Analysis on the Relationship between Population Aging and Employment Dynamics in China-----Based on Threshold Vector Error Correction Model

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Abstract. The social old-age dependency ratio has risen rapidly and the social burden has increased since China entered an aging society in 2001. In this paper, the nonlinear threshold vector error correction model is used to analyze the internal dependence of the elderly population over 65 years old and urban employment in China by using the data from 1990 to 2018. Real example shows that there is a threshold effect between the elderly population in China and urban employment; when the number of employees deviates from the equilibrium value, it will be pulled to the equilibrium level at a rate of 0.0607 units; otherwise, in the second mechanism, there is no long-term equilibrium relationship between the elderly population and urban employment.

1. Introduction
In the 1970s, China began to fully implement the family planning policy, which led to a low development trend in China, a sharp decline in the population of youth and youth, and a significant increase in the elderly population [1]. In recent years, the rapid increase in the old-age dependency ratio of the whole society has made the financial pressure faced by the country facing increasing social security, and the policy requirements for delaying the retirement age have become increasingly urgent [2]. Exploring the dynamic relationship between population aging and urban employment can help to explore methods of aging and solving employment conflicts, and provide scientific and effective suggestions for solving employment problems in the context of Chinese aging population.

Foreign developed countries entered an aging early stage. In the 1970s and 1980s, OECD countries introduced early retirement policies to cope with the high unemployment rate, and vacated jobs to promote employment [3]. But developed countries implemented early retirement plans. When raising funds through taxation, it is possible to increase the equilibrium wage, which leads to a reduction in the overall labor demand [4]. Siliverstovs et al. [5] controlled the impact of related factors such as per capita income and population size, and found that aging has a significant impact on employment share. Compared with developed countries, although Chinese aging process started late, due to the special national conditions of the population, the characteristics of the elderly population are large, the aging rate is fast, and the urban-rural duality is significant [6]. Wang, J.D. et al [7] selected the typical 10 developed countries to use the panel data for error correction, and found that population aging has a significant positive effect on the proportion of employment in the service industry and the proportion of service industry output in the long-term change. Zou, P.K. and Liu, J.L. [8] constructed the VAR model using the population aging rate from 2000 to 2015 and the proportion of employed persons in
related service industries. The empirical results show that population aging has a positive impact on the proportion of employment in the service industry, and it is more obvious in the short term. Liu, C.J et al. [9] made recommendations for Ganzhou to respond to the aging of the population and resolve the contradictions in the job market based on the successful experiences of other countries and provinces in promoting employment and entrepreneurship. Jiang, X. [10] conducted a series of discussion on the employment of college students by analyzing the changes of population aging on Chinese economic development, and put forward opinions and suggestions for the employment of college graduates.

In the impact of population aging on employment in China, panel error correction and VAR model are used in the existing research, and research is relatively rare. According to the research results and analysis methods at home and abroad, this paper selects the population of the elderly population and urban employment in 1990-2018 as a variable, establishes a vector error correction model and a threshold vector error correction model, and conducts comparative analysis to study the employment under the background of aging. Development provides a reference.

2. The theoretical model

2.1. Vector error correction model

Engle and Granger combined the co-integration and error correction models to establish a vector error correction model (VECM) to overcome the deficiencies of the VAR model due to the loss of information, and it has been widely used. The VECM model is set as follows:

$$\Delta x_t = \alpha ecm_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta x_{t-i} + u_t$$

Among them: $\Delta x_t$ indicates $(\Delta \ln c_t, \Delta \ln e_t')$, $ecm_{t-1} = \beta'x_{t-1}$ is the error correction term, which reflects the long-term equilibrium relationship between variables, and $\alpha$ is the adjustment parameter, which reflects that when the equilibrium relationship between variables deviates from the long-term equilibrium state, it is adjusted to equilibrium. The speed of adjustment.

2.2. Threshold vector error correction model

The threshold error correction model is a derivative of the error correction model. The model uses the error correction term as the threshold variable, and considers that the relationship between the variables of the model is different within different threshold ranges. Hansen and Seo considered a two-mechanism threshold co-integration model as follows [11]:

$$\Delta x_t = \begin{cases} A_{1}x_{t-1}(\beta) + \mu_{1}ecm_{t-1}(\beta) \leq \gamma \\ A_{2}x_{t-1}(\beta) + \mu_{2}ecm_{t-1}(\beta) > \gamma \end{cases}$$

Among them: $A_1$ and $A_2$ are dynamic coefficient matrices, $ecm_{t-1}(\beta)$ is the error correction term, and the system is divided as a threshold variable, $\gamma$ is the threshold parameter, and the model (2) divides the system into two kinds of mechanisms according to the size of the threshold variable $ecm_{t-1}(\beta)$. Each variable exhibits a different dependency in different mechanisms. If the co-integration residual $ecm_{t-1} \leq \gamma$, TVECM obeys the first mechanism; if the co-integration residual $ecm_{t-1} > \gamma$, TVECM obeys the second mechanism.

2.3. Threshold co-integration test

The null hypothesis ($H_0$) of the $sup LM$ test of Hansen and Seo construction is that the dynamic relationship between the variables should be fitted using the linear VECM model as shown in model (1), and the corresponding alternative hypothesis ($H_1$) should be used as shown in model (2). The threshold VECM model fits the dynamic relationship between variables [12]. When the co-integration
vector is unknown, the $LM$ statistic is expressed as equation (3), and the threshold and P value of the sup $LM$ test are obtained by the Bootstrap method.

$$\text{Sup}LM = \sup_{\gamma_1 \leq \gamma \leq \gamma_2} LM(\widetilde{\beta}, \gamma) \tag{3}$$

Where $\widetilde{\beta}$ is the estimated value of $\beta$ in the model (1), and $[\gamma_1, \gamma_2]$ is the search interval of the set $\gamma$ value.

3. Real example

3.1. Data and its basic statistical description

This paper selects the annual data of the elderly population over 65 years old (EP) and urban employment (EC) between 1990 and 2018. The data is from the 2019 Statistical Yearbook. The basic statistical description of the variables is shown in Table 1.

| Variable | Mean | Max  | Min  | VAR      |
|----------|------|------|------|----------|
| EC       | 28495.79 | 43419 | 17041 | 8638.988 |
| EP       | 10340.76 | 16658 | 6368 | 2922.531 |

According to the basic descriptive statistics of the data, the average value of the elderly population is 103,407,600, which has increased from 63.68 million in 1990 to 166.58 million in 2018, indicating that the aging situation is getting worse in China. Both show an upward trend, and the upward trend of the two is the same. Therefore, it can be preliminarily judged that there are unit roots in the two groups of data on the elderly population and urban employment.

3.2. Unit root test and co-integration test

In this paper, the unit root test is performed on the two sets of data using ADF statistics. Since the data has obvious time trends, the equations with intercept terms and time trends are selected and the lag order is determined by the Aka Information Criterion (AIC). According to the test results, the following table shows:

| Variable | ADF value | P value | conclusion |
|----------|-----------|---------|------------|
| lnEC     | 1.5751    | 0.9683  | NO         |
| lnEP     | 4.0005    | 0.9999  | NO         |
| ΔlnEC    | -0.4709   | 0.502   | NO         |
| ΔlnEP    | 0.6859    | 0.856   | NO         |
| ΔΔlnEC   | -3.3356   | 0.002   | YES        |
| ΔΔlnEP   | -6.3699   | 0       | YES        |

It can be seen from Table 2, the two statistics at the 5% significance level shown the logarithm of elderly population and urban employment have unit roots, and their second order difference is a smooth process. Therefore, the data can be tested for co-integration relationship to determine the long-term equilibrium relationship between the two statistics. In order to improve the test accuracy, we use the trace test and the maximum eigenvalue test.

| $H_0$ | Characteristic root | Characteristic root test | 5% threshold | Maximum eigenvalue test | 5% threshold |
|-------|---------------------|--------------------------|--------------|-------------------------|--------------|
| r=0   | 0.5617              | 37.6479*                 | 18.3977      | 20.6219*                | 17.1477      |
| r>1   | 0.049               | 1.0261                   | 3.8415       | 1.0261                  | 3.8415       |
It can be seen from Table 3 that in both test methods, at the 5% significance level, the null hypothesis “r=0” is rejected and the null hypothesis “r>1” is accepted. The estimated co-integration equation is \( \ln c_t = 0.1566 + 1.0923 \ln e_{p_t} + u_t \).

### 3.3. Parameter Estimation of Vector Error Model

After determining that there is a long-term co-integration relationship between the two variables, we use the model (1) to study the dynamic adjustment behavior between the variables. The lag order is determined by the AIC criterion as the first order, and the estimation results are shown in Table 4:

| \( \Delta \ln c_t \) | \( \Delta \ln e_{p_t} \) |
|---------------------|---------------------|
| \( \beta \)         | 1.2056              |
| \( ecm_{-1} \)      | -0.0296(0.0189)*   |
| \( c \)             | -0.0372(0.0577)    |
| \( \Delta \ln c_{-1} \) | -0.1169(0.0962)   |
| \( \Delta \ln e_{p_{-1}} \) | 0.7318(0.0138)  |

AIC=-522.9152 BIC=-511.2526 SSR=0.0028

From Table 4, it can be found that in \( \Delta \ln c_t \), the coefficient of the co-integration vector is -0.0296 at the 1% significance level. Indicating that in the long term, if the urban employment is affected by the impact deviates from the long-term equilibrium value, the error correction system The number of urban jobs will be pulled back to equilibrium. In \( \Delta \ln e_{p_t} \), the coefficient of the co-integration vector is 0.0122, indicating that the elderly population is not affected by the correction mechanism.

### 3.4. Parameter Estimation of Threshold Vector Error Correction Model

Before establishing the threshold vector error correction model, it is necessary to check whether the threshold effect exists. This paper uses the statistic to check whether there is a threshold effect. Specifically, the statistic trimming parameter is 0.05. In order to make the result robust, the number of bootstrap iterations is 5000. The statistical calculation results are shown in the following table:

| Statistics | estimated value | Threshold | p value | conclusion     |
|------------|-----------------|-----------|---------|---------------|
| SupLM      | 21.6583         | 19.65     | 0.0493  | Reject the null hypothesis |

According to the test results in Table 4, the \( \text{SupLM} \) statistic is 21.6583, which is greater than the statistic threshold of 19.65, and the p value is 0.0493. The null hypothesis can be rejected at the 5% significance level, which indicates the elderly population and urban employment. There are nonlinear internal dependencies in the number of people; under different mechanisms, the mutual influence relationship between them and the adjustment effect of bias equilibrium are different. The estimated error correction term is \( ecm_t = \ln c_t - 0.90857 \ln e_{p_t} \), and the threshold \( \gamma \) is -0.41. When \( \ln c_t \leq 0.90857 \ln e_{p_t} - 0.41 \), the model is in the first mechanism, 85.2% of the observations fall in this mechanism. When \( \ln c_t > 0.90857 \ln e_{p_t} - 0.41 \), the model is in the second mechanism, 14.8%. Observations fall within this mechanism. The model estimation results are shown in Table 6:

| variable | First mechanism | Second mechanism |
|----------|-----------------|------------------|
| \( \Delta \ln c_t \) (p value) | \( \Delta \ln e_{p_t} \) (p value) | \( \Delta \ln c_t \) (p value) | \( \Delta \ln e_{p_t} \) (p value) |

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According to Table 6, in the first mechanism, the error correction term coefficient in $\Delta \ln ec_t$ is negative and significant at the 5% significance level, indicating that the elderly population and the urban employment number exist when the error correction term is below the threshold value. Co-integration relationship, the long-term co-integration system formed between the two can be adjusted from the non-equilibrium state to the equilibrium state, and the error correction term coefficient is -0.0607, which means that when the number of employees deviates from the equilibrium value, it will be pulled to the equilibrium level at a rate of 0.0607 units. In the second mechanism, the error correction term coefficient in $\Delta \ln ec_t$ is not significant, indicating that the co-integration mechanism between the two groups disappears when the error correction term is higher than the threshold. In $\Delta \ln ep_t$, neither the first mechanism nor the second mechanism error correction coefficient is significant, indicating that there is no long-term linkage mechanism between the two, and it cannot be pulled back to the equilibrium level.

In $\Delta \ln ec_t$ of the first mechanism, the number of employed people in the first phase has a significant short-term impact on the number of employed people in the current period. The number of employed people in the previous period rose by 1%, and the number of employed people in the current period rose by 0.25%. In $\Delta \ln ec_t$ of the second mechanism, the number of employed people in the first phase has a significant impact on the current employment. The current number of employed people has increased by 1%, and the current employment has increased by 0.54%. It shows that regardless of whether there is a co-integration relationship between the elderly population and urban employment, the number of employed people in the first phase has a significant impact on the current employment, and the impact in the second mechanism is greater.

4. Conclusion
In this paper, the vector error correction model and the threshold vector error correction model are used to analyze the internal dependence of the elderly population and urban employment in 1990-2018, and reached the following conclusions:

1. Through the nonlinear statistic test, it is found that there is a threshold nonlinear effect between the elderly population and the urban employment. By comparing with the linear model, the nonlinear model can better fit the relationship between the variables.

2. When the error correction term is not greater than the threshold, the model is in the first mechanism. When the urban employment deviates from the equilibrium value, it will be pulled to the equilibrium level at a rate of 0.0607 units; otherwise, in the second mechanism, there is no long-term equilibrium relationship between the elderly population and urban employment.

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