

The Impact of Population Aging on Trade in Labor-Intensive Industries and Its Multidimensional Heterogeneity

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Abstract. Based on panel data of 31 provinces in China from 2012 to 2023, this paper adopts a two-way fixed-effects model to evaluate the impact of China's population aging on regional trade structure, taking labor-intensive products as an example. It further conducts multiple heterogeneity analyses from four aspects: trade direction, aging degree, level of public health facilities, and industrial structure. The results show that population aging affects the trade of labor-intensive products to a certain extent and exerts a negative impact on trade structure. Meanwhile, its impact is more significant on the export side, while cities with a low aging level are less vulnerable. In addition, the study finds that improving the level of public health facilities and adjusting industrial structure can also weaken the impact of aging on trade to some extent. Accordingly, different policy recommendations are put forward for different types of cities.

Keywords: aging, labor-intensive products, import and export, heterogeneity

1. Introduction

With the continuous advancement of global modernization, the continuous improvement of medical and health conditions, and the general decline in residents' willingness to have children, population aging has become a major global issue of demographic structure, drawing extensive attention from countries around the world. This phenomenon first appeared in developed countries that have completed industrialization and has gradually evolved into an unavoidable long-term trend in their economic and social development. In recent years, with the improvement of economic development, advances in medical technology and a further decline in fertility rates, most developing countries have also gradually entered the stage of population aging. Aging is shifting from a phenomenon unique to developed countries to a common global challenge. According to the data of the Seventh National Population Census released by the National Bureau of Statistics, by 2020, China's population aged 60 and above had reached 264.02 million, accounting for 18.70% of the total population. Compared with 177.65 million in the Sixth National Population Census in 2010, the size of China's elderly population increased by nearly 48.6% in a decade, and the aging process accelerated significantly. In terms of the speed and magnitude of demographic changes, China is experiencing one of the largest and fastest aging processes in the world. Under the dual effects of long-term low fertility rates and rising life expectancy, China's population aging will continue to

deepen in the future, the proportion of the elderly population will rise further, and the bottom of the population age pyramid will continue to shrink while the top expands.

This profound transformation of the population structure is exerting an extensive and far-reaching impact on China's economic and social development. In particular, various issues related to economic operation and foreign trade have become increasingly prominent along with the deepening of aging. On the one hand, the pattern of labor supply has changed, and the traditional demographic dividend has gradually weakened. On the other hand, macro variables such as consumption demand structure, savings behavior and industrial layout have also adjusted accordingly. In this context, how to scientifically understand the economic and trade consequences of population aging has become an important issue for both academia and policymakers. From the supply side, aging directly leads to the shrinkage of the working-age population, the reduction of effective social labor supply, the rise of labor costs, and the gradual weakening of the traditional labor factor advantage, thus restraining the production and supply capacity of the real economy. From the demand side, the consumption structure of the elderly group is relatively simple with low consumption willingness, and their demand is mainly concentrated in service fields such as elderly care and medical treatment. This has greatly compressed the market demand for physical goods, promoted the shift of social consumption structure toward the service sector, and impacted the physical trade market. Against this backdrop, the continuous fading of the traditional demographic dividend relying on cheap labor has significantly restricted the steady development of China's export trade [1].

At present, the academic community has not yet formed a unified view on the comprehensive impact of population aging on the economy and trade, with obvious research divergences. Most scholars have confirmed that aging inhibits the growth of economic and trade scale through channels such as insufficient labor supply, declining savings rates and shrinking domestic demand. However, some studies have pointed out that the changes in factor costs and adjustments in market demand structure brought about by aging can force industrial upgrading, optimize trade structure, and promote the transformation of foreign trade toward high technology and high quality. It can be seen that the impact of population aging on China's trade development is not a simple linear relationship. Its positive and negative effects are intertwined, and the outcome of their combined effects needs further clarification, thus presenting important research value and room for discussion.

Accordingly, this paper uses balanced panel data from 2012 to 2023 and takes labor-intensive products as an example to analyze the impact of population aging on trade structure, focusing on the effect of aging on trade structure. Different from previous studies that mostly focus on the role of aging in total trade volume, this paper takes labor-intensive products as an example to specifically analyze how aging changes the composition and distribution of products with different factor intensities in exports, so as to reveal the specific impact of aging on trade structure in a more detailed manner.

2. Literature review and hypothesis development

The impact of population aging on economic and trade development is a core research topic in the fields of population economics and international trade. Existing academic research has not yet reached a unified consensus, which can generally be divided into two research streams: the inhibitory effect and the structural optimization effect. On the side of negative impacts, most scholars, based on factor endowment and life-cycle consumption theories, have confirmed that population aging suppresses the growth of economic and trade scale through multiple channels. The contraction of labor supply serves as its core transmission mechanism. Aging leads to a decline in the share of working-age population and rising labor costs, which continuously weakens the

comparative advantage of China's labor-intensive product exports and restrains regional export growth [1, 2]. Meanwhile, the consumption of savings by the elderly and their single consumption structure will lower the social savings rate and reduce market demand for physical goods. This not only restricts the capacity expansion of the domestic real economy but also transmits weak domestic demand to the foreign trade sector, undermining the foundation for the development of goods trade [3, 4].

In contrast, some studies, from the perspective of long-term high-quality development, propose that population aging has a significant positive effect on optimizing economic and trade structures. Pressure from rising factor costs will force enterprises to eliminate low-end production capacity, increase investment in R&D and innovation, and promote the transformation and upgrading of export products toward technology and capital intensity, effectively improving export technological sophistication and the quality of foreign trade development [5]. Some scholars also empirically confirm that population aging acts as an important exogenous driving force for the transformation and upgrading of urban export trade, and can effectively optimize regional trade structures [6]. At the same time, the expanding consumption demand for elderly care and medical services driven by aging can boost the growth of trade in services, offset the downward pressure on goods trade, and promote the diversified development of foreign trade formats.

Based on the above analysis, this paper proposes the following hypotheses:

H1a: Population aging inhibits import and export trade.

H1b: Population aging promotes import and export trade.

3. Research design

3.1. Model construction

To examine the impact of regional population aging on the import and export trade of labor-intensive products, this paper adopts the ordinary least squares (OLS) method for baseline regression analysis. To minimize the interference of endogeneity issues such as omitted variable bias on empirical results and improve the accuracy and robustness of regression outcomes, this study introduces a series of control variables into the baseline model, controls for both time and individual fixed effects, and uses balanced panel data. Based on the empirical results of the baseline regression, the overall direction and significance level of the impact of population aging on regional imports and exports of labor-intensive products can be preliminarily determined, providing an empirical basis for subsequent extended analysis in the spatial dimension. The model is constructed as follows:

$$Y_{it} = \alpha_0 + \beta_1 X_{it} + \sum_n \beta_n Control_n + \varepsilon_{it} + \varphi_i + \gamma_t \quad (1)$$

In the equation, Y_{it} represents the dependent variable of region i in year t , α_0 is the constant term, β_1 is the impact coefficient of the core explanatory variable, X_{it} is the core explanatory variable, β_n is the coefficient of the control variable, $Control_n$ is the n -th control variable, ε_{it} is the residual term, γ_t is the time fixed effect, and φ_i is the individual fixed effect.

3.2. Variable selection

The dependent variable in this paper is selected as the natural logarithm of the total import and export volume of labor-intensive products in each region, which measures the scale of foreign trade

in regional labor-intensive products. This measurement method has been widely adopted in academic research on the correlation between labor factors and trade [7]. The core explanatory variable uses the natural logarithm of the regional elderly population to characterize the level of population aging. Logarithmic transformation can effectively alleviate heteroscedasticity and is a standard practice in empirical studies related to population structure [8]. To mitigate omitted variable bias, this paper incorporates several control variables: (1) Regional development level (GDP). Measured by the natural logarithm of the current regional GDP, this indicator comprehensively reflects the economic size, market scale and overall development level of a region, serving as a core indicator of regional economic strength. Including it as a control variable helps avoid estimation bias caused by differences in regional economic development endowments and prevents attributing the impacts of economic foundation disparities to the core explanatory variable, thereby improving the robustness and credibility of regression results. (2) Level of opening-up (FDI). Measured by the natural logarithm of the total import and export volume of foreign-invested enterprises, this indicator reflects the degree of regional opening-up and the depth of foreign capital embedding. As an important link connecting domestic and foreign markets, foreign-invested enterprises exert a significant influence on the regional trade pattern. Introducing this variable aims to control the interference of foreign capital participation and agglomeration effects on foreign trade activities, strip out the direct contribution of foreign capital factors to import and export scale, and more accurately identify the net effect of core variables. (3) Government fiscal capacity (Gov). Measured by the ratio of local general public budget revenue to expenditure, this indicator reflects both the level of local fiscal self-sufficiency and operational status, as well as the government's ability of macro-control and resource allocation. Differences in fiscal capacity often affect regional trade activities through channels such as tax incentives, subsidies and infrastructure investment. Therefore, controlling for this variable helps eliminate systematic differences caused by fiscal policy heterogeneity and ensures that estimation results are not confounded by the intensity of local fiscal intervention [9].

(4) Industrial structure (Ind). Measured by the natural logarithm of the proportion of secondary industry value-added in GDP, this indicator characterizes regional industrial structure and the progress of industrialization. As the main production sector of tradable goods, the scale and share of the secondary industry directly determine the product foundation and trade potential of regional imports and exports. Introducing this variable can effectively control the impacts of industrial structure differences and industrialization progress on import and export activities, avoiding estimation bias caused by different industrial foundations [2].

3.3. Data source

This paper selects balanced panel data from 2012 to 2023 for empirical testing. The research period is set for two main reasons. First, during these more than ten years, China's foreign trade has undergone profound structural adjustments, gradually shifting from scale expansion to high-quality development. Data within the sample period can well reflect the evolutionary characteristics of the trade pattern. Second, compared with unbalanced panel data, balanced panel data avoids sample missing problems, leading to more robust regression estimates and more comparable cross-year and cross-region comparisons. In terms of data sources, macroeconomic and regional indicators are mainly derived from statistical data released by the National Bureau of Statistics, while import and export trade data are obtained from the Database of International Trade Research and Decision Support System. Both sources are highly authoritative. During the raw data processing stage, this paper verified the statistical caliber of each variable one by one, made matching adjustments for

inconsistent parts, and supplemented missing values in individual years to ensure the integrity of time series and minimize bias caused by inconsistent statistical standards. Considering the large values of some control variables, this paper applied natural logarithm transformation to these variables. After such processing, the magnitudes of variables tend to be consistent, and regression coefficients carry the implication of elasticity, facilitating the economic interpretation of estimation results.

4. Result analysis

4.1. Baseline regression results

Table 1 reports the estimation results of the baseline regression model in this paper. In terms of model specification, this paper adopts a standard balanced panel data structure and introduces both individual fixed effects and time fixed effects to control for the inherent characteristics of each cross-sectional unit that do not change over time and common time trend shocks respectively, thereby effectively alleviating estimation bias caused by potential omitted variables. To avoid the interference of subjective selection of control variables on core conclusions, the model incorporates control variables in a stepwise manner, adding four categories of factors that may affect trade structure, namely foreign direct investment, local government intervention, industrial structure and regional economic size, so as to gradually eliminate the interference of confounding factors and examine changes in the magnitude and significance of the core explanatory variable coefficient.

From the regression results, population aging has a significant negative impact on the import and export trade of labor-intensive products, meaning that the deepening of population aging significantly restrains the import and export scale of such products. Specifically, when only the core explanatory variable is included, the coefficient of aging already shows a significant negative feature. With the gradual addition of various control variables, the sign of this coefficient remains unchanged and its significance level stays stable, indicating that the estimation results are highly robust. This result shows that the impact of population aging on labor-intensive trade activities is not only statistically significant but also economically significant and cannot be ignored. To a certain extent, the above empirical conclusion is consistent with theoretical deductions and empirical evidence from mainstream domestic academic circles on the relationship between aging and trade structure, further verifying the rationality and applicability of the mainstream view that aging inhibits trade in labor-intensive products.

This phenomenon can be attributed to the following reasons. First, at the level of factor supply, labor-intensive industries build their comparative advantage on cheap labor. Aging continuously reduces the size of the working-age population, leading to labor shortages and rising labor costs, which in turn affect total import and export volume. Tie Ying et al. empirically found that the declining share of labor force is an important cause of the shrinkage of labor-intensive exports [2]. Second, from the perspective of production efficiency, older workers have relatively weak physical capacity and ability to learn technological updates, and the aging of the labor age structure lowers industrial production efficiency. In addition, consumption of the elderly is concentrated in elderly care and medical services, providing insufficient domestic demand for physical manufactured goods, leading to a continuous decline in corporate capacity utilization, which restricts industrial output and foreign trade scale from both supply and demand ends. Zhu Qin and Wei Taoyuan confirmed that aging significantly inhibits labor productivity, and this restrictive effect is particularly prominent in labor-intensive industries [10]. Third, based on the logic of capital and industrial allocation, rising labor costs drive social capital to gradually shift from traditional processing and manufacturing to

capital-intensive and technology-intensive industries, leaving labor-intensive industries in a dilemma of shrinking investment and insufficient factor supply. Yang Yingzhu and Zhao Lexiang pointed out that while aging drives the transformation and upgrading of foreign trade structure, it crowds out development resources of traditional labor-intensive industries given a fixed total amount of factors, further depressing their import and export levels [11].

Table 1. Baseline regression results

	(1)	(2)	(3)	(4)	(5)
X	-0.656 (-1.433)	-0.727 (-1.566)	-1.135** (-2.427)	-1.135** (-2.427)	-1.288*** (-2.806)
Fdi	-0.184*** (-3.265)	-0.188*** (-3.323)	-0.171*** (-3.076)	-0.171*** (-3.076)	-0.155*** (-2.850)
Gov		-0.070 (-0.925)	-0.125* (-1.668)	-0.125* (-1.668)	-0.059 (-0.785)
Ind			-1.682*** (-3.817)	-1.682*** (-3.817)	-1.529*** (-3.532)
GDP					0.000*** (3.937)
Observations	372	372	372	372	372
R ²	0.950	0.950	0.952	0.952	0.955
Time-fixed effects	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES

4.2. Robustness analysis

To test whether the baseline regression results are robust, this paper adopts three methods for robustness checks:

1. Winsorization of samples. In statistical data processing, extreme values may inevitably appear due to force majeure factors. To eliminate the interference of extreme samples at both ends, this paper conducts bilateral 1%–99% winsorization on the obtained data. Column (1) of Table 2 shows the regression results after winsorization. It can be seen that the results remain significant at the 5% level, indicating that the model is still robust.

2. Replacement of explanatory variables. There are multiple quantitative measures for population aging, and a single aging indicator can hardly fully depict the burden level of population structure. Referring to common practices in existing literature, the total social dependency ratio (the total size of the child population aged 0–14 and the elderly population aged 65 and above) is selected as a substitute for the original aging indicator. The total dependent population is logarithmically processed to generate a new variable *lnnp*, which is included in the model for re-regression, with corresponding results shown in Column (2) of Table 2. After replacing the indicator, the sign of the core variable coefficient does not reverse and passes the 1% significance test, indicating that the research conclusion that aging inhibits imports and exports of labor-intensive products does not change with the measurement method of the explanatory variable, and the model remains robust.

3. Adjustment of clustering level of standard errors. To test the sensitivity of standard error settings, this paper calculates robust standard errors by clustering separately at the individual level

and the time level on the basis of the original baseline regression. As shown in Columns (3) and (4) of Table 2, the results are significant at the 5% level, proving that the model is still robust.

Table 2. Robustness checks

	(1)	(2)	(3)	(4)
Innp		-1.467** (0.573)		
X	-0.979** (0.429)		-1.288** (0.460)	-1.288** (0.587)
Fdi	-0.165*** (0.0555)	-0.146*** (0.0545)	-0.155** (0.0539)	-0.155*** (0.0524)
Gov	0.0653 (0.110)	-0.0532 (0.0755)	-0.0593 (0.0977)	-0.0593 (0.0676)
Ind	-1.404*** (0.447)	-1.370*** (0.425)	-1.529*** (0.388)	-1.529* (0.871)
GDP	1.66e-05*** (3.80e-06)	1.72e-05*** (3.95e-06)	1.46e-05*** (3.34e-06)	1.46e-05 (9.42e-06)
Observations	372	372	372	372
R ²	0.956	0.954	0.955	0.955
Time-fixed effects	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES

4.3. Heterogeneity analysis

The impact of population aging on trade development may show significantly differentiated characteristics across different regions and trade scenarios. A sole focus on the average effect of the full sample may mask the structural differences in the impact of aging. With this consideration, on the basis of the baseline regression, this paper further conducts heterogeneity tests from four dimensions: trade direction, aging degree, level of public health facilities, and industrial structure characteristics. Specifically, in terms of trade direction, this paper runs separate regressions for imports and exports. The export side is mainly affected by labor supply and production costs, while the import side is more related to residents' consumption structure. The asymmetric effects of aging on the supply and demand sides mean that separate estimation helps clarify their respective responses. In addition, whether the impact of aging on trade weakens or amplifies when entering a more advanced stage remains to be explored. The dimension of public health facilities takes into account regional differences in medical resources. Regions with better medical conditions have relatively higher residents' health levels, and workers tend to delay leaving the labor market, which may partially offset the impact of aging on trade. For the industrial structure dimension, samples are grouped according to the proportion of the secondary industry in each region to examine whether the impact of aging differs between regions with a high manufacturing share and those dominated by the service industry. Through grouped regressions in the above four dimensions, this paper presents a more comprehensive picture of the heterogeneous characteristics of aging's impact on trade development and provides more distinguishable empirical evidence for subsequent targeted policy recommendations.

4.3.1. Trade direction

Columns (1) and (2) of Table 3 report the regression results after splitting trade into exports and imports. It can be seen that the regression coefficient of aging on exports is -1.488, significantly negative at the 1% level, whereas the impact on imports is also negative but with a coefficient of only -0.395 that fails the significance test. This comparison indicates that the impact of aging on trade mainly falls on the export side, with relatively limited disturbance to imports. The reason why exports suffer a greater shock is that China's export sector has long relied on labor-intensive manufacturing, and shrinking labor supply and rising labor costs directly weaken the price competitiveness of export products. Imports, by contrast, are driven more by domestic consumption capacity and structure. Although the consumption preferences of the elderly have changed, their overall consumption scale has not contracted significantly, so imports are less affected by aging.

After splitting the dependent variable into export value and import value for separate regressions, it is found that population aging has a significant negative impact on export trade, while its impact on import trade is not significant. The root of this difference lies in their distinct core driving logics: export trade highly depends on factor supply and cost advantages at the production end, and China's exports have long been dominated by labor-intensive products, making them highly sensitive to changes in labor supply [1]. By reducing the size of the working-age population and pushing up labor costs, population aging weakens the production efficiency and export comparative advantage of the manufacturing sector, thus exerting a significant inhibitory effect on exports. In comparison, import trade is driven more by domestic consumption demand. The consumption demand of the elderly is concentrated in service products such as medical care and elderly care, which has a weak substitution effect on imports of physical goods and may even boost import demand for some consumer goods [4], so the negative impact of aging on imports is not significant.

4.3.2. Heterogeneity of aging degree

After grouping the samples by the median of the aging level, Columns (3) and (4) show that the coefficient for low-aging regions is -1.274, significant at the 10% level, while that for high-aging regions is -1.309, significant at the 1% level. The coefficients of the two groups are similar in magnitude, but the high-aging group shows significantly stronger significance and more robust estimation. This suggests that the inhibitory effect of aging on trade has initially emerged in the low-aging stage, yet its impact has not been fully and steadily released. Upon entering the high-aging stage, factors such as shrinking labor supply and changing consumption structure work in combination, making the negative effect statistically more pronounced.

When a region is in the low-aging stage, labor supply remains relatively abundant, the demographic dividend has not fully faded, and upward pressure on labor costs is limited, resulting in a weak impact on trade. When a region enters the high-aging stage, the working-age population shrinks at an accelerated pace, labor shortages become prominent, and the savings consumption and consumption structure changes of the elderly further intensify shifts in market demand. The combination of multiple factors significantly amplifies the inhibitory effect of aging on trade [4].

4.3.3. Heterogeneity of public health facility level

Columns (1) and (2) of Table 4 present grouped tests based on the median of regional public health facility levels. The results show that in regions with low public health facility levels, the coefficient of aging on trade is -1.040, passing the significance test at the 10% level. In regions with high public

health facility levels, although the coefficient is also negative, it does not pass the significance test. This indicates that regions with relatively abundant medical resources can buffer the adverse effects of aging to a certain extent.

The underlying mechanism is that sound public health facilities can effectively improve the health level and labor participation ability of the elderly, prolong their effective working hours, and alleviate labor shortages caused by aging [12]. In cities with better facilities, the elderly have higher health human capital and delay the loss of professional skills, which can partially compensate for the supply gap caused by the decline in the working-age population, thus weakening the negative impact of aging on trade. In cities with poorer facilities, the elderly face limited health conditions and low labor participation rates, exacerbating labor shortages brought by aging and leading to a more pronounced inhibitory effect on trade.

4.3.4. Industrial structure heterogeneity

Columns (3) and (4) of Table 4 group samples by the median of the proportion of the secondary industry across regions. The results show that in regions with a low share of the secondary industry, the coefficient of aging on trade is -1.196, significant at the 10% level; in regions with a high share of the secondary industry, the coefficient rises to -1.376 with significance improved to the 5% level. This comparison reveals that the more developed the manufacturing sector, the more obvious the impact of aging on trade.

This difference is directly related to the varying degrees of labor dependence across industries. The secondary industry is dominated by manufacturing, especially labor-intensive manufacturing, which relies far more on labor than the service industry [6]. In cities with a high share of the secondary industry, trade development highly depends on the export competitiveness of manufacturing. Shrinking labor supply and rising labor costs caused by population aging directly hit the production capacity and export advantages of manufacturing, resulting in a stronger inhibitory effect on trade. In cities with a low share of the secondary industry, the economic structure is service-oriented and less sensitive to changes in labor supply, so the negative impact of aging on trade is relatively weak.

Table 3. Heterogeneity analysis

	(1)	(2)	(3)	(4)
VARIABLES	lnexport	lnimport	Low level of aging	High level of aging
X	-1.488*** (0.506)	-0.395 (0.475)	-1.274* (0.719)	-1.309*** (0.457)
Fdi	-0.187*** (0.0601)	0.0985* (0.0564)	-0.201*** (0.0679)	0.278** (0.112)
Gov	-0.0987 (0.0832)	-0.0639 (0.0781)	0.00194 (0.0979)	0.0796 (0.138)
Ind	-0.669 (0.477)	-2.451*** (0.448)	-0.876 (0.668)	2.007*** (0.579)
GDP	1.84e-05*** (4.09e-06)	-9.22e-07 (3.84e-06)	5.91e-05*** (1.28e-05)	-4.61e-06 (3.32e-06)
Observations	372	372	180	192

Table 3. (continued)

	R ²	0.946	0.968	0.944	0.968
Time-fixed effects	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES
	(1)	(2)	(3)	(4)	
VARIABLES	Low-level public health facilities	High-level public health facilities	Low share of secondary industry	High share of secondary industry	
X	-1.040* (0.557)	-1.188 (0.767)	-1.196* (0.710)	-1.376** (0.549)	
Fdi	-0.185*** (0.0692)	-0.228** (0.0924)	-0.241*** (0.0697)	0.0762 (0.112)	
Gov	-0.0768 (0.0732)	-0.255 (0.248)	0.0308 (0.0968)	0.110 (0.198)	
Ind	-1.963*** (0.505)	-0.633 (0.762)	-0.0368 (0.648)	-2.784*** (0.615)	
GDP	7.47e-06 (4.98e-06)	1.85e-05*** (5.44e-06)	6.06e-05*** (1.19e-05)	7.54e-06** (3.55e-06)	
Observations	180	192	180	192	
R ²	0.935	0.965	0.928	0.978	
Time-fixed effects	YES	YES	YES	YES	
Individual fixed effects	YES	YES	YES	YES	

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5. Conclusions and policy implications

Based on national balanced panel data from 2012 to 2023, this paper takes the import and export trade of labor-intensive products as the research object, empirically examines the impact of population aging on regional trade structure using a fixed-effects model, and conducts heterogeneity analysis from four dimensions: trade type, aging degree, public health facility level, and industrial structure. Multiple robustness tests are also performed. The empirical results show that population aging has a significant negative effect on the import and export scale of labor-intensive products. This conclusion remains valid after winsorization, replacement of the core explanatory variable, and adjustment of clustered standard errors, verifying the reliability of the regression results. In terms of mechanism, population aging reduces the size of the working-age population, raises labor costs, and lowers overall industrial production efficiency. Coupled with changes in household consumption structure and shifts in industrial investment flows, these factors jointly suppress the foreign trade development of labor-intensive industries. This empirical finding echoes the research conclusions of Tian Wei et al. and Tie Ying et al. on the impact of demographic structure on trade in labor-intensive products, and also confirms the rationality of this paper's theoretical hypothesis H1a [1, 2].

The impact of population aging on trade exhibits obvious heterogeneous characteristics. After distinguishing trade types, it can be seen that aging only imposes a significant inhibitory effect on export trade, with no obvious effect on import trade. Exports rely on production-end labor factors for operation and are more sensitive to demographic changes, while imports are dominated by domestic consumption demand. The special consumption orientation of the elderly weakens the negative impact of aging, a mechanism consistent with the research view of Charles Yuji Horioka [4]. After grouping by aging degree, regions with higher aging face stronger negative shocks to trade. Problems such as labor shortages and demand structure changes caused by aging accumulate as aging deepens, gradually amplifying the inhibitory effect on trade activities, which is in line with the conclusion of Tie Ying et al. that the aging effect is degree-dependent [2]. The level of public health facilities exerts a significant moderating effect. In regions with sound facilities, the elderly have higher health human capital and labor participation ability, which can effectively offset the labor supply gap, and the trade-inhibiting effect of aging is no longer significant. In regions with weak public health conditions, the labor capacity of the elderly declines more rapidly, exacerbating labor supply shortages and making the negative impact of aging on trade more prominent. This also supports the research of Yan Li and Zhang Guiyou on health human capital alleviating the negative effects of aging [12]. At the industrial structure level, regions with a higher share of the secondary industry feature more concentrated labor-intensive manufacturing, and the transmission of labor factor changes to trade is stronger, intensifying the negative impact of aging. This is consistent with the analytical logic of Cai Hongbo and Han Jinrong regarding industrial structure, population age structure, and foreign trade transformation [6].

Against the realistic background of deepening population aging and the gradual fading of the traditional demographic dividend in China, combined with the empirical conclusions of this paper, all regions need to formulate differentiated development strategies based on regional demographic structure, industrial foundation, and public service endowment. Regions with a high proportion of labor-intensive industries should accelerate the upgrading of production technology and the popularization of intelligent equipment to replace part of the labor force with technology, weakening the impact of labor supply changes on foreign trade. At the same time, they should promote the transformation of traditional low-end manufacturing to high value-added links and use aging pressure to drive industrial and trade structure upgrading. Regions with a high degree of aging should continuously improve their public health and elderly care service systems, enhance the health level and labor participation ability of the elderly, fully tap into the stock of labor resources, and ease pressure on labor supply.

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