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# Parametric reforms in the PAYG pension fund using automatic balancing mechanisms (a case study of Iran Social Security Organization)

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**Abstract**

The phenomenon of population ageing and non-compliance with the existing laws of the social security pension fund is a great threat to the financial stability and existence of this fund, which indicates the need to correct it even more. This research aims to present the optimal strategy of parametric reforms in the form of different hypothetical scenarios for the reforms of contribution rate, retirement age, and replacement rate reduction in the framework of automatic balancing mechanisms. The data analysis and collection are based on the optimization results of the non-linear model in the MATLAB software environment using ultra-heuristic algorithms of crystal structure and particle swarm. The findings of the research indicate that restoring the stability of the fund in the future 20-year horizon requires a gradual increase of 9 years in the effective retirement age. But this process can be combined with a policy of increasing the contribution rate by 9% or reducing the replacement rate, only requiring an increase of 5 years in the retirement age. Therefore, adopting the policy of reducing the replacement rate and gradually increasing the contribution rate, along with increasing the retirement age, will reduce the trend of increasing the retirement age in order to maintain the stability of the fund.

Keywords: pension system, parametric reforms, automatic balancing mechanisms, nonlinear optimization
2020 MSC: 90C30, 65Kxx

## 1 Introduction

The social security pension fund, covering more than half of the country's population, plays an essential role as one of the main players in the field of social welfare. In recent years, the continuous decrease in the dependency ratio, lack of liquidity to pay current pensions and reliance on bank facilities and pressure on employers to cover the deficit have indicated the emergence of a crisis in this field. Undoubtedly, non-scientific decision-making and non-use of scientific mechanisms, as well as the influence of the government's economic policies and approval of laws without financial burden caused by the implementation by the legislator, have not been ineffective in the financial instability of the fund.

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Due to the emergence of financial instability and the reduction of the effectiveness of traditional social security systems in the world, in order to reduce the obligations of pension funds, extensive reforms and annexations have occurred in other countries. According to the latest report of the OECD Economic Cooperation and Development Organization in 2020, the average retirement age in OECD countries for a full-time worker is 63.4 years for women and 64.2 years for men. Despite the high average retirement age, one of the main reform policies of these countries in recent years has been to increase the retirement age. Meanwhile, Iceland and Norway have the highest normal retirement age of 67 years. Also, the policies aimed at increasing the normal and early retirement age in the future plan of OECD countries and achieving the average normal retirement age of 66.1 years for men and 65.5 years for women can be seen. Meanwhile, the effective retirement age (the average age of a person at the time of retirement) in the social security fund is around 56 years. The life expectancy index among OECD countries is about 80 years on average, and in Iran for the same year of 2020, it is 74.76 years; in this field, we see only a three-year difference. But the effective retirement age difference in the country is much higher compared to other countries. The comparison of these figures for Iran and other countries is very interesting. Concerning the aforementioned, the root of the current crisis can be found in several key factors, such as the phenomenon of population ageing, the low normal retirement age compared to the life expectancy in the country, the generous formula for determining the retirement pension, the existence of day-to-day thinking and lack of foresight. Postponing the problems to the future by the managers, inappropriate economic conditions of the country in the past few decades and the pressure on the resources and expenses with the increase in the age of the fund. The effects of these problems not only in the social security fund but also in other social insurance funds of the country have become tangible to such an extent that in the sixth development plan, serious emphasis has been placed on solving them. 4.22 million primary pensioners and 25.7 million secondary insured persons cover a total of 46 million people in the country. This is despite the fact that the country's largest social insurance organization has faced serious problems in its financial balance in recent years and has passed the breaking point. The liquidity gap created since its occurrence in 2013 equals 1.641 billion Tomans (One toman is equivalent to 10 rials), has been increasing annually, and according to the report of the organization's Statistics and Computing Technology Centre, it is expected to reach 390.045 billion Tomans by 2028. The table 1 shows this well.

Table 1: Indicators of income, expenses and surplus (deficit) in the social security fund [27]

| **surplus (deficit)** | **Expenses** | **Income** | **Year** |
|---|---|---|---|
| 193743 | 159425441 | 159619184 | 2012 |
| (4929493) | 211500205 | 206570712 | 2013 |
| (42317108) | 290114695 | 247797587 | 2014 |
| (64579538) | 404877090 | 340297552 | 2015 |
| (94036319) | 518159490 | 424123171 | 2016 |
| (79912828) | 625809878 | 545897050 | 2017 |
| (97327656) | 735780559 | 638452903 | 2018 |
| (35002165) | 881577175 | 846575010 | 2019 |
| (100930068) | 1083887697 | 982957629 | 2020 |
| (150142400) | 1513292354 | 1363149954 | 2021 |
| (217003224) | 2244201315 | 2027198091 | 2022 |

The purpose of this research is to examine the current situation of the social security pension fund and provide solutions to improve the parameters with the goal of financial stability in mind. Considering that the aforementioned reforms require a coherent and comprehensive theoretical framework and support; Also, until now, an extensive study has not been done to provide possible strategies to modify the retirement age, contribution rate and pension adjustment rate according to the future demographic structure of the country, focusing on the scenarios proposed in this research. Therefore, it is hoped that the current research can create a different attitude to carry out these reforms in the social security system and be useful.

The social security pension fund is facing many problems after reaching maturity and passing the break-even point, and it is expected that the intensity and depth of these problems will increase in the coming years. There is no way to overcome this problem without reforms, but it should be noted that reforming the pension system is a completely redistributive issue, and therefore, it always has winners and losers who cannot compensate for their losses, and this is an important issue. For example, any increase in the contribution rate or modification of the generous pension calculation formula alone can lead to protests and strikes by stakeholders such as employers and pensioners. For this reason, the reforms of the pension system must be accompanied by political considerations. And therefore, the simultaneous combination of different scenarios may have fewer consequences. Therefore, different hypothetical scenarios can be proposed for reforms: First case: the fund decides to modify only the contribution rate and the

retirement age and the pension adjustment rate. In this case, what are the optimal values of each of the mentioned parameters to achieve financial stability? The second case: if the contribution rate is kept constant at the current values, what will be the optimal values of the retirement age and the pension adjustment rate to achieve financial stability? In the third case, if, in addition to the fixed contribution rate, the reduction of the replacement rate is also on the agenda, then what will be the optimal values of the retirement age correction and the pension adjustment rate? If it is one of the forecasts, then what should be the amount of change in the optimal retirement age and the pension adjustment rate to ensure the financial stability of the fund? The present research seeks to provide possible solutions in the framework of the parametric reforms of the social security pension fund by answering the above questions, and providing policy recommendations regarding the parametric reforms and restoring stability of the pension fund.

## 2 Literature review and research background

In the course of economic thought, existing literature in the field of social security is defined under the duties of the welfare state. In Kuper's [17] view, the welfare state means the existence of thoughtful and intelligent policies in the field of providing at least the minimum standard of living for everyone and promoting equality in life opportunities, and there is no doubt about the necessity of focusing all the attention of all official institutions on the provision of public services. In fact, the reason for the creation of social security by governments is that markets have failed to cover many important risks faced by individuals.

Therefore, the issue of retirement and support for the social strata in the framework of the social security law has been assigned to the governments. According to Article 76 of this law, the retirement age is generally set at 60 years for men and 55 years for women, and this age can be changed in certain circumstances. The main duties of this organization, according to the social security law approved in 1976 and its amendments, are the collection and concentration of contribution funds as well as the income from the investment of resources and assets, the implementation of the obligations stipulated in the social security law, including the payment of benefits and short-term and long-term pensions and also providing direct and indirect medical services, management and investment of the organization's reserves. According to Article 2 of the Social Security Law, contributions are the funds that are paid to the organization for using insurance benefits. The social security organization collects different types of contribution rates from the insured in different businesses. These differences are due to the fact that some jobs receive government assistance and also the difference in the obligations of each type of contract. The income from contributions is the most important and main source of income of the social security organization. Any increase in the organization's income, especially contributions, leads to the financial stability of the pension fund. The major part of the Social Security Organization's income is used to finance long-term obligations, and almost a third of the income is used to provide medical services to the insured [1]. The structure of the social security pension fund is a Pay-As-You-Go Defined Benefit pension system. In this type of pension system, the benefits paid to the current retirees are financed from the contributions received from the current employees, and in return, the current employees are guaranteed that their pension benefits will also be passed down from generation to generation. In order to preserve the resources of the fund for the use of future generations and also to fulfill their obligations, according to the future population structure of the country, the managers of the fund should choose strategies that ensure the stability of the fund's financial situation in the future periods.

### 2.1 Persian studies

Dashtban et al. [5] shows the effects of systematic reforms on macroeconomic variables and evaluates the effects of these reforms on the aforementioned variables as favorable in the long term. According to his findings, the situation of income distribution does not necessarily improve with systematic reforms of the pension system. Raghfar and Akbarbeygi [22] estimate the effect of parametric modification of replacement rate change. According to this study, reducing the replacement rate by affecting economic indicators leads to an increase in the number of employees and social security fund inputs, and the financial balance of the fund is restored. Jafari et al. [14] have examined the distributional and welfare effects of systematic reforms in their study. Their findings show that with the applied reforms, the consumption of all generations increased and the savings of individuals and consequently the accumulation of capital decreased, the final result of these developments is the reduction of production at the level of the entire economy. Based on this and due to the widespread stagnation in the country's economy, it is recommended that policymakers do not act hastily in the field of structural reforms of the pension system, i.e. transition to the savings system. Mehdipoor [19] has shown in a study that if no reforms are made in the pension system, in 2090 the ratio of pension payment expenses to contribution income will be almost 4 times. This research predicts an upward trend for contribution rates and retirement ages in the next 75 years. Bahmani et al. [2] examines the effect of reducing the

replacement rate on macroeconomic variables. Their study shows that the aging of the population can increase the cost of the pension system by 7%. A 20% reduction in the replacement rate can lead to a 2% reduction in the cost of the pension system. Pakravan and Khoshnevis [21] show in their study that the effect of variables of life expectancy and population dependence on the organization's financial stability index is negative in the short and long term, and therefore, according to the increasing trend of life expectancy, the duration of benefiting from pension benefits increases. The increase in the aging of the population also leads to a decrease in the supply of labor and a decrease in income from contributions for pension systems. Therefore, the social security organization will face a financial instability in the future, and in order to protect the organization from the negative consequences of population aging, the people in charge should follow the population increase policies and also the serious determination of the social security organization to move towards a full saving system for the long term. Golab and Bazzazan [10] has shown in a study that if the current conditions continue, the social security pension system will suffer an increasing deficit in the coming years, so that in 2092 the contributions should increase by 59%. However, by applying parametric reforms, the financial stability of the system can be maintained until 2054, and the system stabilizing contribution rate will reach 25.5% in 1470. By applying parametric reforms, it is possible to delay the occurrence of the social security organization's deficit, but the system cannot be kept stable in the long term, and complementary reforms are needed. Mohagheghzadeh et al. [20] in a study focusing on parametric reforms using group psychology show that the challenges facing the social security organization are generous pension formula, low retirement age and non-payment of government share contributions. and proposes reforms in the form of reforming the pension formula and increasing the retirement age. Farhadi [6] showed that the increase in the retirement age and the contribution rate can delay the break-even point in the coming years. And by applying parametric reforms, it is possible to delay the occurrence of a deficit in the organization, but in the long term, complementary solutions should be adopted.

### 2.2 Foreign studies

International studies about pension funds have often paid attention to the issue of financial instability of funds and highlighted the need for reforms. In this regard, Feldstein [7] argues that the increase in life expectancy and the aging of the population threaten the financial resources of pension systems based on PAYG (Pay-As-You-Go) balance due to the low retirement age and high replacement rate. Hagemann and Nicolleti [12] and Dang et al. [4] in their study for the countries of the Economic Development Cooperation Organization showed that the phenomenon of population aging in these countries leads to a decrease in investment, economic growth and savings, and on the other hand, a decrease in the financial stability of financial systems. Retirement is based on income-expenditure balance. Haberman and A. Zimbidis [11] developed a method using optimal control techniques and a contingency fund, and using linear functions to calculate retirement pensions and income and wages subject to deduction of contributions, a method for predicting the optimal values of contribution rates and retirement age. They provided retirement within a certain period of time. Whiteford and Whitehouse [26] showed that OECD member countries are experiencing a strong trend of population aging and the proportion of people over 65 years old will double from the current situation between 2000 and 2050. They enumerate the dominant common feature of the reforms in OECD countries as follows: First, the conditions for pension entitlement have become more difficult. Second, they have been less generous in adjusting pension benefits. Third, some pension schemes have linked the level of pension benefits to life expectancy. Finally, a number of countries have chosen pension plans based on defined contribution. Vidal-Meliá et al. [25] describe the benefits of the automatic balancing mechanism as a method for parametric reforms in PYAG pension systems. Based on this approach, a set of predetermined scales is introduced as a law, which is repeatedly applied whenever the system needs reforms according to the financial stability index. The meaning of automaticity is that this mechanism is applied even if politicians do not make decisions and make laws in critical situations. The purpose of successive use is to re-establish the financial balance and determine the values of the necessary parameters of the system for long-term plans and by guaranteeing the stability and liquidity of the system. D'Addio and Whitehouse [3] study the role of automatic balancing mechanisms in OECD countries and the European Union. They designed a review and mechanism with the ability to adjust the pension calculation formula, evaluate the contribution rate to carry out reforms and adjust pensions. They argue that the speed of parametric reforms and the limit of increasing the parameters of contribution rate and retirement age are socially and politically important. Reforms should be done slowly and over a period of about 20 years, and the limits of the parameters should be determined in terms of the wealth of the society in such a way that the minimum pressure is imposed on the society and intergenerational justice is also considered. Godínez-Olivares et al. [8] in a study using linear dynamic programming, designed a mechanism for system stability and predicted the optimal values of contribution rate and retirement age and pension adjustment rate. Godínez-Olivares et al. [9] in another study using non-linear optimization to design two automatic balancing mechanisms to maintain the financial stability of a PAYG pension system by determining the optimal rate of its main parameters such as contribution rate, normal retirement age and fund adjustment rate. Lisenkova and Bornukova

[18] show that Belarus currently has a relatively generous pension system of the income-expenditure type, which the aging population and recent economic problems lead to instability. Their simulation of the pension system using the overlapping generations model shows that by the end of 2055, the deficit of the pension fund will increase to about 9% of the country's GDP. Therefore, they recommend parametric reforms, such as reducing pension benefits, increasing the retirement age to 65 years, as a solution to deal with the financial instability of the fund.

In the framework of the aforementioned theoretical and empirical discussions, in order to restore and maintain the financial stability of the PAYG retirement system, the studies conducted in this field often introduce structural reforms, including solutions to overcome the aforementioned crisis, and another solution is parametric reforms in these funds. they know. Structural reforms are a general change in the financing method of the annuity plan, the most common form of which is the change from an PAYG plan to a full or combined savings plan. But the parametric reforms include amending the rules and regulations related to the entry and exit of people to the fund and the factors affecting the resources and expenses of the fund in the form of increasing or decreasing the contribution rate, adjusting retirement benefits, increasing the retirement age, etc. It is noteworthy that in most of the articles, structural reforms have been considered as a long-term solution and parametric reforms as a short-term solution. From this point of view, reforms of any kind will have significant micro and macro-economic effects, and making decisions without considering them is far from economic rationality. Therefore, making a decision regarding reforms requires paying attention to the effects and consequences of each of the methods with reference to actuarial calculations and experiences of other countries. As it can be seen, so far in domestic studies, the issue of developing a strategy for reforming social security pension fund parameters such as contribution rate, retirement age, and pension adjustment rate in terms of changing the replacement rate in the framework of automatic balance models has not been addressed.

## 3 Model specification

Using the automatic balancing model through the simulation of the stable state of the fund, this research proposes a framework for the gradual reforms of the contribution rate, retirement age and pension adjustment rate in the leading periods in order to achieve the main goal, which is the financial stability of the pension plan. In the framework of this method, using the future structure of the population and forecasting the income and expenses of the system, the optimal paths of the main parameters of the pension fund, including the contribution rate and retirement age, the pension adjustment rate and the liquidity index of the fund for the leading time periods in order to maintain the financial stability and balance of the fund It is simulated. The model proposed by Godínez-Olivares et al. [8] was proposed to analyze the status of the pension plan of the income-expenditure type and since the social security pension fund is also based on this structure, therefore, the present research has benefited from the mentioned method with little interference.

### 3.1 Optimization techniques in a PAYG pension system

In the problem of optimizing the parameters of contribution rate, retirement age and pension adjustment rate in the pension fund with PAYG structure, we are faced with a non-linear model. In general, in a nonlinear optimization problem, the decision variables are expressed as the following vector:

$$\{d\}_n = \{d_n^0, d_n^1, ..., d_n^v\} \in D \tag{3.1}$$

$D \in R^n$ is the decision space and $n$ is the number of periods. where $n \in N$ and $v$ are the number of variables involved in the model. In an PAYG pension system, the decision variables are:

$$d_n^j = (c_n^j, x_n^{((r)j)}, \lambda_n^j) \tag{3.2}$$

$\{c\}_{n\in N}$ is The vector of contribution rate, $\{x^{(r)}\}_{n\in N}$ is the vector of retirement age, $\{\lambda\}_{n\in N}$ is the vector of pension adjustment rate and $n$ is the number of periods and each period is equivalent to one year.

The function $f_n(d_n^j, n)$ which is known as the objective function of the nonlinear optimization problem is expressed as a minimization function. The set of possible answers is:

$$F = \{d_n^j \in D | h_k(d_n^j) = 0, \quad k = 1, ..., l, \quad g_j(D) \leq 0, j = 1, 2, ..., , m\} \tag{3.3}$$

where $h_k$ defines linear constraints, on the condition that $l$ is $k = 1, ..., l$ and $g_j$ defines nonlinear constraints on the condition that $m$ is $j = 1, ..., m$. Limits are defined as upper and lower limits and the rate of change of key variables in time, as well as liquidity limits.

If $d^*$ is able to minimize $f$ (or maximize), then $d^*$ is known as the optimal solution of the nonlinear optimization model. otherwise, the nonlinear optimization will not have a possible solution. If then $F = \phi$ there is nothing that minimizes (or maximizes) the objective function. In order to solve the nonlinear optimization problem in this research, we use meta-heuristic optimization algorithms of crystal structure and particle swarm. Meta-heuristic optimization algorithms are widely used in solving non-linear problems and are able to calculate solutions with high accuracy.

### 3.2 The actuarial balance (AB)

Before describing the Actuarial balancing model as the objective function, first We should define the resource-consumer gap parameter with sign $F_n$. The resource-consumer gap is also referred to as contingency fund because it often has a positive value. In pension funds, the excess resources of the fund are often allocated to investment as a precautionary reserve to cover unexpected future risks. Parameter $F_n$ define as below.

$$F_n = (1 + J_n)F_{n-1} + c_n W_n(g_n, x_n^{(r)}) - B_n(g_n, x_n^{(r)}, \lambda_n), \tag{3.4}$$

contingency fund ($F_n$) consists of the difference of pension expenses from the sum of the principal and the precautionary reserve of the previous period and the contribution income of the current period. These reserves, along with the profit from its investment, if properly managed, can have a beneficial effect in neutralizing adverse economic and demographic shocks to the fund.

In relation (3.4) $c_n$ is Contribution rate throughout the year. $W_n$ is the total salary paid during the year and that is the source of receiving contributions during the year. which is a function of the wage growth rate $g_n$ at the period $n$ and retirement age $x_n^{(r)}$ during $n$.

$B_n$ is the total expenditure of pension payment during the $n$. which is a function of the wage growth rate ($g_n$). $x_n^{(r)}$ is retirement age and $\lambda_n$ is pension adjustment rate. To obtain total annual salary values $W_n$, the source of receiving the contribution in each period, since $W_n(g_n, x_n^{(r)})$ is a function of retirement age and pension adjustment rate. The total expenses of the salary for receiving the contribution for each period are obtained as follows:

$$W_n = \left( \sum_{x=x_e}^{\lfloor x_n^{(r)} \rfloor - 1} 1_{x,n} * wage(x) * (1+g)^n \right) + \left( x_n^{(r)} mod \lfloor x_n^{(r)} \rfloor \right) l_{\lfloor x_n^{(r)} \rfloor, n * wage(\lfloor x_n^{(r)} \rfloor)(1+g)^n} \tag{3.5}$$

where $x_e$ is the age of entering the labor market and that is assumed to have a uniform distribution throughout the year, and $wage(x)$ is also the average salary of each age category. $\lfloor x_n^{(r)} \rfloor$ is Floor Function, which this operator is used to round real numbers down (to the nearest integer or any integer multiple of an arbitrary number). $x_n^{(r)} mod \lfloor x_n^{(r)} \rfloor$ is the operator outside the division is the remainder of the division $x_n^{(r)} / \lfloor x_n^{(r)} \rfloor$ calculates Annuity cost modeling. calculating $B(n)$ is a little more complicated. Because the pension adjustment rate $\lambda_n$ is a dynamic variable over time. Pension payment expenses in the first year $n = 1$ is defined as the following relationship:

$$B_n = \left(1 - \left(x_n^{(r)} mod \lfloor x_n^{(r)} \rfloor\right) l_{\lfloor x_n^{(r)} \rfloor, n}\right) * P_{\lfloor x_n^{(r)} \rfloor, n} + \sum_{x=\lceil x_n^{(r)} \rceil}^{\omega} P_{x,n} l_{x,n} \tag{3.6}$$

where $\lceil x_n^{(r)} \rceil$ is the ceiling Function, which this operator is used to round numbers up. It is also the age when a person can live. Venice $P_{x,n}$ is obtained as follows:

$$P_{x,n} = P_{x-1,n-1} * (1 + \lambda_{n-1}) \tag{3.7}$$

Finally, using the above relationships, the objective function is defined as follows:

$$\min_{c_n, x_n, \lambda_n} \sum_{n=0}^{N} \frac{F_n(c_n, g_n, x_n^{(r)}, \lambda_n, J_n)}{(1+\delta)^n}$$
$$S.t = \begin{cases} c_{\min} \le c_n \le c_{\max}; \quad x_{\min}^{(r)} \le x_n^{(r)} \le x_{\max}^{(r)}; \quad \lambda_{\min} \le \lambda_n \le \lambda_{\max}; \\ c_{1\Delta} \le \frac{c_{n+1}}{c_n} \le c_{2\Delta}; \quad x_{1\Delta}^{(r)} \le \frac{x_{n+1}^{(r)}}{x_n^{(r)}} \le x_{2\Delta}^{(r)}; \quad \lambda_{1\Delta} \le \frac{\lambda_{n+1}}{\lambda_n} \le \lambda_{2\Delta}; \\ F_n \ge 0. \end{cases} \tag{3.8}$$

in relation (3.8), $\delta$ is discount rate and a non-negative non-zero number.

$c_{\max}, x_{\max}^{(r)}, \lambda_{\max} \in R$ and $c_{\min}, x_{\min}^{(r)}, \lambda_{\min} \in R$ are also defined as the upper and lower bounds of the main variables. Phrases $x_{1\Delta}^{(r)} \leq \frac{x_{n+1}^{(r)}}{x_n^{(r)}} \leq x_{2\Delta}^{(r)}$, $c_{1\Delta} \leq \frac{c_{n+1}}{c_n} \leq c_{2\Delta}$, and $\lambda_{1\Delta} \leq \frac{\lambda_{n+1}}{\lambda_n} \leq \lambda_{2\Delta}$ by specifying the upper and lower limits allowed to change each variable during each period in order to avoid jumping the optimal values of age variables and contributions and adjustment rates are necessary. So that $c_{1\Delta}, c_{2\Delta}, x_{1\Delta}^{(r)}, x_{2\Delta}^{(r)}, \lambda_{1\Delta}, \lambda_{2\Delta} \in R$. $J_n$ represents the rate of return of assets during the year $n$. In this model, the liquidity condition for each period, in order to ensure the provision of liquidity for each period in the form of $F_n \geq 0$ apply. Finally, the liquidity index, which shows the ratio of resources to expenses, is defined as follows:

$$Lf_n = \frac{(1+J_n)F_{n-1} + c_n W_n(g_n, x_n^{(r)})}{B_n(g_n, x_n^{(r)}, \lambda_n)} \tag{3.9}$$

## 4 Data and assumptions

Simulation of the future situation of the pension fund requires knowledge of the future structure of the population. Therefore, in order to predict the amount of population covered by the organization, the data related to the population outlook for Iran taken from the "United Nations" database and the reports [15, 16, 23, 24] of the "Higher Social Security Research Institute" [13] and the "International Labor Organization" report were used in this research. In order to predict the amount of resources and expenses of the organization, from the place of payment of contribution and pension, the statistical reports of the database "Statistical Data and Information and Calculations of the Social Security Organization" have been used. The penetration rate of social security based on the total population of Iran is assumed equal to 65% and the research time span includes a period of 20 years from 1401 to 1420. According to the proposal of the International Labor Organization, the wage growth rate based on the annual contribution deduction of 12% and the rate of return on the excess capital of the reserve fund is considered to be approximately equal to the average long-term interest rate of the country's banks, 15%. The contingency fund for the base year 1401, according to the estimate of the organization's statistics management, is equal to 115,270 billion tomans, due to borrowing from the banking system and the existence of a resource deficit with a negative sign. Considering that in each period, a percentage of the employees of the insurance payer become unemployed and leave the category of insurance payers; Therefore, based on the probability of unemployment in each period, these people are removed from the total number of employees of the insurance payer. The minimum age to enter the active population group is 20 years. The laws that lead to the difference in the retirement criteria for men and women and the amount of history, which are parameters for calculating the retirement pension, have been ignored. The lower limit for the contribution rate is 18%, the retirement age is 56 years, and the pension adjustment rate is 5%, and the upper limit for the mentioned indicators is 30%, 69 years, and 40%, respectively. The annual limit of changes in the contribution rate is between 1% and 5% for the retirement age between 4 and 12 months and for the pension adjustment rate between −10% and +40%.

## 5 Solving the model and adjusting the coefficients

### 5.1 Scenario one: optimal values of fund parameters in case of simultaneous modification of contribution rate, retirement age and pension adjustment rate

In the first case, assuming that all three parameters of contribution rate, retirement age and pension adjustment rate are variable, we extract the optimal values. Figure two shows the results of the automatic balancing mechanisms for the social security organization for the next 20 years under the assumptions of the first case. In this scenario, in order to achieve the goal of fund stability, all three variables of the fund are allowed to fluctuate. The results of automatic balance pattern optimization with two methods of crystal structure and particle swarm are shown in Figure 1.

The trend of the graphs in both methods shows that the optimal path of the contribution rate parameter has an upward trend and reaches a rate of 27% with a relatively constant slope until 1420. The normal retirement age will also reach 61.02 and 61.8 in crystal structure and particle swarm methods with a similar trend in the next 20 years. The pension adjustment rate shows a downward trend with a low slope, figures around 5%. Under this scenario, within 20 years, the contribution rate should be 9%, the retirement age will increase by 5 years, and the equilibrium rate of pension adjustment will be around 4-5%. Through the data in the table, it is easy to infer the minimum value of the parameters in each period so that the liquidity of the fund is not jeopardized.

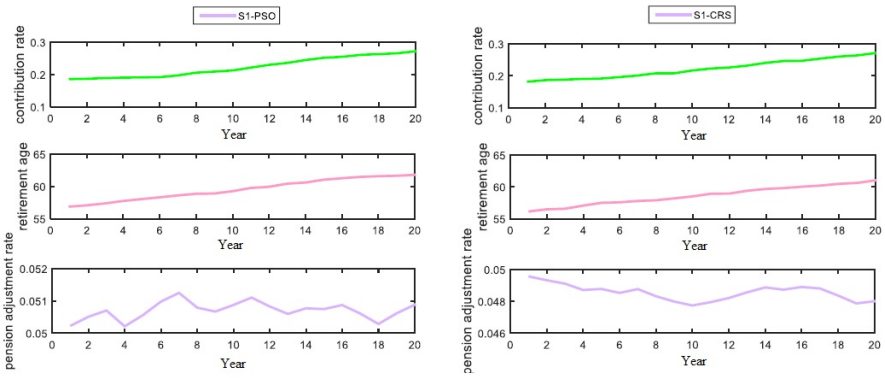


Figure 1: Optimal paths based on in scenario one

### 5.2 Scenario two: extracting the optimal values of the retirement age and the pension adjustment rate with the condition that the contribution rate is fixed

In this case, it is assumed that it is not possible to change and modify the current contribution rate for some reason, and therefore, reforms should be made without changing the contribution rate. Therefore, we keep the contribution rate fixed and only two parameters, retirement age and pension adjustment rate, have the right to fluctuate as variables. Figure 2 shows the results of the ABM model in the second state with two methods of crystal structure and particle swarm. The results show that under this scenario, in order to maintain the stability of the fund, the equilibrium values of the retirement age are higher than the first case of the previous trend and show higher values. Under this scenario, the normal retirement age at the end of the period in crystal structure and particle swarm methods reaches 64.86 and 64.23, respectively. The pension adjustment rate has also taken a downward trend and shows values between 5 and 4.5%. Under this scenario, in the next 20 years, in order to maintain the fund, the normal retirement age should increase by 9 years.

Compared to the first scenario, the second scenario may seem favorable from the employers' point of view because the contribution rate is fixed, because the increase in the contribution rate (in the first scenario) is considered to impose a greater financial burden on the workshops and is considered an anti-production measure. On the other hand, the second scenario may not look favorable from the point of view of insured persons who tend to retire earlier due to the fact that the retirement age is growing more. Therefore, the choice of each scenario can be different depending on which group's interests the policy maker considers preferable.

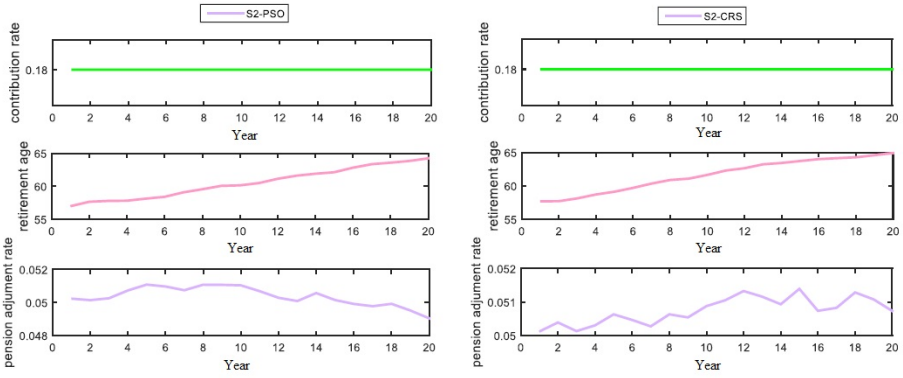


Figure 2: Optimal paths based on scenario two

### 5.3 Scenario three: optimal values of retirement age and pension adjustment rate with fixed contribution rate and reduction of replacement rate

The third situation is considered by combining the conditions of the previous situations with the assumption that both the contribution rate remains constant and the replacement rate decreases by 10%. Figure 3 shows the estimation results under this scenario.

In this case, reducing the replacement rate can improve the liquidity index by reducing the pressure on the organization's expenses, and therefore put the optimal paths of the contribution rate and retirement age parameters in a lower position. Alternative compared to the second case, which only assumes the contribution rate to be fixed, the trend of retirement age is placed in a lower position and shows a lower growth for it. Under this scenario, at the end of the retirement age in crystal structure and particle swarm methods, it reaches 60.93 and 60.67, respectively. The pension adjustment rate also fluctuates with an almost constant slope of 5%. Therefore, if the increase of the retirement age has severe psychological effects on the society lonely (the second case), combining it with the policy of reducing the replacement rate (according to the third case) can have a more favorable result. However, the reduction in the purchasing power of the retired community following the reduction of the merit pension should be planned in another way. Reducing the replacement rate means reducing the ratio of the individual's merit pension to the average salary of the last years of employment. If the pension averaging period is longer. The replacement rate will decrease further. Currently, the way pension is paid in the social security fund is in conflict with the concept of actuarial fairness. Because a person's entitlement pension is not only calculated based on his earnings during all the years of employment, but it is calculated only by averaging the salaries of the last two years of the person's employment. This issue has also led to some abuses. These abuses include the declaration of unusual receipts by employers and insured persons during the last two years of employment, which is done in order to receive more pension. From this, the reduction of the replacement rate, which is the result of increasing the average period of the entitlement pension, can make actuarial fairness possible to some extent. Therefore, if the policy maker's goal is to establish justice in payment and achieve actuarial fairness. It can reduce the replacement rate by increasing the averaging interval.

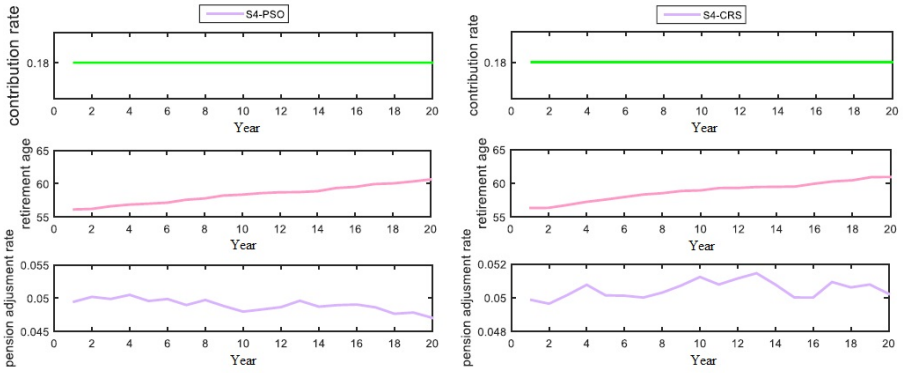


Figure 3: Optimal paths based on scenario three

### 5.4 Scenario four: Optimizing the values of retirement age and pension adjustment rate assuming stability of contribution rate and reduction of replacement rate and changes in dependency ratio (sensitivity analysis of dependency ratio)

The basic assumptions of this mode are similar to the previous mode; The contribution rate is fixed and the replacement rate is reduced by 10%, plus the population structure is different and the dependency ratio actually changes. Figure 4 shows the results of the estimation of the ABM model in the framework of the assumption of scenario four. The red graph shows the effect of a 10% decrease in the support ratio and the blue graph shows the effect of a 10% increase compared to the previous state (green graph). The fourth mode with sensitivity analysis of the support ratio shows that in the state of increasing the dependency ratio, the retirement age in crystal structure and particle swarm methods reached 59.04 and 59.9, respectively, and in the case of decreasing dependency ratio in crystal structure and particle swarm methods, it reached 62.98 and It reaches 63.1. The increase in the dependency ratio is equivalent to the improvement of the fund's situation and the process of reforming the pension rate is lower than before (blue line). A decrease in the support ratio is equivalent to a weakening of the fund's status and shows the correction process higher than the previous state (red line). Regarding the pension adjustment rate, it is completely the opposite. An increase in the support ratio and an improvement in the fund's condition indicate higher rates, and a decrease in the dependency ratio indicates lower equilibrium rates. The result of this observation shows how factors affecting the structure of the population, such as life expectancy, health, etc., can affect the stability of the fund and the optimal amount of retirement age.

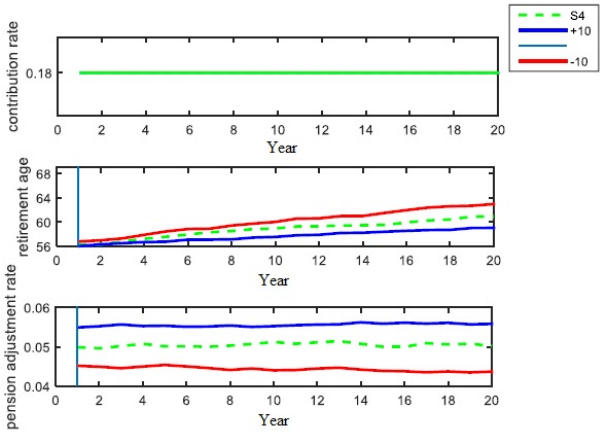


Figure 4: Sensitivity analysis diagram of the dependency based on scenario four

## 6 Model evaluation

In this section, the actuarial automatic balancing mechanisms was estimated in different situations. The results of the evaluations showed that maintaining the financial stability of the fund in the future depends on the modification of the fund's parameters such as the contribution rate, retirement age, pension adjustment rate, and replacement rate. Keeping the contribution rate constant requires a further increase in the effective retirement age in order to maintain the stability of the fund. Reducing the replacement rate along with increasing the contribution rate and retirement age in order to achieve the stability of the fund can reduce the severity of the two parameters of the contribution rate and retirement age. The sensitivity analysis of the dependency ratio shows that changes in the structure of the population, such as the youth of the population, due to the increase in the rate of the working population and the resulting increase in the dependency ratio, can have a positive effect on the process of modifying the parameters by reducing the rate of increase in contributions and retirement age, and vice versa.

## 7 Conclusion

With the emergence of the phenomenon of population ageing, restoring the stable status of the social security pension fund has become the daily discussion of politicians and economists. In such a situation, there are two basic solutions in front of the policymaker. The first solution is parametric reforms, and the second solution is systematic reforms. As it was argued, the basic solution to achieve a stable situation is to carry out systematic reforms. But systematic reforms are a time-consuming process, and their outcome is not visible in the short term. In other words, systematic reforms are not the solution to the current problems of the Fund. Therefore, managers are forced to make parametric reforms in order to find a solution to finance the obligations of the fund. Parametric reforms in the short term can provide the basis for systematic reforms and buy time. Undoubtedly, reforms of any kind will have significant micro and macro-economic effects, and making decisions without considering them is far from economic rationality. Therefore, deciding this matter requires paying attention to the effects and consequences of each of the methods with reference to actuarial calculations and experiences of other countries.

Therefore, the current research aims to provide suggestions and solutions for performing parametric reforms in order to restore and maintain the stability of the fund, during the next 20-year period, within the framework of the ABM model with two optimization methods under innovative algorithms of crystalline structure and particle swarming in a soft environment. MATLAB software was provided.

In the models specified in the present study, in order to simplify the model, the discussion and examination of the optimal values of the replacement rate and the rate of belonging have been omitted. Therefore, investigating these conditions and their consequences can be the subject of future research. By applying parametric reforms, such as increasing the contribution rate, increasing the retirement age, and reducing the replacement rate, it is possible to delay the occurrence of the social security organization's deficit, but the system cannot be kept stable in the long term, and complementary reforms are needed. Therefore, it is suggested that future studies focus more on how to transfer from the current system to alternative systems.

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