Prediction of Population Aging in European Union Based on Copula Function

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***Abstract* — To predict the population aging in European Union, a prediction method based on Copula function is presented in this paper. Copula function has a good nonlinear mapping approximation performance, and it has been widely applied in all kinds of prediction. Copula function is comparatively fast in learning speed and able to avoid local minima, so its predictive value is more close to the true one. Aiming at the outstanding of Hunan population aging, based on the aging index historical data, this paper constructed an impact factor system from three aspects such as economic level, the natural population growth and social security. It also constructed a quantitative population aging prediction model by Copula function model. The result showed that the Copula function model was more accurate and reliable.**

Keywords - copula function; population aging; European Union; nonlinear mapping approximation performance

I. INTRODUCTION

In the 21st century, the process of the population aging is accelerated ceaselessly. The rapid development of aging population can not only increase the social burden, but also increase the family burden. If the population aging continues to intensify in the future, retired and retiring persons in the proportion of the population will continue to increase, the endowment insurance fund expenditure gap will also become bigger and bigger, it will certainly bring social security institution a huge pressure, which will greatly affect the social security level and the improvement of social security scope expansion, and increase workers' economic burden, and ultimately it will affect the sustainable development of society.

Since the aging problems more seriously affect our economy and society. It received more and more attentions. This paper aims to study the effect of population aging on the world economy. The aging problems brought significant impact on the social and economic development, and aggravate the burden of the society. Therefore the aging problems have become the focus of the research in the world. In Meramat's paper [1], firstly he uses factor analysis method, to remove the multi-linearity among the variables. Then we are linear regression analysis method to obtain the derived by linear regression equation. Prediction and residual analysis are conducted. The result show that the model is of high precision, and could be used to make short-term prediction. Secondly he conducts the long term prediction of population aging. The grey system GM (1,1) model is chosen to conduct the analysis, the result show that the model can do long-term prediction. To achieve high precision, James [2] proposes two methods for improvement purpose. One is increasing the sequence length, which is called the new information model. The other is changing the initial conditions of the sequence, which is called the metabolic model. After comparison, he found that the metabolic model is with higher precision. His paper predicts the aging population in China. It was found that China's aging is very serious and is facing more severe problems. The prediction results show the impact of population aging on our society and economy. Several policy suggestions are provided for theoretical basis to solve the aging problems in the future.

The population aging has become the major trends in the world today; European Union is facing the challenge of population aging. The economic behavior of different age stages has a strong heterogeneity; the impacts on the economy are not the same. The strengthening of the trend of population aging is bound by a series of variables, and ultimately can affect the gross domestic product. Therefore, in this context, to study the relationship between the populations aging and gross domestic product is particularly important. European Union is the world's most populous region, the relationship between population and gross domestic product has a crucial impact on European Union's future development.

In the 1970s, China has implemented a two crucial policies related to population and economic growth: family planning policy; reform and opening up policy. The family planning policy sharply declined the number of newborns; reform and opening up policy rapidly promote China's economy. At the same time, the improvement of the people's living standards and medical conditions make the people live longer than before. But these two policies have brought the emergence of an aging population.

Doris' study [3] can advance the understanding of the theory of the population aging and economic growth; deep and comprehensive understanding of the situation of China's aging population; from an empirical point of view, using time series data and the 2010 cross-sectional data on 31 regions, analyzes the relationship between population aging and gross domestic product; considerations for the development of population aging and economic growth policies. The main variables of macroeconomics used to

measure gross domestic product are consumption, saving, net exports and government purchase. First, determine the relationship of population aging and gross domestic product through the analysis of the population aging and gross domestic product value. Then studies the relationship between population aging and consumption, saving, net exports and government purchase respectively, it can further determine the relationship between the population aging and gross domestic product, and provide the basis for the future development of appropriate policies. In James' study [4], analysis result and estimation are more accurately by using micro and macro data. Based on the theoretical research and documentation, describes the saving, consumption, net exports and government purchase feature of China. The author uses relatively cutting-edge research methods, processing endogenous lagged variable system-GMM, and uses State 11.0 software to estimate the relationship between population aging and saving, consumption, net exports and government purchase. The author uses Eviews 6.0 software to test the relationship between the population aging and gross domestic product through time-series and cross-sectional data.

II. Population Aging Problem in China

William's study [5] shows the following innovations: earlier use the data to explore the relationship of population aging and gross domestic product. On the macroeconomics point of view, GDP represented by the expenditure includes four areas: saving, consumption, net exports and government purchase. He discusses the relationship between population aging and the four aspects respectively. Build four conduction mechanism of saving, consumption, net exports and government purchase. Uses the system GMM Estimation treats the panel data. The system GMM estimation overcomes the shortcomings of the OLS and fixed effects analysis, and avoids endogenous model. Hansen test and serial correlation test ensures the reliability of the conclusions. In addition, an earlier study of the relationship between a population aging and government purchases is presented. First, explore the population aging and the government purchase in gross value, on this basis, further study the relationship between population aging and government health spending value. However, due to grasp of the situation, the data collection, and private ability, the article has the following inadequacies: the data is not perfect, this article only gives the population aging and gross domestic product analysis of China's31administrative districts, not includes Hong Kong, Macao and Taiwan regions. Doing the GMM Estimation, selects a certain number of control variables, in order to make the model more accurate estimates. However, the control variables selected, although as far as possible the important control variables into the model, but also unable to achieve comprehensive selection. Although this will not have significant impact on the results of the study, but also should be improved. Current social conditions, higher demands on the old-age security system; 4-2-1 number of families increased, a higher demand for social welfare and security. These changes should be listed in the scope of the study, but this study does not make a further study.

Ageing of population is a serious challenge faced by China in future. The aging population will grow fast in the 1st half of this century according to the projection of UN. The proportion of aging population over 60 years old is going to 31.1%, which means there will be 1 elderly among 3 people. The aging trend will lead to an inevitable dent on the economy and society of China. "Aging before getting rich" is a remarkable characteristic of current trend of aging population, which has passive impact on Economy of China that has been emerging already. How to keep the growth of economy by transferring the trend of "aging before getting rich" to aging while getting rich" is a hot-issue. The ageing of population is the consequence of demographic transition. By constructing an overlapping-generations model, this essay demonstrates the mechanism of demographic bonus generation during the transition and proves the inevitability of changing from bonus to debts. China is going to enter a new stage of population ageing following the escalation of total dependency ratio, which is called ageing without bonus (or ageing with demographic debt). In this stage, continued development of economy demands continued improvement of labor productivity. At the same time, the improvement of labor productivity is also crucial to the PAYG system which is the basement of aging society. This is demonstrated by a pension finance balance model under the system of cash basis.

The core issue of Population Resources and Environmental Economics is how to allocate resources for material production and population production to meet the people's livelihood and reproduction needs, and as much as possible to protect the environment, promote people-centered sustainable development. Chinese population policy bases on the creed that social development needs moderate population. Reproductive choice thus transformed to national implementation of the "control population, improve population quality". From the "optimum population" point of view, this family planning policy seems rational because of rapid population growth and decline in mortality. After World War II, baby boom occurred, some countries fear that population growth and "bomb". However, the current world fertility situation has undergone a fundamental change. From the World Fertility Report data we know that the level of fertility in developed countries has generally declined since the 1970s, this low fertility levels is unprecedented. China's total fertility rate is also below replacement level for many years and the demographic dividend will disappear soon. The current policy in the Eleventh Five-Year period sticks to "to stabilize the low fertility level", and did not specify the standards to stabilize the low fertility level. Shanghai and some other cities' total fertility rate has been below 1 for many years, the long-term above or below the replacement level is not sustainable, new policy should be adopted as soon as possible in order to promote the balanced development of the population. Lin [6] studies the changes of China's population policy and its implications on economic and social development; Chinese population policy causes much benefit and some social and economic problems as

aging, sex ratio increasing, etc. New policy should be considered as the next 5-year-plan coming soon. Adjusting population policy is feasible after 30-year policy. Its Pareto improvement to realize the TFR=2.0 Population Policy, and it will be better than the current population policy.

Analysis of the economy growth since the China Reform shows that the improvement of labor productivity is the major driving force for economy growth while there are still many limitation factors. 1) Perspective of structure analyzing: First of all, labor productivity is mainly promoted by secondary industry and the other 2 industries increase slowly; secondly, the effect of employment structure transfer is not obvious due to the low education level of rural labors and insufficient civilization. 2) Perspective of factors analysis: The productivity is mainly droved by material capitals. However, the Neo-Economy Growth theory and the experiences of developed country told us that the long-term growth of economy is supported by the TFP based on human capital. In an ageing society, promotion of labor productivity means that the huge wealth requirements by ageing society can be met by small labor population. Consequently, transforming the growth pattern to promote the labor productivity is the only way to produce sufficient material as the basement for the challenge of ageing society in the future of China.

In 1870s, France took the lead becoming aging country, some European and American countries also marched into the old age national ranks. In recent years, China's population is ageing fast. There are growing concerns about the aging population. Population structure has the direct bearing on economic development, and the number of labor force. Different age groups have different consumption structures. The implementation of the second child policy, the development of population structure will enter a new stage.

The change of this population pyramid, we know that the population ageing is gradually deepened. According to the sixth national census, the aging degree of different regions is different, old people's healthcare different. The old people's source of income between urban and rural areas is different. Elderly people in rural areas are facing a pension plight. Population ageing of city has showed some regional characteristic, also brought some problems. By using the model, selecting parameters to predict four key years of population structure of the pyramid is important. Forecasting the coming years, as the change of policy, the number of 0-14 years old children's and its proportion will gradually increasing, the total number of people aged65and up will gradually increasing. As time goes by, the existing population of working-age population will gradually transition to the elderly population, elderly population will increase sharply. Population ageing will increasing the pressure of health care, provide of the aged. According to the questionnaire data, people with different ages, different economic conditions and the different health conditions, their endowment will vary. Influenced by local traditional concept, old people tend to choose family pension, when the family endowment couldn't satisfy her/his pension demand, according to their economic conditions, physical health, there will consider home endowment or institution endowment which one to choose. Many retired intellectuals are tend to choose housing supporting, community home endowment institutions, mutual support, mutual endowment. Through the survey we found that the family pension mode in has some shortages, such as weakening of family pension mode function, obvious regional difference, and the shortage of funds. Because of traditional ideas and the lack of funds institutions endowment has a low level of specialization and standardization. Housing supporting is just started; the single source of funds, narrow coverage, and service level needs to be improved. Draw lessons from foreign advanced countries, successful pension patterns, combining with the characteristics of local population ageing and endowment patterns, considering the characteristics of the questionnaire of desire, we come out some suggestions: developing diversified pension mode, providing multiple service; Perfect the relevant legal system; Increasing financial and social capital; Endowment real estate development, the establishment of elderly community; Cultivate professional service personnel, improve the service level.

China in the early days of reform and development of the working-age population proportion of the total population, the dependency ratio is relatively low, and to create a favorable demographic conditions for economic development. In recent decades, the sustained and rapid economic growth has become one of the world "miracle". The late 20th century, however, to control the rapid population growth, China's implementation of the family planning policy, which makes the birth rate decreased rapidly; With the national economic development and people's living conditions improve, the average life expectancy of the population in China has been extended, the birth rate decreased and the extension of the average life expectancy of the population of these two factors together to speed up the process of China's aging population. Today, China has already entered the ranks of countries with aging and population center of gravity tends to be constantly shifted to a heavy burden on the pension system in China.

The impact to China's old-age insurance system in order to better quantify the changes in population structure, we first establish a population projection model and the model consists of a combination of population transfer model and based on the theory of time series constructed two models of the newborn population projection model. Anita's [7] paper constructs based on the principle of the National Bureau of Statistics survey of the population of all ages showing a regular change over time, the rate of population transfer. The rate of population transfer and the National Bureau of Statistics population data of all ages can either forward predict the future population, can also be introduced back cannot find on the website of the National Bureau of Statistics of all ages historical population data. However, the model does not have a new birth population, in order to get the newborn population, the paper also constructed newborn population projection model. The population projection model is just the local forecast; the overall majority of the data is the use of population transfer characteristics and the statistical regularities, which takes full advantage of past

statistics and population age distribution structure, which greatly improved the forecast, reducing the error.

III. COPULA FUNCTION

Markov process is an important branch of stochastic process. So that it has been widely applied to many fields, for example, modern physics, biology, management science, information processing, automatic control, computer science, financial insurance and so on. Where $\{X(t), t \in T\}$ is a stochastic process, and $0 \le t_1 < t_2 < ... < t_n \in T$ If the values of process X(t) are $x_1, x_2, ..., x_{n-1}$ and x_n at these moments $t_1, t_2, ..., t_{n-1}$ Equation of Markov process can be written as Eq. (1):

$$F(x_n, t_n; x_{n-1}, t_{n-1}; x_{n-2}, t_{n-2}; ...; x_1, t_1) = F(x_n, t_n; x_{n-1}, t_{n-1}) \quad (1)$$

Markov process also has a special feature that is the stability ineffectiveness theory. When a stochastic process is a Markov process, its stability ineffectiveness means that information of process $x_1, x_2, ..., x_{n-1}$ has all been stored in information of process x_{n-1}.Information of process x_n can be solved with information of process x_{n-1} and information of process x_n has nothing to do with information of process x_1, x_2,…， x_{n-2}. All transition probability of Markov chain can compose a matrix that is called matrix of transition probability. Matrix of transition probability can be written as Eq. (2) by one-step transition probability:

$$P = \{P_{ij}, i, j \in s = (0,1,2...,n)\} = \begin{bmatrix} P_{11} & P_{12} & ... & P_{1j} \\ P_{21} & P_{22} & ... & P_{2j} \\ . & . & & . \\ . & . & ... & . \\ . & . & & . \\ P_{i1} & P_{i2} & ... & P_{ij} \end{bmatrix} \quad (2)$$

Each element of matrix P is non-negative number and sum of each row element equals one. Before algorithm of random switching frequency can be written as Eq. (3):

$$f_{n+1} = f_s + S \times R \quad (3)$$

In Eq. (3) f_{n+1} is frequency of switching function at the time n+1, f_s is frequency of rated switching functions is random number between[-1， 1]and R is random gain. Random algorithm can make frequency of switching function that according to random regularity distribute within a range [f_s-R, f_s+R]. Through algorithm of random switching frequency, Markov chain technique was applied to SVPWM technique base on random switching frequency. State space of Markov chain, in theory, the bigger the better. Along with state space bigger, random numbers would take up more and more resources of processor. In other words, bigger state would make matrix of transition probability have more unknown parameters, so that experimental simulation is not easy to be achieved. Synthesizes each kind of situations, feasibility of infinite state Markov chain technique that is applied to variable-frequency population aging prediction system would be proven by simulation results of two-state and three-state Markov chain technique.

Specific design scheme of two-state Markov chain technique as follows: switching frequency is called state one when it is greater than f_s. Switching frequency is called state two when it is less than f_s, so that actual mathematical expectation of switching frequency would to equal theoretical mathematical expectation of switching frequency as much as possible. Switching state figure of two-state Markov chain is shown in Fig. l.

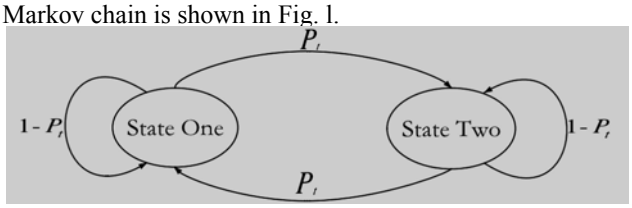


Figure 1. Switching state figure of two-state Markov chain.

As can be seen from Fig. l, if current switching frequency of system belongs to state one, percent probability of next switching frequency that belongs to state two is p_t,. But percent probability of next switching frequency that still belongs to state one is 1- p_t, In a similar way, if current switching frequency of system belongs to state two, percent probability of next switching frequency that belongs to state one is p_t. But percent probability of next switching frequency that still belongs to state two is 1- p_t. Matrix of transition probability of two-state Markov chain can be written as Eq.(4):

$$P = \begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix} = \begin{bmatrix} 1-P_t & P_t \\ P_t & 1-P_t \end{bmatrix} \quad (4)$$

According to matrix of transition probability of two-state Markov chain, simulation model of two-state Markov chain that is derived in the MATLAB/SIMULINK software platform is shown in Fig. 2.

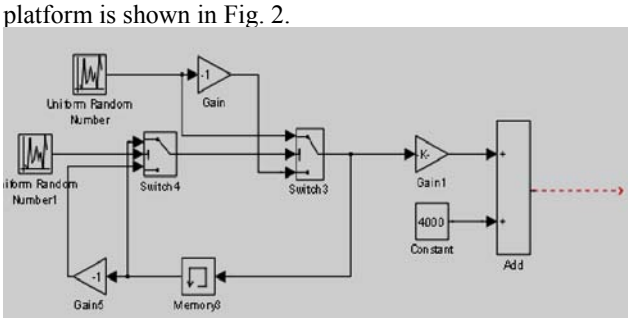


Figure 2. Simulation model of two-state Markov chain.

Specific design scheme of three-state Markov chain technique as follows: change range [f_s-R, f_s +R] of switching frequency is divided into three parts [f_s –R, f_s -kXR], [f_s -kXR, f_s +kXR] and [f_s +kXR, f_s +R], coefficient $k \in (0,0.36)$. In order to further analysis, three change ranges of switching frequency are respectively called state one, state two and state three. Switching state figure of three-state Markov chain is shown in Fig.3.

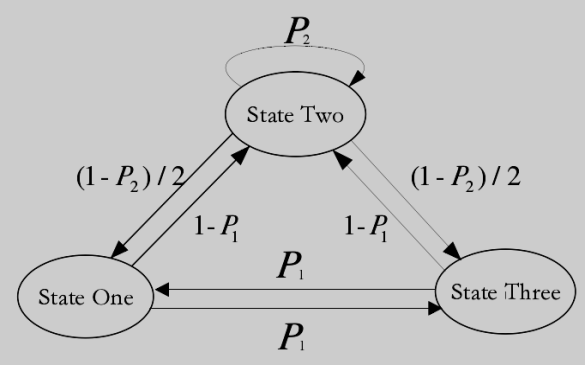


Figure 3. witching state figure of three-state Markov chain.

As can be seen from switching state diagram figure, if current switching frequency of system belongs to state one, next switching frequency only belongs to state two or state three. Percent probability of next switching frequency that belongs to state two is $1\text{-}P_1$. Percent probability of next switching frequency that belongs to state three is P_1. If current switching frequency of system belongs to state two, percent probability of next switching frequency that belongs to state one or three is $(1\text{-}p_2)/2$.But percent probability of next switching frequency that still belongs to state two is p_2.If current switching frequency of system belongs to state three, next switching frequency only belongs to state one or two. Percent probability of next switching frequency that belongs to state one is P_1. Percent probability of next switching frequency that belongs to state two is $1\text{-}P_1$.

IV. Prediction of Population Aging in European Union

Copula algorithm is added to variable-frequency population aging prediction system on the basis of random switching frequency algorithm. Relationship between Markov chain algorithm and random switching frequency algorithm is shown in Fig. 4.

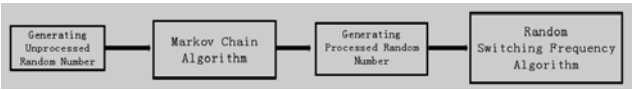
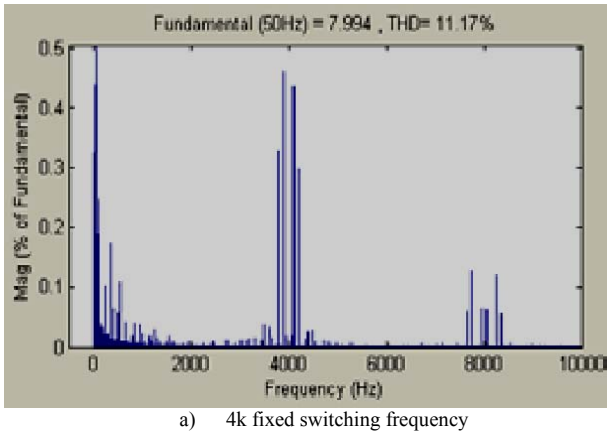
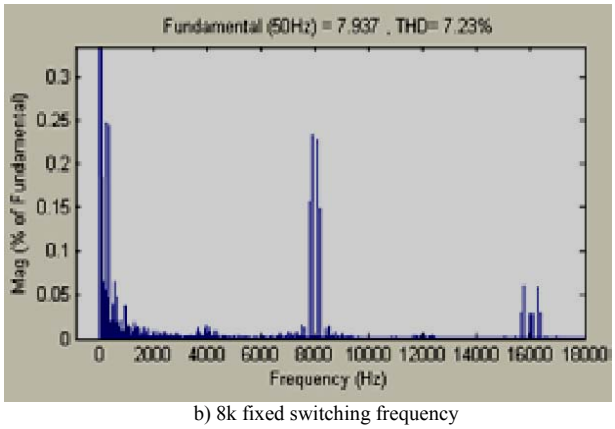


Figure 4. Relationship between Markov chain algorithm and random frequency algorithm.

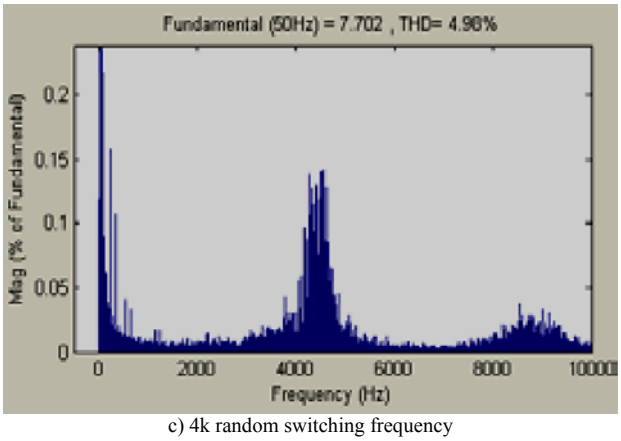
In MATLAB/SIMULINK software platform, this paper respectively sets up simulation model of fixed variable-frequency population aging prediction, simulation model of random variable-frequency population aging prediction technique, simulation model of two-state Markov chain and simulation model of variable-frequency population aging prediction of three-state Markov chain. Experimental simulation results of variable-frequency population aging prediction system are shown in Fig. 5. Fig. 5(a) and Fig. 5(b) are Fast Fourier Transform Algorithm (FFT) that is outputted by variable-frequency population aging prediction when switching frequency are 4k or 8k respectively. Fig. 5(c) and Fig. 5(d) are FFT of current that are outputted by variable-frequency population aging prediction when switching frequency are 4k or 8k respectively. Fig. 5(e) and Fig. 5(f) are FFT of current that are outputted by variable-frequency population aging prediction technique of two-state Markov chain when switching frequency are 4k or 8k respectively. Fig. 5(g) and Fig. 5(h) are FFT that are outputted by r variable-frequency population aging prediction technique of three-state Markov chain when switching frequency are 4k or 8k respectively.



a) 4k fixed switching frequency

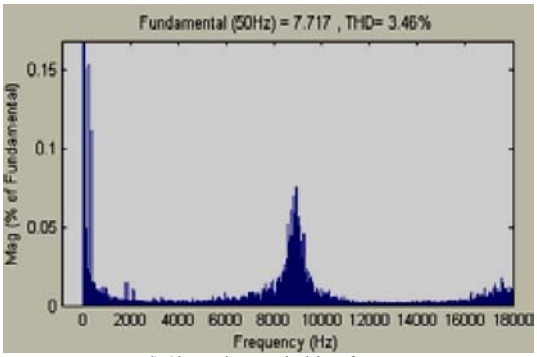


b) 8k fixed switching frequency

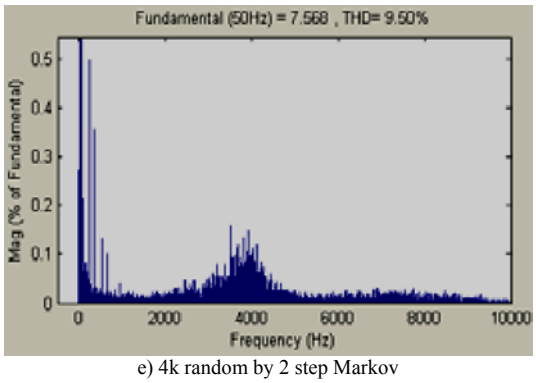


c) 4k random switching frequency

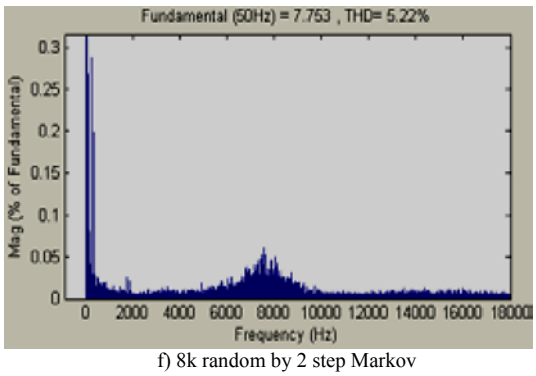
Figure 5 continues on the next page.



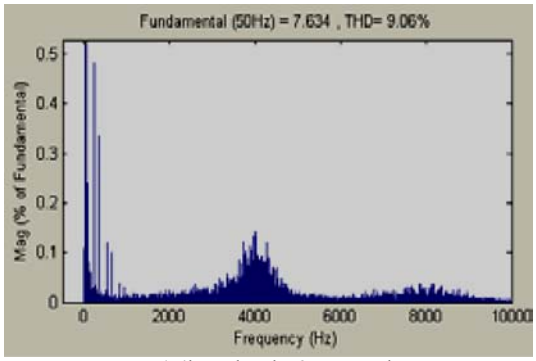
d) 8k random switching frequency



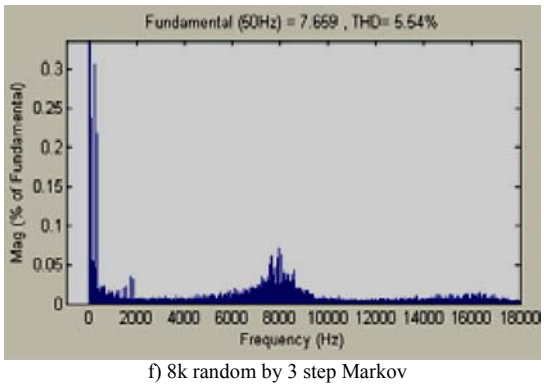
e) 4k random by 2 step Markov



f) 8k random by 2 step Markov



e) 4k random by 3 step Markov



f) 8k random by 3 step Markov

Figure 5. Experiment Analysis.

Although random variable-frequency population aging prediction technique is a feasible method, this solution also has some problems in real application. Problem that will inevitably produce multiple random numbers that are consecutive greater than mathematical expectation or consecutive less than mathematical expectation can make harmonic amplitude still maintain high. Regarding of these problems, the data analysis proposes a more effective method that is random variable-frequency population aging prediction. So that the Copula function model is more accurate and reliable.

V. CONCLUSION

The rapid development of aging population can not only increase the social burden, but also increase the family burden. If the population aging continues to intensify in the future, retired and retiring persons in the proportion of the population will continue to increase, the endowment insurance fund expenditure gap will also become bigger and bigger, it will certainly bring social security institution a huge pressure, which will greatly affect the social security level and the improvement of social security scope expansion, and increase workers' economic burden, and ultimately it will affect the sustainable development of society. Copula function has a good nonlinear mapping approximation performance, and it has been widely applied in all kinds of prediction. Copula function is comparatively fast in learning speed and able to avoid local minima, so its predictive value is more close to the true one. Regarding of these problems, the data analysis proposes a more effective method that is random variable-frequency population aging prediction. The result showed that the Copula function model was more accurate and reliable.

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