PREDICTING THE DEVELOPMENT OF VOLUNTARY PENSION FUNDS IN SERBIA BY APPLYING THE MATHEMATICAL METHOD OF LINEAR REGRESSION

Ivan D. Radojkovic
"Dunav" voluntary pension fund management company, Nis, Serbia

Boban Gajic
"Dunav insurance", a.d.o. Belgrade, Serbia

Branislav Randjelovic
University of Nis, Faculty of EE, Nis, Serbia

ABSTRACT

The introduction of private pension funds, which operate with the state pension fund, is the essence of the reform of the pension system in Serbia. Private pension funds are based on voluntary benefits. Thus, the functioning of the pension system takes place in three interconnected processes: payments to a voluntary pension fund, investment of free funds, and ultimately programmed payments – pensions. Stability in the voluntary pension funds and predictability of payments allow the quality of investment portfolio to be formed and achieve a long-term yield of investment. In this work we implement the method of least square approximation for data processing and a mathematical method of linear regression, which give a link between the observed size, in our case, the number of fund members, the average salaries in Serbia and the size of Fondex, and to be used to predict the number of fund members depending on other sizes. Based on the data obtained by approximation function we can estimate number of fund members, in dependence of average salary and size of FONDEX.

Keywords: *pension system, voluntary pension funds, linear regression*
JEL: *C38, G11, G23, J32*

1. INTRODUCTION

The reform of the pension system in Serbia, which has been going on for years, is yielding results because the state participates in the financing of pensions, where the average state pension was 26,738.00 RSD in February 2018[1]and 28,216.00 RSD in February 2019[2].Mandatory and voluntary pension insurance operates in Serbia. The pay as you go financing system can work well if the national economy is on the rise and when the number of employees is significantly higher than the number of retirees. If there is no economic self-sustainability of the public pension fund, financed according to the pay as you go principle, the state inevitably intervenes as a financier using general budget funds, and if they are insufficient, it uses special taxes on tobacco, alcohol, gasoline, luxury goods, etc. (Jelena Kočović, Predrag Šulejić, Tatjana Rakonjac Antić 2010, p.493 [1]). Private pension funds function as a fully funded financing system, often called a capital accumulation system or a system of capitalized funds. Basically, the amount of pension compensation depends on the amount of accumulated premiums (contributions) and the return on invested premiums (contributions). (Jelena Kočović, Predrag Šulejić, Tatjana Rakonjac Antić, Osiguranje 2010, p.493 [1]). At the end of the fourth quarter of 2019, 201,587 users[3] were in the accumulation phase. It should be noted that the membership in the fund is divided into two phases - the accumulation phase (the period in which the funds are paid) and the withdrawal phase (the period when the member withdraws

[1]http://www.croso.gov.rs/lat/Statistika/Prosecna_zarada_penzija/(accessed June 16, 2018).
[2]http://www.croso.gov.rs/lat/Statistika/Prosecna_zarada_penzija/(accessed March 07, 2020).
[3]https://www.nbs.rs/internet/latinica/62/62_2/dpf_04_19.pdf p.9

the accumulated funds)[4]. The stability of inflows into voluntary pension funds and the predictability of payments enable the formation of a quality investment portfolio and the realization of a long-term return on investment. (Ivan Radojković, Boban Gajić 2017, p.34 [7]). The strategic goal in this area is to introduce a healthy multi-pillar pension system.(Ivan Radojković 2012, p.41 [2]).

2. CHARACTERISTICS AND SIGNIFICANCE OF VOLUNTARY PENSION FUNDS

The enactment of the Law on Voluntary Pension Funds and Pension Plans, adopted in September 2005 - which entered into force on 1 April 2006, with its first amendment on 7 May 2011 - provided the legal framework for pension reform. in Serbia. This law introduces the third pillar of pension insurance. Private pensions are completely independent of state pensions and are based on the principle of personal accounts. The funds of the private pension fund are invested in financial instruments that provide portfolio optimization, ie. give the best ratio of investment risk and rate of return. Voluntary pension fund funds are invested in accordance with the following investment principles prescribed by law:

1) *the principle of security*, which is achieved by investing in securities of issuers with a high rating;
2) *the principle of portfolio diversification*, which is achieved by investing in various financial instruments (government bonds, corporate bonds, treasury bills, shares, bank deposits, mortgage bonds, etc.). By applying different quantitative methods, horizontal diversification is performed, ie.the selection of specific securities within different types of instruments on offer. The most important issuers of financial instruments are the state, commercial banks, companies, and local self-government;
3) *the principle of maintaining liquidity*, which is achieved by investing in securities that can be quickly sold and bought at a stable price. The fund's goal is to have a sufficient percentage of liquid financial instruments in its portfolio to be able to meet its obligations at any time[5].

Articles 31, 32, 33 and 34 of the Law on Voluntary Pension Funds and Pension Plans ("Official Gazette of RS", no. 85/2005, 31/2011), precisely define where the assets of a voluntary pension fund can be invested. The members of the Fund themselves choose the Fund to which they will pay the money, the manner and amount of payment, as well as the manner of payment of the pension. There are currently four voluntary pension fund management companies operating in Serbia[6], which manage seven voluntary pension funds[7]. Fund members can start withdrawing funds at the age of 53 or 58, depending on when they joined the Fund[8]. The data in the table indicate solid returns of funds, which indicates that the funds place the collected funds well.

Table following on the next page

[4]https://www.nbs.rs/internet/latinica/62/62_2/dpf_04_16.pdf p.12
[5]http://www.dunavpenzije.com/saznajte-više/investiciona-politika/Investiciona načela (accessed April 27, 2017).
[6]https://www.nbs.rs/internet/cirilica/62/62_pf.html(accessed May 10 2017).
[7]http://www.mojnovac.rs/fondovi.1.html(accessed May 10, 2017)
[8]http://www.dunavpenzije.com/vesti/stupile-na-snagu-izmene-i-dopune-zakona(accessedMay 10, 2017).

Table 1: Number of members, assets and rates of return for voluntary pension funds operating in Serbia[9] (Source: Statistical Anex of NBS for December 2019.)

Fund	Members	Assets (in millions of RSD)	Yield (2019)
Generali Basic	46535	13.075,8	9,14%
Generali Index	4966	1.095,6	8,34%
Raiffaisen Future	35064	5.459,9	4,87%
Raiffaisen Euro Future	4464	225	2,91%[10]
DDOR GarantEkvilibrio	53517	6.050,3	5,63%
DDOR GarantŠtednja	19287	1.328,4	7,85%
DUNAV	87195	18.010,5	6,80%

Yield rates of voluntary pension funds are also favorable if the exchange rate movements during the last year are taken into account. On January 3, 2019, 1 euro amounted to 118.3439 dinars[11] and on December 31, 2019, 1 euro amounted to 117.5928[12]. As a percentage, the fall of the euro is 0.64%, while the annual inflation in 2019 was 1.9%[13]. Based on the information from Table 2, positive trends can be observed in the growth of the Fund's net assets as well as in the number of beneficiaries. The influence of various factors in society on the development of pension funds, as well as the possibility of predicting development in this domain, are the subject of a number of papers from different countries and parts of the world, on which we based our research in this paper (H.C. Benediktsson, T.T. Gerbertssonand J.M. Orszag, 2001 [3];D. Blake, 2004 [8];S. Chlon, 2002 [9]; W.L. Dellvaand G.T.Olson, 1998 [10];R. Ottenand D. Bams, 2002 [11]; A.F.M.Shamsuddin, 2001 [14]; A. Kabašinkskas, K. Šutiene, M. Kopaand E. Valakevičius, 2017 [16]; C. Marti, J.C. Matallin and M.A.Fernandez, 2009 [17], J.Bikker, O.W.Steenbeek and F.Torrachi, 2011 [20], Ch.Cheng and F.Uzelac, 2016 [21], W.Gerke, F.Mager, T.Reinschmidt, C.Schmieder, 2008 [22]).

Table following on the next page

[9]https://www.raiffeisenfuture.rs/fondovi/euro-future/euro-future/prinosi.125.html (accessed March 10, 2020)
[10]https://www.raiffeisenfuture.rs/fondovi/euro-future/euro-future/prinosi.125.html, (accessed March 10, 2020)
[11]https://www.kamatica.rs/kursna-lista/nbs/2019-01-03(accessed March 08, 2020).
[12]https://www.kamatica.com/kursna-lista/nbs/2019-12-31(accessed March 08, 2020).
[13]http://www.cekos.rs/indeksi-potro%C5%A1a%C4%8Dkih-cena-u-2019-godini(accessed March 08, 2020).

Table 2: Key indicators of voluntary pension funds in Serbia development[14]

Indicators	Companies for managing voluntary pension funds	Voluntary pension funds	Members	Contracts	Net estate of funds in millions RSD[15]
2010	6	8	166780	220451	9.862,7
2011	6	9	174868	234405	12.452.3
2012	5	9	179823	240369	16.011,3
2013	4	6	183508	244462	19.007,7
2014	4	6	187997	252072	23.565,3
2015	4	7	190492	258680	28.874,8
2016	4	7	183553	250460	32.790,1
2017	4	7	185445	253900	36.200,0
2018	4	7	192295	261726	40.185,0
2019	4	7	201587	275833	45.245,5

3. LINEAR REGRESSION

By the term linear regression (O.David, 2017 [4]) we mean any modelling of the relationship between a quantity, which we call a dependent variable (we can denote it by y) and one or more quantities, which we call independent variables (we can denote them by $x_1, x_2 \dots x_n$,), so that that model is a linear dependence on independent variables[16],forms

$$y = a_1x_1 + \ a_2x_2 + \cdots + a_nx_n + b,$$

where$a_1, a_2 \dots \ a_n, \ b$are real numbers. If the dependence is on several independent variables, the process is called multiple linear regression. If the dependence of the variable y on only one independent variable x

$$y = ax + b,$$

then it is a simple linear regression.

Linear regression is easy to use in practical applications, because models that linearly depend on their unknown parameters are easier to model than models with nonlinear dependence on parameters. Most applications of linear regression fall into one of the following two types:

- If the goal is prediction, linear regression is used to determine the predictive model according to the considered data set of values of dependent and independent quantities. When the appropriate model is obtained, then the corresponding value of the dependent variable $y$can be determined for some new values of the independent variable y.
- If the goal of regression analysis is to quantify the strength of the relationship between the dependent variable y and each of the independent variables$x_1, x_2 \dots x_n$. In this paper, we will use the first approach, using an approximation procedure, known as the least squares method (discrete mean square approximation).

The least squares method (discrete mean square approximation) (G.V. Milovanović 1991 [5])belongs to the so-called the best approximations, ie.approximation methods in which the criterion is the minimization of the error according to one of the norms.

[14]https://www.nbs.rs/internet/latinica/62/62_2/ .
[15]Source: National Bank Serbia
[16]https://sr.wikipedia.org/sr-ec/Linearna_regresija, (accessed April 20, 2020).

Specifically, this is the norm L^2, ie. the total sum of the squares of the errors in the approximation nodes is minimized (G.V. Milovanović, M.A. Kovačević, 1991 [6]). We also have had, on our minds, some results of previous considerations regarding predictions and risk models (T.C.Wong, C.H.Hui, C.F.Lo, 2010 [18], A.Amendola, M.Restaino, L.Sensini, 2011 [19]).

4. MAIN RESULTS

In this paper, we applied the method of linear regression to the given data from the following table, which shows the values of the average salary in Serbia, the value of FONDEX, as well as the number of fund members in a period of 5 years (2015-2019).

Table 3: Data for the Republic of Serbia for the period 2015-2019

Year	Average salary	FONDEX	Fund members
2019	54.908,25	3064.86	201587
2018	49.642,59	2862.92	192295
2017	47.887,67	2713.39	185445
2016	46.836,75	2592.50	183553
2015	44.436,50	2407.45	190490

We first applied a simple linear regression, to determine the dependence of the number of fund members on the average salary, and then a simple linear regression to arrive at a relationship between the number of fund members and FONDEX. Finally, we received a complex, multiple linear regression, to determine the dependence of the number of fund members on both the average salary and the FONDEX. The obtained dependences are given in the next two sections, together with the prediction tables.

4.1. Simple linear regression

Based on the data from Table 3, where we take the number of users for the independent variable (y), and as the dependent variable (x) the average salary, we will apply the procedure of forming a linear regression approximation function, form

$$\varphi_1(x) = a + bx,$$

by the method of least squares . We will start from the initial condition, that the error of approximation in the nodes is equal to zero, ie. $\varphi_1(x_k) = y(x_k)(k = 1,...,n)$. We have system of linear equations

$$\begin{cases} \varphi_1(54.908250) = a + b \times 54.908250 = 201587 \\ \varphi_1(49.642590) = a + b \times 49.642590 = 192295 \\ \varphi_1(47.887670) = a + b \times 47.887670 = 185445 \\ \varphi_1(46.836750) = a + b \times 46.836750 = 183553 \\ \varphi_1(44.436500) = a + b \times 44.436500 = 190490 \end{cases}$$

If we transform this system into a matrix form, we have

$$\underbrace{\begin{bmatrix} 1 & 54.908250 \\ 1 & 49.642590 \\ 1 & 47.887670 \\ 1 & 46.836750 \\ 1 & 44.436500 \end{bmatrix}}_{A} \times \begin{bmatrix} a \\ b \end{bmatrix} = \underbrace{\begin{bmatrix} 201587 \\ 192295 \\ 185445 \\ 183553 \\ 190490 \end{bmatrix}}_{\vec{b}}$$

Table 4: Prediction of the number of fund members depending on average salary

Avarage salary in Serbia	Fund members
50.000,00	194966
52.500,00	204753
55.000,00	214541
57.500,00	224329
60.000,00	234117
62.500,00	243904
65.000,00	253692
67.500,00	263480
70.000,00	273268

and we solve, by means of

$$A \times \vec{x} = \vec{b} \ / A^T \quad \Rightarrow \quad A^T A \times \vec{x} = A^T \vec{b}$$

$$(A^T A) \times \vec{x} = A^T \vec{b} \ / (A^T A)^{-1} \quad \Rightarrow \quad \vec{x} = (A^T A)^{-1} \times A^T \vec{b} = \begin{bmatrix} -790.405006 \\ 3915.118438 \end{bmatrix}$$

So the linear regression function for this case is

$$\varphi_1(x) = -790.405066 + 3915.118438x \, .$$

Using the obtained function, we can make a prediction of the number of fund members, depending on further possible changes in the average salary, which is shown in Table 4.

On the other hand, if we take the number of users for the independent variable (y) and FONDEX as the dependent variable (x), then we apply the procedure of forming a linear regression approximation function, form

$$\varphi_2(x) = a + bx,$$

by the method of least squares.

We will start with the initial condition, that the error of approximation in the nodes is equal to zero, ie. $\varphi_2(x_k) = y(x_k)(k = 1,...,n)$

$$\begin{cases} \varphi_2(3064.86) = a + b \times 3064.86 = 201587 \\ \varphi_2(2862.92) = a + b \times 2862.92 = 192295 \\ \varphi_2(2713.39) = a + b \times 2713.39 = 185445 \\ \varphi_2(2592.50) = a + b \times 2592.50 = 183553 \\ \varphi_2(2407.45) = a + b \times 2407.45 = 190490 \end{cases},$$

If we transform this system into a matrix form, we have

$$\underbrace{\begin{bmatrix} 1 & 3064.86 \\ 1 & 2862.92 \\ 1 & 2713.39 \\ 1 & 2592.50 \\ 1 & 2407.45 \end{bmatrix}}_{A} \times \underbrace{\begin{bmatrix} a \\ b \end{bmatrix}}_{\vec{x}} = \underbrace{\begin{bmatrix} 201587 \\ 192295 \\ 185445 \\ 183553 \\ 190490 \end{bmatrix}}_{\vec{b}},$$

and we solve, by means of

$$A \times \vec{x} = \vec{b} \ / A^T \quad \Rightarrow \quad A^T A \times \vec{x} = A^T \vec{b}$$

$$(A^T A) \times \vec{x} = A^T \vec{b} \ / (A^T A)^{-1} \quad \Rightarrow \quad \vec{x} = (A^T A)^{-1} \times A^T \vec{b} = \begin{bmatrix} -1164.563403 \\ 69.974794 \end{bmatrix}$$

So the linear regression function for this case is

$$\varphi_2(x) = -1164.563403 + 69.974794x$$

Using the obtained function we can make a prediction of the number of fund members, depending on further possible changes of FONDEX, which is shown in the table 5.

Table 5: Prediction of the number of fund members depending on FONDEX

FONDEX	Fund members
3000.00	208760
3050.00	212259
3100.00	215757
3150.00	219256
3200.00	222755
3250.00	226254
3300.00	229752
3350.00	233251
3400.00	236750

4.2. Complex linear regression

Based on the data from Table 3, where we take the number of users for the independent variable (z), and the average salary x value of FONDEX y as dependent variables, we will apply the procedure of forming a multiple linear regression approximation function, form

$$\varphi_3(x, y) = a + bx + cy,$$

usingleast squares method. We will start with the initial conditions, that the error of approximation in the nodes is equal to zero, ie.

$$\varphi_3(x_k, y_k) = z(x_k, y_k)(k = 1, ..., n).$$

$$\begin{cases} a + b \times 54.908250 + c \times 3064.86 = 201587 \\ a + b \times 49.642590 + c \times 29862.92 = 192295 \\ a + b \times 47.887670 + c \times 2713.39 = 185445 \\ a + b \times 46.836750 + c \times 2592.50 = 183553 \\ a + b \times 44.436500 + c \times 2407.45 = 190490 \end{cases}$$

If we transform this system into a matrix form, we have

$$\underbrace{\begin{bmatrix} 1 & 54.908250 & 3064.86 \\ 1 & 49.642590 & 2862.92 \\ 1 & 47.887670 & 2713.39 \\ 1 & 46.836750 & 2592.50 \\ 1 & 44.436500 & 2407.45 \end{bmatrix}}_{A} \times \underbrace{\begin{bmatrix} a \\ b \\ c \end{bmatrix}}_{\vec{x}} = \underbrace{\begin{bmatrix} 201587 \\ 192295 \\ 185445 \\ 183553 \\ 190490 \end{bmatrix}}_{\vec{b}}$$

and we solve, by means of

$$A \times \vec{x} = \vec{b} \ / A^T \quad \Rightarrow \quad A^T A \times \vec{x} = A^T \vec{b}$$

$$(A^T A) \times \vec{x} = A^T \vec{b} \ / (A^T A)^{-1} \qquad \Rightarrow \quad \vec{x} = (A^T A)^{-1} \times A^T \vec{b} = \begin{bmatrix} -600.7212221 \\ 9158.414506 \\ -93.69044454 \end{bmatrix}$$

So the linear regression function for this case is

$$\varphi_3(x, y) = -600.7212221 + 9158.414506x - 93.69044454y$$

Using the obtained function we can make a prediction of the number of fund members, depending on further possible changes in the average salary and FONDEX, which is shown in the following table:

Table following on the next page

Table 6: Prediction of the number of fund members depending on average salary and FONDEX

Average salary	FONDEX	Fund members	Average salary	FONDEX	Fund members
50000	3000.00	**176249**	52500	3000.00	**199145**
50000	3050.00	**171564**	52500	3050.00	**194460**
50000	3100.00	**166880**	52500	3100.00	**189776**
50000	3150.00	**162195**	52500	3150.00	**185091**
50000	3200.00	**157511**	52500	3200.00	**180407**
50000	3250.00	**152826**	52500	3250.00	**175722**
50000	3300.00	**148142**	52500	3300.00	**171038**
50000	3350.00	**143457**	52500	3350.00	**166353**
50000	3400.00	**138772**	52500	3400.00	**161669**
50000	3450.00	**134088**	52500	3450.00	**156984**
50000	3500.00	**129403**	52500	3500.00	**152299**

Table 7: Prediction of the number of fund members depending on average salary and FONDEX

Average salary	FONDEX	Fund members	Average salary	FONDEX	Fund members
55000	3000.00	**222041**	57500	3000.00	**244937**
55000	3050.00	**217356**	57500	3050.00	**240252**
55000	3100.00	**212672**	57500	3100.00	**235568**
55000	3150.00	**207987**	57500	3150.00	**230883**
55000	3200.00	**203303**	57500	3200.00	**226199**
55000	3250.00	**198618**	57500	3250.00	**221514**
55000	3300.00	**193934**	57500	3300.00	**216830**
55000	3350.00	**189249**	57500	3350.00	**212145**
55000	3400.00	**184565**	57500	3400.00	**207461**
55000	3450.00	**179880**	57500	3450.00	**202776**
55000	3500.00	**175196**	57500	3500.00	**198092**

Table 8:Prediction of the number of fund members depending on average salary and FONDEX

Average salary	FONDEX	Fund members	Average salary	FONDEX	Fund members
60000	3000.00	**267833**	62500	3000.00	**290729**
60000	3050.00	**263148**	62500	3050.00	**286044**
60000	3100.00	**258464**	62500	3100.00	**281360**
60000	3150.00	**253779**	62500	3150.00	**276675**
60000	3200.00	**249095**	62500	3200.00	**271991**
60000	3250.00	**244410**	62500	3250.00	**267306**
60000	3300.00	**239726**	62500	3300.00	**262622**
60000	3350.00	**235041**	62500	3350.00	**257937**
60000	3400.00	**230357**	62500	3400.00	**253253**
60000	3450.00	**225672**	62500	3450.00	**248568**
60000	3500.00	**220988**	62500	3500.00	**243884**

Table 9: Prediction of the number of fund members depending on average salary and FONDEX

Average salary	FONDEX	Fund members	Average salary	FONDEX	Fund members
65000	3000.00	**313625**	67500	3000.00	**336521**
65000	3050.00	**308940**	67500	3050.00	**331836**
65000	3100.00	**304256**	67500	3100.00	**327152**
65000	3150.00	**299571**	67500	3150.00	**322467**
65000	3200.00	**294887**	67500	3200.00	**317783**
65000	3250.00	**290202**	67500	3250.00	**313098**
65000	3300.00	**285518**	67500	3300.00	**308414**
65000	3350.00	**280833**	67500	3350.00	**303729**
65000	3400.00	**276149**	67500	3400.00	**299045**
65000	3450.00	**271464**	67500	3450.00	**294360**
65000	3500.00	**266780**	67500	3500.00	**289676**

Table 10: Prediction of the number of fund members depending on average salary and FONDEX

Average salary	FONDEX	Fund members	Average salary	FONDEX	Fund members
70000	3000.00	**359417**	72500	3000.00	**382313**
70000	3050.00	**354732**	72500	3050.00	**377628**
70000	3100.00	**350048**	72500	3100.00	**372944**
70000	3150.00	**345363**	72500	3150.00	**368259**
70000	3200.00	**340679**	72500	3200.00	**363575**
70000	3250.00	**335994**	72500	3250.00	**358890**
70000	3300.00	**331310**	72500	3300.00	**354206**
70000	3350.00	**326625**	72500	3350.00	**349521**
70000	3400.00	**321941**	72500	3400.00	**344837**
70000	3450.00	**317256**	72500	3450.00	**340152**
70000	3500.00	**312572**	72500	3500.00	**335468**

5. CONCLUSION AND DIRECTIONS OF FURTHER RESEARCH

In first two sections of this paper, we analyzed the work of voluntary pension funds in Serbia in terms of financial results. In the continuation of the paper, we modelled the behavior and interdependence of the private pension fund members and two relevant parameters, which are in corelationwith fund members. In the first case, the approximation function, which represents a mathematical model of behavior, that is not relevant enough, because it takes into account only one of the factors, and that is the average salary in the country. In the second case, the approximation function that represents the mathematical model of behavior is more relevant, but still insufficient, because it takes into account only FONDEX as variable. Finally, the last approximation function, a mathematical model in which the number of fund members is modeled over the average salary and size of FONDEX, gives a very precise picture and gives opportunity for good prediction of growth and development of the pension system, number of fund members, and its relevance is based on interaction and influence of two independent factors.

Based on the data obtained in Tables 6, 7, 8, 9 and 10, we can be sure of a good estimate obtained by this mathematical model, specifically on the current situation, with the current average salary and the current size of FONDEX. Further research and analysis should consider determining the structure of the population, which could affect the improvement of the performance of voluntary pension funds in Serbia. With these new solutions and a better employment ratio, and with an increase in the number of members who pay contributions to private pension funds (eg that 10% of the population saves in private pension funds, currently about 2%), future retirees in Serbia can expect safer and more certain the future

6. DECLARATION OF INTEREST

The authors report no conflict of interest. The authors alone are responsible for the content and writing of the paper.

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