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Application of actuarial modeling to determine the rate of health insurance in solidary health care systems: a case of Slovakia

Jana ŠTRANGFELDOVÁ[1], Daniela MALIŠOVÁ[2]

Abstract: *The method of actuarial modeling is applied in pension or social insurance schemes. However, the possibilities of using this method also occur in non-life insurance, which includes health insurance. The aim of the paper is to point out the application of actuarial modeling to determine the rate of compulsory health insurance in the solidarity health system. For this reason, in the paper we use Slovak Health System based on Bismarck model as a case study for application of the chosen method. In the case study we use a PESTLE analysis for better understanding of current situation. The paper uses secondary data collected in the period 2009 - 2019 from the official documents of Ministry of Health of the Slovak Republic. Based on actuarial modeling we determine the rate of health insurance for the economically inactive population at 6.3 % of the assessment base. This is a change of 2.3 points compared to the current official rate and 9.03 points increase in the state's share in the creation of resources from compulsory health insurance. The paper has an application character. Therefore, we conclude that the method of actuarial modeling can be used to determine the rate in the solidary health care systems.*

Keywords: actuarial modeling, health insurance, health system, public finance.

JEL: C58, H51, I13

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Introduction

With the development of health care systems, financial and insurance schemes are also beginning to take shape around the world, the aim of which is to cover health care. There is some evidence that investing in health can be considered an investment in the future (Turnock, 2004). The benefit of this investment is the improvement of health and an increase in the average life

[1] Associate Professor, Department of Public Economics and Regional Development, Matej Bel University, Banská Bystrica, Slovakia, e-mail: jana.strangfeldova@umb.sk

[2] PhD Candidate, Department of Public Economics and Regional Development, Matej Bel University, Banská Bystrica, Slovakia e-mail: daniela.malisova@umb.sk

expectancy of the population. In this context, modern health systems significantly improve the health status of the population, which results in increased social well-being (Figueras, et al., 2008).

At the same time, health systems provide health care to all citizens of society through health services (Androniceanu et al., 2020). Models of health systems may vary from country to country. It should be borne in mind that health systems are influenced by internal and external determinants (South, et al. 2013). In this context, the aim of the paper is to point out the use of actuarial modeling to determine the rate of compulsory health insurance in the solidarity health system. The application of the method of actuarial modeling in countries using solidarity-based health care systems is rare. For this reason, we use the case study method to analyze the health insurance rate in the Slovak Republic. For the correct determination of the factors influencing the rate of health insurance, we use the qualitative analysis of PESTLE factors.

1. Application of Actuarial Modeling in Health Insurance

Actuarial modeling as a scientific discipline has undergone revolutionary changes since the 1980s due to the expansion of high-speed computers and the combination of stochastic actuarial models with modern financial theory (Hickman, 2013; Fress, et al. 2014). The enhanced importance of actuarial modeling has found its application in pension, social or health care schemes. Actuarial modeling in these insurance schemes as opposed to deterministic approaches uses simulation techniques (Subramaniam, 2008). This means that actuarial modeling can be used to illustrate different development scenarios. But it is not a condition that the use of this approach will determine future developments unquestionably correctly. A more extensive study in this area was conducted by Emrechts (2000), which compares the actuarial and financial approaches to determining health insurance rates. As he points out, it would be appropriate for financial modeling to be enriched in the future with actuarial modeling. We agree that the intersection between these approaches can be used in the future to set prices in health insurance schemes.

From the above findings, we state that the application of the actuarial method can also be used for non-life insurance. Despite the fact that health insurance is closely connected with the health and life of a person, according to their nature, we classify it as non-life insurance in insurance schemes (Kováč, 2009). Another possibility of using up-to-date modeling is the identification of the most suitable alternative when choosing from insurance products provided on the market (Haochen, 2017). Currently, this approach finds its application in commercial insurance. However, in countries where compulsory health insurance is applied (population system with elements of the Bismarck social model), this approach can be used in the future to specify the package covered by this insurance (more on health insurance models in Cichon and Normand, 1994; Lameire, et al., 1999; Kos, 2018). Differentiation of compulsory health insurance would reduce state budget expenditures and consequently could also reduce contributions to

health and health insurance (Škrovánková and Simonka, 2004) used in joint and several insurance systems.

A more detailed specification of actuarial modeling (Bătrînca and Burcă, 2011) mathematically expresses the elements involved and is based on multiple interrelated assumptions regarding various aspects. For this reason, it is relatively easy to vary and adapt to the current need for situation modeling. Tsanakas, et al. (2016) point out that different types of uncertainty can occur when using actuarial modeling. This uncertainty may be associated with the human factor, in the sense of limited managerial expertise. This uncertainty can manifest itself when the input conditions change. As a solution, models need to be redesigned to better approximate environmental risks (Grondys et al., 2021). The second type of uncertainty is associated with the use of appropriate statistical tools. Small deviations, or improperly chosen statistical tool, can cause changes in simulated designs. Further uncertainty is associated with external determinants, which we classify as PESTLE - political, economic, social, technological, legislative and environmental (Rastogi and Trivedi, 2016). Actuarial modeling includes multifactor sequential estimates expressed in a simulation. As health insurance and long-term care insurance present complex problems (Macdonald, 2002), the application of actuarial modeling can be considered a suitable solution.

2. PESTLE analysis of the Slovak´s Health Insurance System: a Case Study

Slovak republic´s health insurance system is based on elements of the Bismarck model, i.e. the main element is social solidarity. Social solidarity is characterized by the application of the institution of compulsory health insurance. From the point of view of the organizational principle, in countries that apply elements of the Bismarck model, compulsory health insurance forms a major part of health care financing (Gerlinger and Schmucker, 2009). The aim of compulsory health insurance (Rosenbrock and Gerlinger, 2014) is to provide health care in times of illness, critical life or loss of employment (Ohanyan and Androniceanu, 2017) through universal reimbursement of health care to insured people who contribute to a common fund managed by a health insurance company.

Compulsory health insurance in Slovak Republic is regulated by The Act of the National Council of the Slovak Republic no. 580/2004 Coll., which designates the state as the payer of insurance for economically inactive population (IPO). The premium for this cohort is set at 4 % of the assessment base. According to the law, the levy rate for the economically active population (APO) is set at 14 % of the assessment base. Since 2006, there have been changes in the collection of premiums for IPOs, and in the years 2017 - 2019, this rate is often changed during the year and set below the official value. In 2019, the IPO rate changes up to three times a year, while the average rate for this year is at the level of 3.6 % of the

assessment base (average monthly wage in the national economy at the level of 1,092 EUR in 2019). The consequence of this change in the rate is a reduction in the payment for compulsory health insurance for the IPO and a transfer of responsibility for the creation of resources from the health insurance to the APO. After taking into account the health and social contributions of APO, we do not consider it appropriate to further increase this burden.

In terms of reflecting socio-economic characteristics (Baláž, et al., 2013; Bartošovič, 2017) until 2060, the assumption arises that the average life expectancy in Slovakia will continue to increase (currently at the value of 75.82 years). And the total population will fall, however. The expected break in development will occur after 2030. The consequence of this demographic break will be the transfer of APO to a higher productive to retirement age. This development concerns in particular the relocation of a large generation of the population born in the 1970s, who are leaving the labor market and being replaced by a small generation of the population born in 1980-1990. For this reason, from the point of view of health care financing, a problem arises that requires a long-term sustainable solution.

We monitor the development of health care financing from compulsory health insurance based on professional work and research (Zee and Kroneman, 2007; Figueras, et al., 2008; Němec, 2008; Ondruš, et al. 2017). Zachar (2013) focus on the current Slovak health care financing situation. In their research, they present the possibilities of changing the system of financing health care and in this context a change in the choice of health contributions. One of the possibilities for a change in the current setting of the Slovak health care system is the transition to a related Czech premium collection system. The Czech insurance scheme works with a fixed rate of the positive (rate 13.5 % according to the law) from the assessment base. However, the assessment base can be changed once a year with effect from January of the following year (Němec, 2017; Strnád and Gladkij, 2001). When changing the assessment base, the development of the average gross wage in the economy as well as the possibilities of the state budget are taken into account. Such a setting of the choice of health contributions is more stable and predictable for the budgeting of health facilities and the administration of health insurance companies. The reason is that the health care system (Wendt, et al., 2009) should respond in a balanced way to the needs and expectations of society.

Another important factor influencing the result of actuarial modeling is public expenditure on health care. Private expenditures are based on a willingness to pay for health care beyond the coverage of compulsory health insurance. For comparison, in Slovakia in 2018 total public expenditure on health care accounted for 5.4 % of GDP and total private expenditure only 1.3 % of GDP. The Ageing Europe Strategy (2019) states that in the coming periods, public spending on Slovak health care will grow faster in comparison with other member states of the European Union. The main reason is the increasing demand for health care from the elderly. Annual reports from health insurance companies show that between 2009 and 2019, public expenditure per capita increased by an average of 668 EUR. A negative factor in recent days is the ongoing pandemic, which affects the country's macroeconomic indicators, especially the development of the average wage in the national economy and the level of unemployment (Androniceanu &

Marton, 2021). Due to the lack of data, this dynamic societal development cannot currently be fully taken into account when creating a scenario to determine an alternative rate for economically inactive population. However, in terms of the reflection of PESTLE factors, we take into account the sectoral characteristics of the health sector. In the Slovak health care system, as a result of the unfinished economic transformation since the 1990s, debt has been created for a long time, which expresses the examined indicator of the total annual debt of the health care system. Since 2010, the value of debt has been a burden, the removal of which is a long-term problem. The benefit of the proposed change in the health insurance rate for an IPO is therefore the possibility of eliminating the debt burden.

3. Material and Methods

The database for the application of actuarial modeling was created from official reports and data of the Statistical Office of the Slovak Republic, Reports on the performance of public health insurance, Reports on revisions of health care expenditures, Annual reports of health insurance companies, documents and decrees of the Ministry of Health and the Ministry of Finance. In terms of time, we use data available for the last decade. The reduction in the time series is due to the merger of health insurance companies as well as the use of the latest secondary data available only until 2019. Based on this limitation, we interpret the simulations created for 2020 and 2021 under ceteris paribus conditions. However, we are currently working to improve the approximation of the presented model.

Based on theoretical and practical knowledge (Booth, et al. 2020), we compiled a proposal for a Slovak insurance scheme to calculate an economically appropriate rate of compulsory health insurance for economically inactive population (IPO). As follows from the mapping of economic factors of the PESTLE analysis, we do not consider it appropriate to increase the rate of compulsory health insurance for economically active people (APO). We express the opinion that the proposed actuarial model can be used in other joint and several insurance schemes. However, we consider it crucial to formulate internal and external factors in a given country, for example through PESTLE analysis, regression analysis or causal analysis. To eliminate the shortcoming associated with the inappropriate use of statistical methods in the paper, we apply a harmonic average. The harmonic mean is used to determine the centre of variability of a feature that, despite a certain constant value, is indirectly related to another feature. At the same time, the sum of such features does not make sense (Jensen, et al., 1997). The harmonic average is used when we are working with percentages.

The paper is based on the research of Špirková, et al. (2017), which initiated steps to identify the optimal rate for IPOs and APOs. Based on the PESTLE analysis, we extend this approach to the total debt in healthcare and the determination of an alternative premium rate for the IPO. In the calculation, we use a uniform assessment base determined as the average gross wage in the national economy two years ago.

In the paper we use the following notations:
$TE_{Publici}$ – total expenditures on health care from public resources,
TD_i – total year debt in healthcare,
$GS_{i.}$ – yearly average gross salary in national economy,
APO_i– economically active population,
IPO_i – economically inactive population,
$I_{L(APO)}$ – health insurance premium rate for economically active population by the law (premium rate 14 % from gross salary),
$I_{L(IPO)}$ – health insurance premium rate for economically inactive pupulation by the law (premium rate 4 % from gross salary),
$I_{L(IPOi)*}$ - new health insurance premium rate for economically inactive population,
THP_i – total health insurance premium.

The following procedure summarizes the individual partial steps of actuarial modeling. From a practical point of view, we recommend inducing this procedure in order to eliminate errors in the calculation. In the first step Eq. (1), we calculate the volume of prescribed total income from compulsory health insurance. Please note that the amount of total prescribed income may not be the same as the amount of total paid income from compulsory health insurance for the entire population.

$$GS_{i-2} * \frac{I_{L(APo)}}{100\%} * APo_i + GS_{i-2} * \frac{I_{L(IPo)}}{100\%} * IPo_i = THP_i \quad (1)$$

We express the ratio of THPi with the total cost of health care from public sources to the qi quotient (q_i,> 1). In this case, it expresses the percentage increase in the total written premium from compulsory health insurance compared to the total expenses. Mathematical adjustment Eq. (2) to percentages. The qi quotient expresses the deficit that arises between the total written premium and the sum of total public expenditure on health care and the total annual debt in health care.

$$\left(1 - \frac{THP_i}{TE_{Public_i} + TD_i}\right) * 100 = q_i \quad (2)$$

The equation for expressing the rate of the economically inactive population is compiled on the basis of equality Eq. (3). The right-hand side expresses the difference between the missing amount of funds from compulsory health insurance and the written premium from compulsory health insurance collected from the economically active population. The left side of the equation expresses the alternative rate of compulsory health insurance for the economically inactive population $I^*_{L(IPo)i}$ which is unknown.

$$I^*_{L(IPo)i} = \left(\frac{THP_i + \frac{q_i}{100\%} * \left(TE_{Public_i} + TD_i\right)}{GS_{i-2}} - \frac{I_{L(APo)_i}}{100\%} * APo_i}{IPo_i} \right) * 100 \quad (3)$$

The proposed scenario for calculating the alternative rate of compulsory health insurance covers all health expenditure from public funds and the administrative costs of health insurance companies. By adding the element of total debt in healthcare to the formula, we extend this perception to include above-limit medical performances, overdue liabilities, liabilities of healthcare facilities to the Social Insurance Agency and other items that are the content of the total annual debt of healthcare.

4. Research Results

We interpret the obtained results using tables and graphs. With the database created (Table 1) we will work in the application of the presented calculation.

Table 1. Input data for the calculation of the alternative rate of health insurance

Order	Year	Average Yearly Gross Salary	Economically Active Population	Economically Inactive Population	Total Expanditures on Health Care from Public Resources	Total Debt in Health Care
(i)	(y)	(GS_i)	(APO_i)	(IPO_i)	($TE_{publici}$)	(TD_i)
1	2007	8 024 €	2 649 200	2 742 200	3 141 664 000 €	268 010 000 €
2	2008	8 676 €	2 691 200	2 706 100	3 595 868 000 €	640 450 000 €
3	2009	8 928 €	2 690 000	2 719 500	3 743 555 000 €	846 190 000 €
4	2010	9 228 €	2 706 500	2 715 300	3 790 819 000 €	1 137 780 000 €
5	2011	9 432 €	2 680 000	2 712 400	3 865 617 000 €	1 033 690 000 €
6	2012	9 660 €	2 706 500	2 697 800	4 005 449 000 €	1 049 600 000 €
7	2013	9 888 €	2 715 000	2 695 000	4 143 156 000 €	1 253 760 000 €
8	2014	10 296 €	2 721 000	2 694 000	4 217 012 000 €	1 242 330 000 €
9	2015	10 596 €	2 738 300	2 687 952	4 319 215 000 €	1 377 820 000 €
10	2016	10 944 €	2 758 100	2 677 243	4 669 452 000 €	1 382 390 000 €
11	2017	11 436 €	2 754 700	2 688 420	4 573 408 000 €	1 463 730 000 €
12	2018	12 156 €	2 746 300	2 703 062	4 801 142 000 €	1 514 720 000 €
13	2019	13 104 €	2 741 400	2 709 000	4 931 000 000 €	1 579 720 000 €

(*Source:* Authors, 2020)

In the monitored periods, written premiums (Table 2) increased by 173.34 mil. EUR per year. The reason is the increasing height of the measuring base. During the monitored periods, the average gross wage increased by 4.17 % per year (450 EUR per year). The total premiums paid in the monitored years is lower than the prescribed value. This fact is due to the low success of the collection of premiums by health insurance companies, which in 2019 achieved only 98.34 % success. Within the delegated competence of the state, health insurance companies

hold the function of collecting and redistributing funds from compulsory health insurance. The success of premium collection reflects the health insurance company's approach to premium collection and the state of processing of the premium prescription, but also the payment discipline of premium payers.

The factor in determining the alternative rate is the debt in healthcare. The method of determining the alternative IPO rate is based on equality in the sense of covering health care expenditures from public resources, including health care debt. In arguing this approach, we start from the situation that the state repays the health care debt once a year through the approval of debt relief policies. While, the debt is generated by public health facilities in its administration. We assume that if the state increases the payment for its policyholders (the economically inactive population), it is not necessary to invest additionally a large amount of funds to rehabilitate the debt. In terms of consequences, the primary increase in the state's payment for the IPO at the input when setting the annual budget is more beneficial for the creation of health resources and their subsequent redistribution. The elimination of fluctuations in setting the IPO rate during the year will remove the administrative burden on health insurers, which is reflected in the administrative costs covered by health insurance, as well as the uncertainty of health facilities in allocating resources.

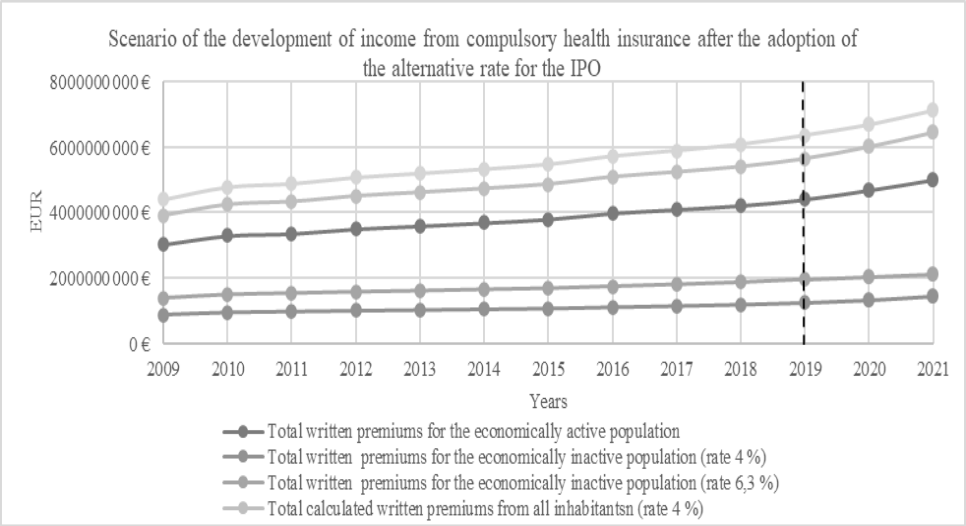
Table 2. Calculation of the total written premium (THPi) and the alternative rate for the economically inactive population in the period 2009 - 2019

Order	Year	Total premiums for the economically active population	Total premiums of economically inactive population	Total calculated written premiums from all inhabitants	Quotient	Alternative rate for economically inactive population
(i)	(y)	(THPAPoi)	(THPIPoi)	(THPi)	q_i	$I^{*}_{L\,(IPo)i}$
1	2007	2 045 352 000 €	894 302 300 €	-	-	-
2	2008	2 233 063 562 €	980 630 290 €	-	-	-
3	2009	2 163 438 159 €	1 158 252 001 €	3 894 883 272 €	15,14%	7,18%
4	2010	2 217 495 020 €	1 282 803 160 €	4 229 740 872 €	14,18%	6,97%
5	2011	2 377 295 504 €	1 207 549 167 €	4 318 437 888 €	11,86%	6,40%
6	2012	2 427 816 127 €	1 358 203 934 €	4 492 393 416 €	11,13%	6,26%
7	2013	2 572 969 397 €	1 276 828 000 €	4 601 872 800 €	14,73%	7,13%
8	2014	2 765 843 000 €	1 211 534 000 €	4 720 842 000 €	15,12%	7,23%
9	2015	2 874 783 000 €	1 348 865 000 €	4 853 822 231 €	14,80%	7,17%
10	2016	2 952 659 700 €	1 392 101 000 €	5 078 231 421 €	16,09%	7,53%
11	2017	3 308 158 095 €	1 299 279 000 €	5 225 892 101 €	13,44%	6,85%
12	2018	3 630 945 000 €	1 188 977 441 €	5 391 063 429 €	14,64%	7,13%
13	2019	3 978 637 183 €	1 174 113 691 €	5 628 296 016 €	13,55%	6,85%

(*Source:* Authors, 2020)

In this context, there is a declining payment of the state for the IPO every year. In the years 2017 - 2019, the total premium for the IPO recorded an average annual decrease of 62.5 mil. EUR despite an increase in the number of IPOs by an average of 10,500 persons per year. The annual levy for an economically inactive person in 2019 amounted to 412.13 EUR. In comparison with the officially determined premium rate (rate 4%), this is a difference of 45.31 EUR and a difference of 1,181 EUR in comparison with the annual payment of an economically active person. This finding points to the fact that the lack of funding for the main source of health financing also affects the health deficit. In order to improve the management of health care, a health policy has been in place since 2013 aimed at debt relief, which is mainly institutional state health care facilities. In 2019 was used for debt relief 273.48 mil. EUR. Nevertheless, debt in the healthcare sector still represents a billion item, consisting mainly of overdue receivables.

Figure 1. Scenario of the development of income from compulsory health insurance after the adoption of the alternative rate for the IPO (in EUR)



(*Source:* Authors, 2020)

Based on the results of actuarial modeling, we determine the alternative rate for the IPO with a harmonic average of 6.292664 % ≐ 6.3 % of the assessment base. At this rate, the IPO premium would increase by 263.03 EUR per capita in 2019. At the same time, the value of the rate is still twice the level of the APO rate. However, this change would contribute to an increase in the state's share in the creation of resources from compulsory health insurance.

Table 3. Impact of the change in the rate of compulsory health insurance on public finances (in EUR)

Year	2018	2019	2020	2021
State budget (deficit)	**-1 182 240 000**	**-2 201 480 000**	**-11 952 630 000**	**-8 058 470 000**
Tax revenues	10 769 329 000	11 079 930 000	10 732 957 000	11 800 000 000
Health insurance companies	**5 020 000 000**	**5 510 000 000**	**5 690 000 000**	**5 940 000 000**
Premium from Economically Active Population	3 780 000 000	4 460 000 000	4 520 000 000	4 510 000 000
Premium from Economically Inactive Population	1 240 000 000	1 050 000 000	1 170 000 000	1 430 000 000
Premium from Economically Inactive Population (after change)	1 863 685 563	1 951 747 812	2 021 351 556	2 093 437 527
Tax revenues (after change)	10 145 643 437	10 178 182 188	9 881 605 444	11 136 562 473
Health insurance companies (after change)	5 643 685 563	6 411 747 812	6 541 351 556	6 603 437 527

(*Source:* Authors, 2020)

In the presented scenario, the state's share would increase from the original level of 23.13 % to 32.15 % for 2019. Figure 1 contains a simulation of the scenario of income development from compulsory health insurance with a prediction of the official and alternative IPO rate. In the calculation for 2020 and 2021, we take into account the development of the population according to economic activity and the unemployment rate. For 2020, we expect an unemployment rate of 7.38 % and for 2021 an 8 % unemployment rate. The change in the rate will increase the total written premium for 2020 by 698.73 mil. EUR and for 2021 it is an increase of 657.81 mil. EUR. We reiterate that in this scenario we do not mention other socio-economic slippages caused by the pandemic crisis due to the lack of metadata.

The increase in the IPO rate has an impact on public finances (Table 3). The change increases tax expenditures from the population, increases the state's share of expenditures on public health insurance and increases the income of health insurance companies. This transfer shifts funds to health insurance companies to finance health care, resulting in a negative impact on the state budget deficit. In the monitored periods of 2018 - 2021, the change would increase the deficit by 760.05 mil. EUR on average. Provided that the levy burden on APOs does not increase. However, the debt in health care would be eliminated and the responsibility for the generation of income from compulsory health insurance by the state would be strengthened. The main role of the state is to protect public health, because health is a national priority (Carande-Kulis, et al., 2007). At the same time, according to forecasts, the demographic development of the population will be declining from 2025. The result will be a gradual reduction in income from compulsory health insurance.

5. Conclusions

The aim of the paper is to point out the application of actuarial modeling to determine the rate of compulsory health insurance in the solidarity health system. In this context, we apply the method to the solidarity health system of the Slovak Republic. From the analysis of PESTLE factors, we find that the insurance scheme is influenced by several negative factors that affect the generation of income from compulsory health insurance. For this reason, we use actuarial modeling to determine an alternative health insurance rate for an economically inactive population. Based on data collected in the period 2009 - 2019, we determine in the scenario an alternative rate for the IPO to 6.3 % of the average gross wage in the national economy. This is an increase in the rate by 2.3 points compared to the currently officially declared rate according to the law.

In comparison with the research, we find that Sivák, et al. (2014) suggest the rate of IPO to be 6.1 % and with the assumption of an increase to 8.2 % by 2030. While this growing change takes into account the cyclicality of the economy. The proposed alternative in the paper therefore falls within the interval given by the author and can be considered valid. In paper (Páleník, et al., 2010) the authors provide a more global view of the issue of the insurance scheme in Slovakia. They provide an insight into the long-term development of the deficit in health care, stating that health contributions will need to be gradually increased to 21 % of gross wages.

The basic recommendation is to increase the dynamics of economic growth with a strategy of employment and growth. In comparison with the proposal of the Slovak Medical Chamber (2020), which recommended increasing the health insurance rate of the economically inactive population to 5%, this is an increase of 1.3 %. We can state that the need to increase the examined rate is current. Also, the method of actuarial modeling is suitable for determining the rate of health insurance taking into account several factors. Due to the truncated data, we consider the proposal of the alternative rate and its calculation to be adequate to apply in the situation after the economic stabilization of the country.

The contribution of the paper is the application character, thanks to which the paper is a precursor in the study of the issues of the currently set up insurance system using the institute of compulsory health insurance. For the application of actuarial modeling, we recommend in the future a thorough analysis of external and internal factors that affect the examined insurance scheme.

Authors Contributions

The author/authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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