the estimated results of fixed effect panel regression, which shows that the above regression results are reliable.

4.4 Impact Mechanism Test

After the internal theoretical analysis of the influence of aging population on the technical complexity of export products, this paper holds that the aging population not only directly promotes the improvement of the technical complexity of export products, but also indirectly promotes the improvement of the technical complexity of export products through increasing R&D investment, increasing education expenditure, increasing urbanization rate, and raising consumption level. Therefore, based on equation (2), this paper adds four variables to form the following mediation effect model:

$$lnExpy_{i,t} = \beta_0 + \beta_1 Adro_{i,t} + \beta_2 Sr_{i,t} + \beta_3 Fdi_{i,t} + \beta_4 Trade_{i,t} + \beta_5 Rrd_{i,t} + u_i + \lambda_i + \varepsilon_{i,t} \quad (3)$$

$$W_{i,t} = \beta_0 + \beta_1 Adro_{i,t} + \beta_2 Sr_{i,t} + \beta_3 Fdi_{i,t} + \beta_4 Trade_{i,t} + \beta_5 Rrd_{i,t} + u_i + \lambda_i + \varepsilon_{i,t} \quad (4)$$

$$lnexpy_{i,t} = \beta_0 + \beta_1 Adro_{i,t} + \beta_2 Sr_{i,t} + \beta_3 Fdi_{i,t} + \beta_4 Trade_{i,t} + \beta_5 Rrd_{i,t} + \beta_6 W_{i,t} + u_i + \lambda_i + \varepsilon_{i,t} \quad (5)$$

where W represents the set of mediating variables. Specifically, R&D investment represents the ratio of R&D investment to GDP, education expenditure defines government spending on science and education, urbanization rate means the ratio of urban population to the total population, and consumption level represented by the level of consumption of the population exponentially deflated by the base period of 2000.

After regressing the mediating effects model, the Bootstrap method is used to test the direct effects of population aging on the technical complexity of exported products and four indirect effects with R&D inputs, education expenditures, urbanization rate, and consumption level mediating variables.

Table 6. Test Results of Impact Mechanism

Intermediary variable	Intermediary effect	BS times	Coefficient	Z value	P value	95% confidence interval
Up	Indirect effect	1000	3.2089	9.85	0.000	[2.570322, 3.847637]
	Direct effect	1000	3.5826	7.40	0.000	[2.634337, 4.531054]
Rgd	Indirect effect	1000	1.0869	4.16	0.000	[0.5753843, 1.59849]
	Direct effect	1000	5.7047	12.70	0.000	[4.824522, 6.584954]
Cpi_2000	Indirect effect	1000	3.9554	8.44	0.000	[3.036893, 4.874047]
	Direct effect	1000	2.8362	7.72	0.000	[2.115766, 3.556644]
Ee	Indirect effect	1000	0.4269	2.41	0.000	[0.079775, 0.774053]
	Direct effect	1000	6.3647	13.31	0.000	[5.4273, 7.302222]

It can be seen from Table 6 that the p value of the indirect effect estimation coefficient of the intermediary variables R&D investment, education expenditure, urbanization rate and consumption level is less than 0.05, and the deviation corrected bootstrap confidence interval under the 95% confidence of all variables does not contain 0 value, which verifies that the four intermediary effects are significant. Population aging will indirectly promote the progress of technological complexity of China's export products through R&D investment, education expenditure, urbanization rate and consumption level. After controlling the intermediary variables, the confidence interval corresponding to the direct effect does not contain 0, indicating that the aging of the population will also have a direct impact on the improvement of the technical complexity of export products. In addition, the estimated coefficients of direct and indirect effects of all intermediary variables reported in table x are positive, indicating that under the action of four different intermediary variables, population aging will significantly promote the technical complexity of export products. Therefore, hypotheses 1, 2, 3, 4, and 5 have been verified.

5. Research Conclusion

By assuming the impact of population aging on the technical complexity of export products, this paper constructs a fixed effect panel OLS model after the model test. It then carries out fixed effect panel regression based on provincial panel data. The results show that the elderly population ratio can significantly improve the technical complexity of export products. The sub-sample regression results show that the elderly population ratio has the greatest impact on the technical complexity of export products in the western region. Therefore, it can be inferred that the development of the western region is relatively backward. A large number of young labor force go out to work, resulting in the imbalance of population structure and the aggravation of aging, which urges us to give full play to the advantages of the elderly population on the technical complexity of export products. Based on this, this paper puts forward the following suggestions.

Firstly, solve the regional gradient differences in China, transfer industries to the central and western regions, and introduce policies to drive industrial development. Compared with other regions, the western region is still relatively backward, the employment posts and treatment are far from satisfactory, and a large number of young labor force outflow. Moreover, due to the long-term lack of a young labor force, when the production efficiency of senior employees begins to decline, the production efficiency of enterprises will decline. In order to prevent such situations, relevant departments should timely introduce policies to attract the transfer of industry, so as to release or migrate a large number of labor posts, maintainand stabilize the productivity of the western region,and reduce regional gradient differences.

Secondly, capture the population aging vent to maximize the benefits produced during the aging period. The results show that population aging has a significant positive impact on the technical complexity of export products. Therefore, it can be inferred that older employees with rich work experience are likely to show higher work efficiency in most enterprises or units. However, relevant research shows that this high work efficiency can not be maintained for a long time, and the work efficiency of elderly employees often presents an inverted U-shape. Therefore, all units should predict and grasp the rising peak of work efficiency of elderly employees, and take certain measures to maintain and improve the work enthusiasm of employees of this age, so as to give full play to their initiative and promote the maximization of overall production efficiency.

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