Temporal and Spatial Evolution of Population-Economic-Pension Coordination Degree

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Abstract

Based on the analysis of the coupling coordination mechanism of population agglomeration, regional economy and pension insurance, this paper constructs the evaluation index system of the coupling coordination degree of the three. By using the coupled coordination degree model, the comprehensive level of population agglomeration, regional economy and pension insurance development and the spatialtemporal evolution of the three coupled coordination degrees in 30 provinces, autonomous regions and municipalities in China from 2005 to 2018 were estimated. The results show that the comprehensive evaluation index of inter-provincial population agglomeration first increased and then decreased, the comprehensive evaluation index of economic development continued to increase, and the comprehensive evaluation index of old-age insurance remained stable. The mean coupling coordination degree of PEP system first increased and then decreased. In 2018, the whole country, eastern, central and western regions were in the Well coordination stage, and only the northeast region was in the Primary coordination stage, and there was a trend of further deterioration. Taking 2014 as the boundary point, the coupling coordination degree of PEP system presents a spatial change trend of "south rising and north falling" and "west rising and east falling".

Keywords

Pension insurance; Population agglomeration; Coupling Coordination.

1. Introduction

The pension insurance system is not only the internal requirement of economic and social development, but also the important guarantee of economic and social development. Benefiting from the population structure favorable to economic development formed by the population transformation, the rapid economic growth provides sufficient material basis for the development of the pension insurance system. Since the formal establishment of the pension insurance system model combining social pooling and individual accounts in 1997, the solvency of the system has been unprecedentedly improved, the level of basic pension treatment has been greatly improved, and the robustness of the pension insurance system has been enhanced year by year. After the economy entered the new normal, the working-age population declined, labor costs rose rapidly, and economic growth slowed down. At the same time, the decrease of family children and the extension of life expectancy lead to the increasing demand for pension security, the solvency of the system is facing severe challenges, and the correlation and binding characteristics of population, economy and pension insurance are increasingly prominent. Therefore, research on the coupling and coordinated development of Population agglomeration,

regional Economic-Pension insurance (PEP system) is of great significance to promote the sustainable development of China's economy and society.

2. Literature Review

The research on the relationship between population agglomeration, regional economy and pension insurance at home and abroad has been fruitful. Population agglomeration refers to the phenomenon, process and trend that part or all of the population in a certain geographical area converges to one or more specific areas in the geographical area for various reasons(Liu Ruiwen et al.(2010)). From the relationship between population agglomeration and regional economic development, population agglomeration affects regional economic growth, but there is no consensus in the research conclusions. Some scholars believe that population agglomeration will promote technological innovation and labor productivity improvement in population agglomeration through population size, population age structure, human capital and other factors, and then promote regional economic growth (Romer(1999); Ciccone(2000); Chen Le et al. (2018)). Some scholars have concluded that population agglomeration will not only bring agglomeration economy, but also lead to congestion effect. The relationship between population agglomeration and economic growth is an "inverted U" shape, that is, the scale of population agglomeration cannot exceed the ability of regional economic growth to absorb population, otherwise the effectiveness of population agglomeration on economic growth will decrease or even have a negative impact (Brulhart and Sbergami (2009); Wang Zhiyong (2018)). However, it has become the academic consensus that regional economic development difference is the main cause of population agglomeration. Cai Fang (1995) proposed that the dual economic structure and the urban-rural income gap are important factors driving the flow of rural population to the city. Sun Tieshan et al. (2009) established a dynamic VPM model to investigate the impact of social and economic attributes of regional central cities on population agglomeration and diffusion.

From the perspective of the relationship between population agglomeration and the pension insurance system, population migration is generally regarded as an effective measure to reduce the financial consequences of population aging on the insufficient funds of the public pension plan. The research conclusion also shows that population agglomeration is conducive to improving the degree of population aging in the agglomeration area, and thus alleviating the pressure of pension expenditure in the region(Gal(2008); Liu Changping et al.(2008)).Tong Yufen and Wang Yingying (2015) Based on the national floating population monitoring data, the empirical results show that the government's input in public services and social welfare has a significant positive impact on the choice of floating population inflow places. Hou Huili (2016) further studies show that participation in pension insurance can increase the floating population's willingness to settle in cities, but the willingness to settle is related to city size.

From the perspective of the relationship between economic development and pension insurance, economic development is the material basis for the sustainable operation of pension insurance. Factors such as the system model, overall planning level, contribution rate and treatment level of pension insurance will affect employment, consumption and financial expenditure, which will further affect regional economic development. Peng Haoran and Shen Shuguang (2007) studied the impact of pay-as-you-go on economic growth by using the endogenous growth model of overlapping generations. Wang Wei (2012) discussed household consumption, savings and education investment decisions and their impact on China's economic growth under the hybrid pension system by constructing a three-phase overlapping generation model. Cong Chunxia and Shao Dayu (2019) pointed out that the imbalance of pension insurance payments in China will increase the financial burden of local governments,

which will hinder the formation of a fair market competition environment, and then affect the comprehensive development of the whole region.

To sum up, most existing studies focus on the pair relationship between population and economy, population and pension insurance, and economy and pension insurance. The research perspective has also evolved from unilateral consideration of causality to consideration of different factors into the same system, and a lot of research results have been achieved, but few studies have studied the interaction between the three from a systematic perspective. Basically, there is no research on the evolution law of the three coupling coordination from the perspective of spatio-temporal coupling coordination.

In view of this, this paper takes 30 provinces, cities and autonomous regions in China (excluding Hong Kong, Macao, Taiwan and Tibet due to data availability and other reasons) as the research object, and tries to construct the coupling coordination evaluation index system of PEP system on the basis of analyzing the coupling coordination mechanism of the three. To explore the comprehensive development level and coupling coordination degree of the three subsystems in 30 provinces, regions and municipalities in China from 2005 to 2018, in order to provide reference for the coordinated and orderly development of population, economy and pension insurance.

3. Research Methods and Data Description

Interactive mechanism analysis of population agglomeration, regional 3.1. economy and pension insurance

Population agglomeration, regional economy and pension insurance are mutually promoting and restricting relations, and a deep understanding of the interaction mechanism among the three is the primary issue to promote the coordinated development of population agglomeration, regional economy and pension insurance (Figure 1). Regional economic development is the core driving force of population agglomeration. Generally speaking, the urbanization level, labor demand, rationality of industrial structure, supply of public services and scale of fiscal revenue in regions with higher economic development level are superior to those with average economic development level. The imbalance of inter-regional economic development attracts population migration to specific regions and forms population agglomeration in these regions. For the pension insurance, economic growth is an important guarantee for the sustainable operation of the pension insurance, and the material basis for the improvement of the solvency and security ability of the system. In economically developed areas, there are more enterprises above designated size, and enterprises and individuals have the ability to continuously pay pension insurance premiums for a long time. Coupled with the inflow of migrant workers, the pension insurance system has a relatively low support rate, and the pension insurance fund has a strong payment capacity, which can ensure the payment of pensions on time and in full. In economically backward areas, there are fewer enterprises above designated size, the industrial structure tends to focus on a certain type of industry, there are fewer employment opportunities and positions, the outflow of working-age population is serious, the ability of enterprises and individuals to continuously pay contributions for a long time is not strong, and the income and expenditure of pension insurance funds are difficult to balance, and it is necessary to rely on fiscal expenditure to ensure that pensions are paid on time and in full. Therefore, the imbalance of inter-regional economic development is also an important reason for the imbalance of inter-provincial pension insurance funds. Population agglomeration plays an important role in promoting economic development and the stable operation of the pension insurance system. The scale effect of population agglomeration provides highly skilled human capital for the agglomeration area, and promotes the improvement of enterprises' innovation ability in the process of interpersonal knowledge

exchange, thus promoting the upgrading of industrial structure and economic growth in the region. In this process, the floating population transferred to the secondary and tertiary industries to find employment and start businesses to obtain stable jobs, which effectively diluted the degree of population aging in the region, improved the support rate of the pension insurance system to a certain extent, and played a role in enhancing the payment ability of the pension insurance fund. Therefore, the premise of population agglomeration promoting the economy and the pension system is that the economy of the agglomeration area can absorb the migrants. Otherwise, agglomeration will bring congestion effect that is not conducive to productivity growth, and the population agglomeration pattern of economically developed areas and economically underdeveloped areas is different(Chen Xinying(2015)).Pension insurance is an important guarantee for the stable development of social economy. Pension insurance can affect people's employment, school concept and savings tendency, and promote the stable development of social economy by guiding the rational consumption of social members. On the one hand, the pension insurance has realized the sharing of the fruits of economic development and improved the guarantee ability of the pension insurance system. The more powerful the pension insurance is, the more it can reduce the dependence of the elderly on the support of their children, encourage families to reduce births, and instead increase the investment in children's education, so as to promote the accumulation of human capital and economic growth. On the other hand, the stronger the solvency of the pension insurance, the less pressure on local fiscal expenditure under the provincial overall planning, the greater the space for rate reduction, the corresponding reduction of enterprise operating costs, attracting the influx of labor, promoting population agglomeration and regional economic and social development. It can be seen that population agglomeration, regional economic development and pension insurance system promote and restrict each other, and it is of certain theoretical and practical value to measure and analyze the coupling and coordination of the three.



Figure 1. Interaction mechanism diagram of PEP system

3.2. Evaluation index system construction and data source

3.2.1. Evaluation index system

A scientific and reasonable evaluation index system is the prerequisite for accurately grasping the coupling and coordination level of PEP system. Based on the comprehensive consideration of the coupling coordination mechanism of population agglomeration, regional economy and pension insurance, the evaluation index system of coupling coordination degree of PEP system is constructed by referring to existing literature and following the principles of scientificity, comprehensiveness and operability, as shown in Table 1. There are many forms of population agglomeration, such as rural-city migration, city-city migration and inter-provincial migration, etc. However, the form of population agglomeration in China is more represented by population migration from rural areas to urban areas. Therefore, population agglomeration in this paper is mainly characterized by population urbanization. The population agglomeration subsystem

contains two primary indexes, namely, population agglomeration scale and population agglomeration quality. The scale of population agglomeration includes the number of urban population, urbanization rate, the proportion of working-age population in urban areas and the proportion of elderly population, which reflects the influence of population agglomeration on the scale and age structure of urban population in various provinces. According to existing studies, the quality of population agglomeration includes the proportion of urban working-age population, the proportion of population aged 65 and above, the number of college students per 10,000, and the proportion of education, science and technology expenditure in general financial expenditure. The first two items reflect the impact of population agglomeration on the age structure of urban population in each province, and the last two items reflect the impact of population agglomeration on the potential human capital storage in each province(Chen shuyun and Yang Jiankun(2017)).

subsystem	Primary index	Secondary index	weight
Population	scale	urban population	0.170
		urbanization rate	0.165
		working-age population	0.164
		elderly population	0.167
	quality	education	0.166
		expenditure	0.168
Economic	aggregate	GDP	0.128
		investment	0.152
		consumption	0.129
		trade	0.143
	structure	primary industry	0.153
		secondary industry	0.158
		tertiary industry	0.136
	covered	contributors	0.132
		support rate	0.117
Pension		contributors/employees	0.119
	benefit	average pension	0.103
		replacement rate	0.120
		increase	0.108
	fund	fund rate	0.113
		income/GDP	0.112
		outcome/GDP*	0.078

Table 1. Index system and weight of coupling coordination degree of PEP system

The regional economic subsystem consists of two first-level indicators, namely economic aggregate and economic structure. Economic aggregate includes regional GDP, total retail sales of consumer goods, total investment in fixed assets of the whole society and total import and export trade, reflecting the regional economic situation from the perspectives of production, consumption, investment and trade. Whether the industrial structure is reasonable directly affects the growth rate and quality of regional economy, this paper uses the industrial structure to characterize the economic structure, including the proportion of the primary industry, the proportion of the secondary industry and the proportion of the tertiary industry.

This paper measures the current situation of pension insurance from the perspective of the number of people covered, the level of pension and the situation of pension fund. The number covered includes the number of contributors, the system support rate and the ratio of the number of contributors to the number of urban employees, where the ratio of the number of contributors to the number of urban employees reflects the actual coverage rate of the pension

insurance system. The pension level includes the average pension, the pension replacement rate and the pension growth rate. The average pension replacement rate is the ratio between the average pension and the average social wage in the same period, reflecting the degree of security corresponding to the current living standard of the pension. The ability to pay includes the fund rate, the ratio of fund income to GDP, and the ratio of fund expenditure to GDP. The fund rate is the ratio of accumulated assets at the beginning of the year to annual expenditure. which measures the annual pension fund's ability to pay.

3.2.2. Data source and preprocessing

The sample data for the indicators in this paper are the annual statistical data of urban population, economy and pension insurance in 30 provinces from 2005 to 2018, which are specifically derived from China Statistical Yearbook, China Population and Employment Statistical Yearbook and provincial and urban Statistical Yearbook from 2006 to 2019. In order to eliminate the impact of different dimensions, orders of magnitude and attributes of the data on the measurement results, referring to the research method of Zhu Jiangli and Li Zilian (2015), this paper first standardized the index data, and used the entropy method to objectively determine the weight of each evaluation index. The calculation results are shown in Table 1.

Coupling coordination degree model 3.3.

Coupling refers to the relationship of interaction and influence between systems or elements, and coordination refers to the relationship of coordination and cooperation and virtuous cycle between systems or elements. Using the coupling coordination degree function, we can reveal the interaction and mutual promotion of population agglomeration, economic development and pension system. The steps are as follows:

First, according to the weights of each index determined before, the comprehensive development level index of the three systems is obtained by using the multi-objective weighted summation method. x_{ij} , y_{ij} and z_{ij} , i=1,2,...,n, j=1,2,...,m represent each indicator after

standardized treatment. a, b and c represent the indicator weights. $U_{ij}^1 = \sum_{k=1}^6 a_{k,j} \times x_{ij}^k$, $U_{ij}^2 = \sum_{k=1}^7 b_{k,j} \times y_{ij}^k$

and $U_{ij}^3 = \sum_{k=1}^9 c_{k,j} \times z_{ij}^k$ are the evaluation functions of each subsystem of population, economy and pension.

Second, according to Liao Chongbin's (1999) generalized model, the calculation formula of

coupling degree is $C = \left[\frac{U^1 \times U^2 \times U^3}{\left(\frac{U^1 + U^2 + U^3}{3}\right)^3} \right]^{1/3}$. The formula for calculating coordination degree is

 $D = \sqrt{C \times T}$, where $T = \alpha U^1 + \beta U^2 + \gamma U^3$. Considering that the status of the three is not exactly equal, the improvement of economic development level is the source of the sustainable development of population agglomeration and pension insurance system, and population agglomeration and pension insurance in turn promote regional economic growth. Therefore, $\alpha = \gamma = 0.3$, $\beta = 0.4$. In order to better explain the degree of coupling and coordination development of population agglomeration, regional economy and pension insurance, the coupling and coordination degree is divided into ten levels, as shown in Table 2.

D value	phase	D value	phase
0.01 <d≤0.09< td=""><td>Extreme dissonance</td><td>0.50<d≤0.59< td=""><td>Barelycoordination</td></d≤0.59<></td></d≤0.09<>	Extreme dissonance	0.50 <d≤0.59< td=""><td>Barelycoordination</td></d≤0.59<>	Barelycoordination
0.10≤D≤0.19	seriousnessdissonance	0.60 <d≤0.69< td=""><td>Primary coordination</td></d≤0.69<>	Primary coordination
0.20 <d≤0.29< td=""><td>moderatedissonance</td><td>0.70≤D≤0.79</td><td>Well coordination</td></d≤0.29<>	moderatedissonance	0.70≤D≤0.79	Well coordination

Table 2. Coupling coordination degree grade classification standard

0.30 <d≤0.39< th=""><th>milddissonance</th><th>0.80<d≤0.89< th=""><th>Better coordination</th></d≤0.89<></th></d≤0.39<>	milddissonance	0.80 <d≤0.89< th=""><th>Better coordination</th></d≤0.89<>	Better coordination
0.40 <d≤0.49< td=""><td>Borderlinedissonance</td><td>0.90<d≤1.00< td=""><td>Quality coordination</td></d≤1.00<></td></d≤0.49<>	Borderlinedissonance	0.90 <d≤1.00< td=""><td>Quality coordination</td></d≤1.00<>	Quality coordination

4. Spatiotemporal Dynamic Analysis of the Coupling Coordination Degree of Population, Economy and Pension Insurance

4.1. Temporal evolution analysis of population agglomeration, regional economy and comprehensive development level of pension insurance

The comprehensive evaluation index model is used to estimate the evaluation index of subsystems of population agglomeration, regional economy and pension insurance and the comprehensive evaluation index of population agglomeration, regional economy and pension insurance, as shown in Figure 2. The comprehensive evaluation index of population aggregation, regional economy and pension insurance in China shows an obvious upward trend, which can be roughly divided into two stages: fluctuating upward trend from 2005 to 2014; The period from 2015 to 2018 is a period of fluctuation decline.



Figure 2. Population agglomeration, economic development and pensiont insurance system comprehensive evaluation index

The change trend of the comprehensive evaluation index of population agglomeration is different in the two stages. From 2005 to 2014, the comprehensive evaluation index of population agglomeration increased continuously, from 0.137 to 0.633, and the average of the comprehensive evaluation index of population agglomeration in 30 provinces and municipalities was 0.451, which was higher than the national average of the comprehensive evaluation index in 13 provinces. From 2015 to 2018, the comprehensive evaluation index of population agglomeration decreased year by year, from 0.681 to 0.424, and the average of the comprehensive evaluation index of population agglomeration in 30 provinces and municipalities was 0.565, which was higher than the national average of the comprehensive evaluation index of population agglomeration in 30 provinces and municipalities was 0.565, which was higher than the national average of the comprehensive evaluation index in 15 provinces.

In terms of regional economic development, the comprehensive evaluation index of economic development has shown a steady upward trend as a whole, creating conditions for population agglomeration and accumulating material foundation for the stable development of the pension insurance system. Affected by the global financial crisis, the comprehensive evaluation index of economic development in 2007 and 2008 dropped significantly. Under the joint action of prudent fiscal policy and monetary policy, the market economic system has been unprecedented expanding since 2009, and the economy has entered a period of rapid growth.

By 2018, the comprehensive evaluation index of economic development reached 0.809, with an average annual growth rate of 8.54%. However, sustained economic growth has not achieved the strategic goal of coordinated development of regional economy, and the economic development gap between regions has experienced a process of narrowing and then expanding. From the standard deviation of the comprehensive evaluation value of economic development, the standard deviation of the comprehensive evaluation index of national economic development shows a positive U-shaped change on the whole, and the turning point is 2014, which indicates that after China's economic development has entered the new normal, the economic development gap between regions has a widening trend due to the impact of economic structure adjustment, optimal allocation of resources and the transformation of old and new momentum.

The basic pension insurance for urban workers is not at a high level, which, to a certain extent, divides the links between regions, makes it difficult for pension funds to receive and disbursement uniformly, and the pension insurance treatment is uneven, leading to the different development levels of the inter-provincial pension insurance system, and the imbalance pattern of the pension insurance system is still formed. From 2005 to 2018, the national average of the comprehensive evaluation index of pension insurance was slightly upward, which was 0.385 in 2005 and 0.400 in 2018. From the perspective of stages, the national mean and standard deviation of the comprehensive evaluation index of pension insurance in 30 provinces and municipalities from 2005 to 2018 were 0.439 and 0.081, and the mean and standard deviation of pension insurance from 2015 to 2018 were 0.447 and 0.071, indicating that the development gap of pension insurance between provinces and regions was narrowing.

4.2. Population agglomeration, regional economy and pension insurance spatial coupling coordination development analysis

Based on the coupling coordination degree model, the coupling coordination degree of PEP systems in 30 provinces and cities from 2005 to 2018 can be calculated, and the corresponding levels are divided according to the coupling coordination degree values, and the spatiotemporal evolution of the coupling coordination development of PEP systems is analyzed. From 2005 to 2018, the average coupling degree and coupling coordination degree of the national PEP system were 0.956 and 0.669, respectively. The three subsystems were highly correlated and mutually promoting. From the perspective of time evolution (see Figure 3), the mean coupling coordination degree of the national PEP system first increased and then decreased, but the overall trend was rising, from 0.459 in 2005 to 0.724 in 2018, and the coupling coordination level changed from the verge of maladjustment decline to intermediate coordination development. From a regional perspective, the variation trend of the mean coupling coordination degree in different regions during the study period was the same as the national mean, and by 2018, the mean coupling coordination degree in eastern, northeastern, central and western regions was 0.732, 0.633, 0.723 and 0.741, respectively. The coupling coordination level of the PEP system in the eastern region has experienced a process from Borderline dissonance- Better coordination - Well coordination, the Northeast region has experienced a process from Barely coordination-Well coordination-Primary coordination,, and the coupling coordination level of the PEP system in the central and western regions has changed from Borderline dissonance to Well coordination.



Figure 3. The coupling coordination degree of PEP system in the country and four regions

At the end of the 20th century, China successively put forward the strategies of western development, northeast revitalization and central rise, which together with the strategy of giving priority to the development of the eastern region formed the overall strategy of China's regional development. However, under the influence of various factors, the economic development of the western region is relatively slow, while the advantages of the eastern region in public service, income level, urban carrying capacity and industrial development attract the inflow of various production factors, among which the continuous large-scale population agglomeration to the eastern coastal areas is the most significant. Population agglomeration, promoted the development of the pension insurance system, provided a stable social environment for economic development, and thus promoted the further development of the economy. The western region, because of its weak economic strength and serious population outflow, not only restricts economic growth, but also is not conducive to the development of pension insurance system. During 2005-2014, the degree of PEP system coupling coordination in the eastern region was higher than that in the central and western regions.

After the economy has entered the new normal, the cost of various factors in the eastern region has continued to increase, the space for government investment in infrastructure has gradually decreased, and the core driving force of economic growth has changed from factor intensive to innovation-driven. By undertaking industrial transfer and new-type urbanization, the central and western regions have attracted a large number of labor forces gathered in the eastern region to return, providing a rich labor force for industrial transfer, and the industrial transfer also provides highly matched job opportunities for the returned labor force in the local.The "high investment - high growth" development mode and stable employment environment in the central and western regions make the coupling and coordination degree of PEP system in the central and western regions exceed that in the eastern regions. However, due to the reduction of the total labor supply scale, the mean of PEP system coupling and coordination degree has not changed the trend of decline. As a traditional heavy industrialization base, the economic downturn and labor force outflow in Northeast China have led to severe challenges to the solvency of pension insurance in this region, and the coupling coordination degree of PEP system has seriously declined, and there is a trend of further deterioration.

5. Conclusion

The continuous expansion of the differentiation of regional economic development leads to the cross-regional flow of labor force, and the flow of labor force further intensifies the interregional economic development gap. In the state of regional division of the system, regional economic development difference and labor flow lead to regional imbalance of pension insurance. In turn, the imbalance of pension insurance affects economic development and population flow. The relationship between population, economy and pension insurance leads to the dynamic evolution of PEP system coupling coordination degree between regions.

Based on the panel data of 30 provinces in China from 2005 to 2018, this paper studies the spatio-temporal evolution of the coupling coordination degree of population agglomeration, regional economy and pension insurance. Firstly, after entering the economic new normal, the comprehensive evaluation index of population agglomeration has decreased, the population agglomeration has shifted from the eastern coastal areas to the inland, and the current population return to the central and western provinces and the population re-agglomeration in the eastern provinces coexist. The regional economic comprehensive evaluation index continues to increase, and the gap between regions has a widening trend. Generally, the economic development trend of the southwest, central and southern, southeast coastal areas is generally better than that of the northwest and northeast regions. The comprehensive evaluation index of pension insurance remained stable and slightly increased, and the development gap between provinces and regions of pension insurance was narrowing. Secondly, the average of PEP system coupling coordination degree in the country and various regions first increased and then decreased, but the overall trend was rising. In 2018, the national, eastern, and western regions were in the stage of Well coordination, while the northeast region was in the primary coordination stage, and there was a trend of further deterioration. Taking 2014 as the boundary point, the coupling coordination degree of PEP system presents a spatial change trend of "rising in the south and falling in the north" and "rising in the west and falling in the east". The coupling degree of PEP system in the central and western regions, especially in the provinces covered by the Yangtze River Economic Belt, is strengthening, while it is weakening in the northeast and northwest regions.

The gathering of population will drive the development of economy, and whoever grabs the talent, whose economy will continuously burst out new vitality. At the same time, the population agglomeration can also improve the age structure of the population and reduce the pressure of pension insurance payment. However, the excessive concentration of population will lead to the problem of excessive urban burden, and the payment ability of pension insurance will also be affected by the reduction of financial transfer. We should give full play to the role of government guidance and overall planning to realize the positive interaction between population, economy and pension insurance.

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