

# Economic Horizons



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# Economic Horizons



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## EDITORIAL

In addition to the continual endeavors of the Journal Editorial Board aimed at improving the quality of the published contributions, as well as increasing the visibility of the Journal through including it in the referent bases of the academic journals: EconLit, EBSCO, DOAJ, Cabell's Directories, ProQuest ABI/INFORM, Ulrich's Web, we point out - particularly in relation to the openness of the Journal for the scientifically valid contributions from abroad - that the five scientific papers written by the authors from abroad (India, FYR of Macedonia, Canada, Vietnam, Nigeria) (33.33% of the total number of the scientific papers published in the Journal in 2017) have been published in Volume 19 of the *Economic Horizons*, after the double-blind review process and revisions.

In August this year, *Thomas L. Saaty* (1926-2017) - a distinguished professor at the University of Pittsburgh, USA, a member of the National Academy of Engineering, USA, the creator of the scientifically and practically relevant instrumentarium for decision-making the Analytic Hierarchy Process and the Analytic Network Process - passed away. With his authentic, world-recognized scientific contributions, particularly those to Operational Research, professor T. L. Saaty obligated the academic community, and as a perennial member of the International Board of the *Economic Horizons*, and publishing his author's paper (Saaty, T. L. (2010). *Economic Forecasting with Tangible and Intangible Criteria: The Analytic Hierarchy Process of Measurement and its Validation*. *Economic Horizons*, 12(1), 5-45) has directly and significantly contributed to the improvement of the quality and reputation of our Journal. With gratitude, we remember him with respect.

With the obituary written by *Predrag Mimovic*,

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dedicated to professor Thomas L. Saaty, Issue 3 of Volume 19, Year 2017 of the *Economic Horizons* scientific journal contains one original scientific paper, three review papers, the preliminary communication, the Subject Index of the papers published in the Journal in 2017, and the List of the authors and the titles of all contributions published in the *Economic Horizons* during 2017.

Starting from the premise that a well-designed fiscal policy is necessary for stabilizing an economic cycle and launching sustainable growth, *Nguyen Thi Nguyet* explores the relevant influences of the fiscal policy instruments on Vietnam's economic growth at the provincial level, during the period 2006-2015, bridging in that way the gap in research mainly focused on the national level. In addition to the importance of reliance on the appropriate theoretical framework that is explicitly pointed out, the limitations of previous research studies and the ways of their improvement are identified. Relying on the economic growth model, the descriptive statistics of the fiscal variables, the simple and multiple regressions, the fixed effects and random effects methods are employed in the empirical research. The hypothesis that the fiscal policy supports the provincial economic growth in Vietnam is confirmed by the obtained results. The introduction of the other control variables, such as monetary supply, the credit flow, and the total capital, as well as a longer period of time in order to facilitate the comparison between the periods of time with different fiscal policies, are singled out as relevant for further research.

Within the research in the relevant issues concerning pension frauds, the way of the strategic management of pension funds, as well as a possible reduction of these frauds with the aim of guaranteeing a sustainable pension scheme in Nigeria, *Amaka E. Agbata*, *Chizoba M. Ekwueme* and *Edirin Jeroh* have formulated and tested three hypotheses by employing

the multiple regression analysis models with the aid of Minitab version 17. The research results have shown that, despite the provisions stipulated in the Pension Reform Act (PRA), pension frauds are not significantly reduced, and the accumulated assets from pension funds have not been adequately diversified into profitable investment alternatives.

Relying on the assertion that the improvement of the supply chain performance results, in principle, in increasing the effectiveness of both the companies integrated into a supply chain and the entire supply chain as well, *Daniela Tadic* and *Aleksandar Djordjevic* develop a model for the evaluation and ranking of the companies involved in a supply chain based on the interval fuzzy numbers type-2 and the TOPSIS method. In accordance with the appropriate modeling of uncertainty and the modifications of the conventional TOPSIS method, the developed model is flexible in terms of changing the number of performances, their significance and values, and thus it can be employed for solving similar problems in different industrial branches. The proposed model has been tested on the real-life data from the automotive supply chain in Central Serbia.

After presenting the key features of some deterministic methods for claim reserving (the Chain Ladder Method, the methods based on the loss ratio calculations, The Average Cost per Claim Method, the Bornhuetter-Ferguson Method, the Stanard-Bühlmann Method) as well as the Methodology for calculating claim reserves prescribed by the National Bank of Serbia, *Zlata Djuric* and *Bojana Maracic* apply the most frequently used deterministic methods to the data of the operations of one insurance company in the Republic of Serbia (RS), within a single line of insurance, in order to determine the extent of the deviation of the projected amounts from the actual realization of the damage. In addition, the actuarial practice of non-life insurance companies operating in the territory of the RS has been considered with

the aim of revealing differences in the applied methodology.

Marking geotechnology as one of the fastest growing technologies in contemporary circumstances, *Vladimir Senic* considers some of the relevant dimensions of the analytical potential that geographical information systems (GIS) have in the provision and improvement of the different services of the public interest. The examples of good practice in the areas of health systems, the maintenance of public order and peace, rescue services and public administration have presented. It is concluded that "the analytical component of GISs allows decision-makers to manage much more rationally with the often limited available resources, while providing a higher level of the service quality to citizens as end-users".

On behalf of the Editorial Board and my own behalf, I would like to thank the authors of the contributions published in this Issue. At the same time, we owe special gratitude to the reviewers for their efforts and constructive and critical comments and guidelines for the authors of the submitted manuscripts.

Besides the detailed Subject Index of the papers published in the Journal in 2017, this Issue contains the List of the authors and the titles of all contributions published in the *Economic Horizons* in 2017.

At the end of this Editorial, we would like to inform the academic community that professor *Tomasz Rojek*, Cracow University of Economics, Faculty of Management, Cracow, Poland has become a member of the International Editorial Board of the *Economic Horizons* journal, starting from Issue 3 Volume 19 of the Journal.

Additionally, please be advised that the Ministry of Education, Science and Technological Development of the Republic of Serbia has financially supported the printing of the *Economic Horizons* journal by its Decision No. 451-03-381/2017-14-2 as of September 28, 2017.

Editor-in-Chief

Slavica P. Petrovic

*Slavica P. Petrovic* is a Professor at the Faculty of Economics, University of Kragujevac, the Republic of Serbia, in retirement from October 1, 2016. She received her PhD degree in Business Economics and Management at the Faculty of Economics, University of Belgrade, the Republic of Serbia. The key areas of her scientific interest and research are systems thinking, systems methodologies for structuring management problem situations, soft and critical Management Science, scientific research methodology.

## OBITUARY

### Thomas L. Saaty (18 July 1926 - 14 August 2017)

Predrag Mimovic\*

*Faculty of Economics University of Kragujevac, the Republic of Serbia*

Professor *Thomas L. Saaty*, a distinguished professor of the University of Pittsburgh, the designer of the Analytic Hierarchy Process (AHP) and the Analytic Network Process (ANP), a new theoretical and methodological approach to the decision-making process, passed away in August 2017.

Born in Mosul, today's Iraq, in 1926, and educated in Beirut, he arrived in the United States in the early nineteen-fifties.

He defended his doctoral dissertation titled: *On the Bessel Tricomi Equation in the field of mathematics in 1953, at Yale University, under the supervision of Einar Carl Hille.*

Professor T. L. Saaty worked at the Operations Evaluation Group of the Massachusetts Institute of Technology (MIT) at the Pentagon, the Office of Naval Research, and the Arms Control and Disarmament Agency at the U.S. State Department.

He began his academic career at the Wharton School of the University of Pennsylvania, as a professor of statistics and operations research (1969-1979), and moved to the University of Pittsburgh at the invitation of the dean, where he worked until his death, being

the most famous member of Joseph M. Katz Graduate School of Business.

He is the author (for example, Saaty, 1959; 1980; 1982; 1994; 1999; 2001; 2005) and co-author (for example, Dantzig and Saaty, 1973) of a large number of scientific papers in the field of mathematics, statistics, and operations research. A special place in his work belongs to the issues of the synthesizing impact and coordination of information in the decision-making process. On this basis, he developed the Analytic Hierarchy Process theory, based on hierarchical problem decomposition and the pairwise comparison of decision-making elements using the 1-9 comparison scale, and, shortly afterwards, extended it to the cases of dependence between the elements of the same or different levels, as well as the feedback loop, which has proven to be a very useful approach in the group decision-making process and in solving large and complex multi-criteria decision-making issues, both in business and in the macroeconomic area.

In recognition of the development and generalization of the AHP/ANP approach to multi-criteria decision-making, in 2005, he became a member of the National Academy of Engineering (NAE), a part of the National Academies of Sciences, Engineering, and Medicine (NASEM) of the United States of America. He received the Impact Award, awarded by the Institute for Operations Research and Management Science

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(INFORMS), for his contributing to solving complex decision-making issues.

Professor Thomas L. Saaty will remain remembered not only as an architect of decision-making theory, but also as a tireless traveler and researcher, an intellectual giant, who, with his creative and innovative approach, made a tremendous contribution to the development of Operations Research and Theory and Methodology of Decision-Making, and as “the man who changed the way things are measured”.

In the end, I would like to express my personal gratitude to Professor T. L. Saaty for the unselfish support he gave me during all these years, from the moment we first met in 2003. It was an honor to have the opportunity to personally meet and cooperate with him.

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## FISCAL POLICY AND PROVINCIAL GROWTH: THE CASE OF VIETNAM

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Hanoi City, Vietnam*

This paper focuses on the evaluation of the impact of the fiscal policy on the growth of Vietnam at the provincial level. A fiscal policy plays a huge role in a national economy. Policy-makers often use flexible fiscal and monetary policies to achieve the overall goal of economic growth. In order to assess the impact of the fiscal policy instruments on economic growth, integrated analyses combined with quantitative analyses are used in the paper so as to find the relationship between the key expenditure items. The government has an impact on economic growth. The results and methodology will elicit quantitative approaches in policy reviews.

**Keywords:** fiscal policy, fiscal decentralization, tax, expenditure, growth

JEL Classification: H30, H70, H20

### INTRODUCTION

Since the economic reform began in 1986, Vietnam has been making a shift into a socialist-oriented market economy, so it could not avoid the economic cyclicity of fluctuating up and down. So as to stabilize - "flatten" the economic cycle, the majority of countries in the world need the hands of the state to moderate the cyclicity of their markets. The fiscal policy is certainly one of the powerful instruments of the "hands of the state" with that respect.

Not only does an ineffective fiscal policy do harms to economic potentials and stability, but it may also cause an economic recession, and even lead to a political crisis and a comprehensive crisis as well. A public debt crisis that has been taking place throughout Europe, typically in Greece, Ireland and Portugal, is a practical piece of evidence for this assertion. Therefore, a prudent fiscal policy is required in order to stabilize the economic cycle and drive sustainable growth.

In the world, the fiscal policy is implemented in various ways; still, there are a lot of failures and controversial debates. The theory of the fiscal policy itself is not perfect because its development history is formed in the context of the "boundary"- often

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attached to a single country or a certain scope of space, rather than being adjusted in the new context of the “non-boundary” - integration and globalization, as it is the case today. Similarly, the monitoring of the fiscal policy in Canada, Sweden, Japan and the US or Chile shows that an expansionary fiscal policy is not always effective in stabilizing the economic cycle. Furthermore, the fiscal decentralization policy in China, Brazil, or India also delivers different impacts towards the stabilization of the economic cycle. Besides, there are many questions in place: why did the “golden rule” emerge and why has it been effective in the UK, but not in other countries as well? Why does Chile succeed in regulating its fiscal policy, on the one hand, whereas, on the other, it is not a powerful economy? So, what is it that determines the effectiveness of a fiscal policy? Where is the “golden key” to the fiscal policy needed to stabilize the economic cycle? Each policy has its own features and is associated with a different success. So, what are such conditions, which factors and instruments may enable us to determine the successfulness of a fiscal policy? All these show that the fiscal policy resembles an “art”, requiring a solid foundation of theory and practical experience. Therefore, this affirms the need for conducting a further research study of both theories and fiscal decentralization.

In Vietnam, since the financial crisis of 2008-2009, the great efforts the Government has made with respect to finding out the way out for the economy seem to be disabled. The Government has implemented the fiscal instruments in coordination with a monetary policy intervention; the most outstanding is the USD 8-billion-worth stimulus package intended to overcome the influences of the crisis. However, the economic growth has not met the expectations: there has been a significant drop in attracting FDIs; many public investment projects have been inefficient with an ICOR greater than 5; the inflation has become unexpectedly instable, and the same situation has been evident with respect to the interest rate in the financial and banking systems. On the other hand, because Vietnam is becoming more broadly and more deeply integrated into the world economy, the estimated trade openness of the country moves around 150%, which has been computed by having

taken into account the total import and export revenue over the GDP; the risk of macroeconomic instability is larger due to the fact that it has been suffering from the negative fluctuation of the world economy. Furthermore, there is evidence showing that the Vietnamese economy is cyclical and that the fiscal policy of Vietnam tends to be pro-cyclical, with an ever-increasing number of the limitations in the fiscal policy management (Nguyen, 2014; Le, 2017). If this pattern of the low efficiency of the fiscal policy continues to exist and apply, as it is a reality in other countries, its economy may be in danger of entering into a crisis with unpredictable consequences. Therefore, it is highly necessary to find out solutions to the right fiscal policy and there is also the need for coming to a comprehensive framework of the theories of the fiscal policy in order to stabilize the economic cycle.

The issue becomes more urgent when looking at reality up to date; Vietnam is still lacking in a comprehensive theoretical framework of the fiscal policy towards the stabilization of the economic cycle and in the new context of integration and globalization; this leads to the absence of the solid scientific basis suitable for the local conditions with the aim of adjusting and perfecting the fiscal policy, thus leading to sustainable development. Thus, the forecast and the policy recommendation and the planning and exercising of the fiscal policy are all but convincing and successful.

From the reality as the same has been described above, this project is expected to provide us with a theoretical framework of the fiscal policy towards stabilizing the economic cycle that would be coherent, comprehensive and updated to the largest possible extent. In the paper, the theories and the analytical models are systematized and the empirical studies are assessed so as to extract the experience lessons in monitoring the fiscal policy. On the basis of the theoretical and empirical research study, the paper will provide the scientific and practical bases and the arguments, and will be the founding study for further empirical studies in Vietnam afterwards, and for the most part, it will provide the theoretical bases as guidance to and directions for managing the fiscal

policy effectively in the current context, as well as the basis for the policy planning for future governments.

Therefore, based on an in-depth literature review, this paper concentrates on the main question of how the fiscal policy affected provincial growth in the period from 2006 to 2015, an episode of the strong market economy towards the socialist-oriented one in Vietnam, and which conditions supported the impact.

The hypothesis that the fiscal policy supports provincial economic growth is tested by applying the S. Devarajan, S. Swarop and H. F. Zou (1996) method with the OLS and random-effect models.

The answer may raise the policy implications for Vietnam so as to improve the efficiency of the fiscal policy. The remaining part of the paper is organized as follows: In Section 2, the employed methodology including the model, the variables, and the data is briefly described. Section 3 is focused on the empirical results and analysis. In the final section, the conclusions are given and certain policy implications are highlighted.

## LITERATURE REVIEW

### Literature Review in the World

The global financial crisis in the period from 2008 to 2009 once again showed the fact that economic cycles take place unpredictably, simultaneously forcing governments to intervene in the economy in order to limit its negative impacts on the operation of markets. In parallel with that, the studies of the role of the fiscal policy towards stabilizing the economic cycle have been executed so as to correctly assess the power of the fiscal instruments and the effectiveness of the Government's management of the policy. For example, X. Debrun and R. Kapoor (2010) construct a regression model in order to analyze the data of 49 countries, including both developed and developing ones. They find that automatic stabilizers reduce the variation in the output, so, these instruments could stabilize the economic cycle.

Having studied the fiscal policy in Chile, M. Gutiérrez and J. E. Revilla (2011) found that a prudent fiscal policy stance from the good times of the economy was very important for the government to follow a counter-cyclical fiscal policy in bad times and avoid the negative influence on the economic cycle. This implication can also be seen with M. Floden (2012) in the case of the Swedish economy during the past two decades.

Recently, there have been a larger number of the studies conducted that have placed an interest in the fiscal policy as a powerful instrument for the stabilization of the economic cycle. These studies focus on the modelling theories in order to implement an empirical research study based on the real data of economic variables. These models focus on estimating the fiscal multiplier in order to assess the link between the multiplier and the state of the economy. More specifically, estimated multipliers show how and to what extent the fiscal tools (will) result in and increase or decrease in aggregate demand; then, policy-makers would intervene in order to change the economic cycle through the multiplier effect. However, different estimation methods under different economic conditions derive the different and various results that show that the fiscal policy has multi-dimensional effects on the economic cycle itself. The following are the major studies analyzing the impact of the fiscal policy through constructing empirical models:

The SVAR (Structural Vector Autoregressive) model has been well-used to analyze the impacts of the monetary policy by B. S. Bernanke (1986), S. R. Aiyagari, L. J. Christiano and M. Eichenbaum (1992). O. Blanchard and R. Perotti (2002), however, are considered as the pioneers in applying this model in analyzing the impacts of the fiscal policy. They think that a discretionary fiscal policy does not contemporaneously respond to change in the economic output, so they construct a SVAR model, whose critical point is the technique of identifying fiscal shocks. Having applied the said model and technique in analyzing the data in the US for the period 1947-1997 in order to estimate the multiplier, the two economists concluded that the expansionary fiscal policy could raise the output; however,

government spending was crowding out with a part of private investment. The conclusion implies the fact that the fiscal policy bears both positive and negative impacts on the economic cycle.

Using O. Blanchard and R. Perotti's (2002) technique, another research study at the national level includes: R. Shaheen and P. Turner (2010), having applied it in Pakistan for the period from 1973 to 2008 found out that government spending generated positive impacts on the GDP level and the inflation, that the spending multiplier was positive in the short term, but the same was negative in the long run; the shocks in government spending, as well as the increase in the tax rate, led to an increase in the interest rate. These results imply that the expansionary fiscal policy may reduce a long-term output, although it may also raise an output in the short run, for which reason the same may negatively affect the economic cycle.

Applying SVAR to five countries in the OECD, R. Perotti (2005) had also been analyzing these five countries in the OECD approximately two years before and reaffirmed that the impacts of an increase in government spending or a decrease in the tax rate on the GDP are minor and that the same had a downtrend over time, that a multiplier greater than 1 could only be found in the US before 1980, and that a decline in the variance of fiscal shocks would lead to a decline in the GDP variations.

Apart from the technique offered by O. Blanchard and R. Perotti (2002), A. Mountford and H. Uhlig (2008) construct another SVAR model to assess the effects of the fiscal policy, but they apply another approach so as to identify fiscal shocks; the model purely utilizes the methodology of analyzing time series data, does not require an assumption about the non-contemporaneous response of the fiscal policy or another auxiliary information to identify fiscal socks as in O. Blanchard and R. Perotti (2002). This model could forecast effects due to innovation in the fiscal policy in the future, could distinguish change in the fiscal variable due to a fiscal shock, a business cycle or shocks in the monetary policy. Based on the quarterly data in the US for the period from 1955 to 2000, the two economists find that the best fiscal policy

is that intended to reduce tax and the cost of the expansionary fiscal policy in the long run is greater than the benefit achieved in the short run.

More recently, K. Mertens and M. O. Ravn (2012) have extended the SVAR model with respect to the assessment of the impact of the fiscal policy under the assumption that fiscal shocks could be anticipated, specifically a change in the tax rate; the authors do not find any policy anticipation effects on aggregate demand; a decrease in tax always influences an increase in the output, consumption and investment. Thus, the fiscal policy has a positive impact on the economic cycle through a tax instrument.

M. Baxter and R. G. King (1993) were the pioneers in using the GE model in order to quantify the impact of the fiscal policy. They found multiplier effects in the long run, associated with government spending, that a permanent change in government spending has greater effects than a contemporaneous change, and that public investment demonstrated great impacts on the output and private investment.

F. Lorenzo, M. Libero and S. Luca (2009) applied the DSGE model and added a proportion of non-Ricardian households in order to estimate the impacts of the fiscal policy in Europe, and the findings they came to have shown that the effects of government spending are minor. More specifically, change in fiscal variables seems to prolong, government spending leads to an increase in private consumptions in the short run, whereas changes in social welfare generate greater multiplier effects for the household; a cut in income tax and consumption tax strongly impacts the output and consumption, and a cut in capital income tax would influence private investment in the medium term, so these instruments of the fiscal policy could well be able to stabilize the economic cycle.

D. Furceri and A. Mourougane (2010) developed a fiscal DSGE model with an endogenous government bond yield so as to assess the impacts of the fiscal policy on the output, its components and the public debt pattern in the OECD countries. The simulations of the model show that the fiscal policy has positive effects on the other economic activities, especially in the short term. Bigger multipliers are found in

public investment, public spending and a decrease in income tax. The multipliers also depend on liquidity constrained to households; therefore, given the effectiveness of financial markets, the fiscal policy could help stabilize the economic cycle.

Some other studies applying the DSGE regarding the impacts of the fiscal policy could also be found in S. R. Aiyagari, L. J. Christiano and M. Eichenbaum (1992), V. A. Ramey and M. D. Shapiro (1998), A. Kriwoluzky (2009), V. A. Ramey (2008), F. M. Leeper, F. B. Walker and S. S. Jang (2008).

Apart from evaluating the role of the fiscal policy in stabilizing the economic cycle through the models of a quantitative analysis as previously mentioned, there is one method of identifying the fiscal stance that is widely used by the economists of the IMF, and that is the measuring of the fiscal impulse. The fiscal impulse is defined as the difference between the cyclical adjusted fiscal balance in the year  $t$  and the actual fiscal balance in the year  $(t-1)$ . The cyclical adjusted fiscal balance or structural fiscal balance means a balance with an assumption that the economy is operating at a potential output, keeping the economic conditions in the previous year unchanged. Therefore, the fiscal impulse is used to assess the impacts of the discretionary fiscal policy towards aggregate demand, and does not take the cyclical changes into account.

Increases in the structural deficit (surplus) will imply an expansionary fiscal impulse. In various periods of the economic cycle, the fiscal impulse can show that the fiscal stance of a country is either loose or tight. Therefore, the fiscal impulse can be used to assess the impacts of the fiscal policy on aggregate demand at a certain level. The fiscal impulse successively expands for the period of time when the economic output is already above the potential output, which means that the fiscal policy is not applied effectively, because the government is following a pro-cyclical policy rather than a counter-cyclical policy, which in the long run will have negative impacts on the stabilization of the economic cycle.

J. S. Garry (1986) studies and points out the different measurement of the fiscal impulse by the OECD and the IMF and the strength of such a different

measurement, illustrating it with the data in some countries, whereas P. Renee and J. John (2002) study and develop the indicators for the fiscal impulse that are appropriate for the assessment of the impacts of the fiscal policy on the economic cycle through the responses to the aggregate demand in New Zealand.

Economic theory suggests that fiscal decentralization (FD) would increase economic growth. The empirical findings, however, are much more ambiguous. H. Davoodi and H. Zou (1998) are probably among the first to have empirically investigated this question. They used a panel of 46 countries between the years 1970-1989 in order to measure the effect of the FD on growth and find a negative link between the FD and growth in developing countries, but no link in developed economies.

Still, other studies focus on a specific country, such as the US or China. N. Akai and M. Sakata (2002) analyzed a cross-section of the US states and found a positive link between decentralization and economic growth. D. Stansel (2005) analyzed a cross-section of the 314 US metropolitan areas and came to similar conclusions. Both studies rely on a constant measure of fiscal decentralization, which might be correlated with unobserved attributes at the state level. They also have a very limited sample size of 50 states. Indeed, their results fail to survive robustness checks. D. Xie, H. Zou and H. Davoodi (1999) provide us with a time series for the US data, and suggest that the relationship between decentralization and growth is non-linear, and that there is an optimal level of decentralization.

## Literature Review in Vietnam

Central Institute for Economic Management - CIEM (2010), the research study entitled "Fiscal-Monetary Policies Stabilizing Macroeconomics and Promoting Economic Growth in Vietnam", reviews the general situation when the fiscal and monetary policies in the recent years, especially in 2009, are concerned. The research study pronounces the different determinants that could affect macroeconomic issues and growth, and on this basis it provides a few suggestions for the implementation of these two policies in the short

run, in the medium run and in the long run, with the purpose of boosting growth in 2010 and years afterwards.

The CIEM (2011) - the research study entitled "The Fiscal Policy and the Budget System" reviews the regulation of the fiscal policy and the budget system of Vietnam with respect to some important items, such as: the budget revenue, government spending, decentralization in managing and using the state budget etc. The research study recommends some solutions to stimulate economic growth.

Studying the impacts of the stimulus packages of the government in response to the 2008-2009 global financial crisis, N. A. Nguyen, D. C. Nguye, D. N. Nguyen and T. H. Bui (2010) concluded that those fiscal solutions bear certain effectiveness associated with the positive effects of easing the monetary policy.

D. A. Vu (2011), a Ministerial-level research project: "Coordinating the Fiscal Policy and the Monetary Policy to Stabilize Macro-Economics and Promote Economic Growth over the Period 2006-2010", outlined a number of the issues regarding the coordination of the fiscal policy and the monetary policy in Vietnam during the past few years. Based on the study, he recommends some solutions to the coordination of the two policies with respect to the stabilization of macro-economics and driving growth for the period 2006-2010.

T. K. T. Nguyen (2013) mentions the pattern of coordinating the fiscal policy and the monetary policy, pointing out the limitations in the policy management and the recommendation; the author suggests that empirical models should be constructed so as to identify a suitable policy under specific circumstances and that a policy instrument should be quantified in order to assess the impacts of an individual policy on aggregate demand.

P. L. Nguyen and S. Anvar (2011) examines the impacts of fiscal decentralization on the provincial economic activities and finds that the decentralization of public investment exerted positive influences on the provincial economic growth over the period 2002-

2007, but that it also had negative influences over the period 1997-2001, the time immediately after the Asian financial crisis. This means that in the different phases of the economic cycle fiscal decentralization has different impacts on the provincial growth and the economic cycle of the country as a whole. The author also finds that, in both periods mention above, the decentralization of the current expenditure generates negative impacts on growth.

Besides, there have also been research studies focused on the role of the fiscal policy when the stabilization of the economic cycle is concerned. H. M. Dinh (2005), with the non-parameter approach to the constructing of the general indicators for the economic cycle, through the Period Average Trend (PAT) methodology and the maximization of the simple correlation coefficients, came to the study's preliminary results showing that Vietnam seems to have a growth cycle. Recently, D. T. Su (2013) has carried out a study of the impact of the Vietnamese fiscal stance over the period 1994-2008 by applying the approach of measuring the fiscal impulse and has demonstrated the fact that the fiscal policy in Vietnam tends to be pro-cyclical. However, the study only focuses on measuring the fiscal impulse for the period prior to the global economic downturn, and does not provide a comprehensive analysis of the impact of the fiscal policy on the stabilizing of the economic cycle in Vietnam.

### **The Limitations of the Earlier Research Studies and the Ways to Improve Presented in This Study**

The shortcomings of the existing studies in Vietnam are as follows:

- The theory of the fiscal policy in Vietnam and its role in stabilizing the economic cycle have been studied quite recently in the world, but in Vietnam no study really focuses on systemizing a framework of the various theories nor does any such study focus on providing a scientific basis containing guidance for a more-in-depth research study of reality. Therefore, most of the

existing studies have been focused on carrying out qualitative analyses until now.

- International studies concentrate on building quantitatively analytical models, which is considered as the approach that could correctly assess the role of each fiscal instrument, so the policy recommendations are very coherent. The domestic studies of this issue of interest cannot keep pace with those international in terms of their lacking a quantitative analysis due to a variety of reasons, one of these being the absence of a theoretical framework that would be used as the scientific basis for building an econometric model, which has led to a limitation in researchers' research capacity.
- There is no study that would coherently and comprehensively generalize the lessons experienced regarding the implementation of the fiscal policy in the world. Most of the existing studies are focused on the real situation of the fiscal stance in Vietnam in different periods, suggesting some policy recommendations, but they are lacking in empirical evidence.

Therefore, the project is expected to fill all the emptiness in the literature on the fiscal policy in Vietnam, both in terms of theory and practice, towards stabilizing the economic cycle. Firstly, the project systemizes the framework of the theories, the analytical models applied in many other countries. Secondly, it provides scientific guidance for the domestic researcher to appropriately develop these theories and models under the conditions prevailing in Vietnam. Thirdly, the project directly provides the theoretical basis to the empirical study of the case of Vietnam. Fourthly, the project reviews the overall lessons experienced regarding the implementation of the fiscal policy in the world in a coherent and comprehensive manner, comparing the theories and different practice, which further empirical studies could be implemented and a relevant policy recommendation generated from.

## METHODOLOGY

### The Research Model

In the study, quantitative methods are used with a regression analysis based on the model of the economic growth theory by S. Devarajan *et al* (1996). The data used for the regression analysis have mainly been obtained from the Ministry of Finance, the World Bank, the Asian Development Bank and the GSO data. The specific model is as follows:

S. Devarajan *et al* (1996) developed the model of economic growth that covers the structure of the components of government spending and distinguishes between the cost-effective and ineffective components. Accordingly, the production function is assumed to represent the performance of a constant scale, with the inputs of the components of capital and government spending.

$$Y = AK^\alpha G_1^\beta G_2^{1-\alpha-\beta} \quad (1)$$

Where  $Y$  is the output,  $K$  is the capital stock,  $G_1$  and  $G_2$  are the two components of government spending,  $A$  is the productivity level, and  $\alpha, \beta$  are the intensity using the factor of production.

Assume that government spending is financed by a fixed tax rate  $\tau$  on income, allowing the government to balance the budget in each period.

$$G = G_1 + G_2 = \tau Y \quad (2)$$

Call  $\phi$  is the share of the share of expenditure  $G_1$  in the total government expenditure. Then

$$\begin{aligned} G_1 &= \phi \tau Y \\ G_2 &= (1 - \phi) \tau Y \end{aligned} \quad (3)$$

The economy consists of the same households pursuing the goal of maximizing the benefits of their whole life cycle

$$U = \int_0^{\infty} e^{-\rho t} U(C) dt \tag{4}$$

With the benefit function of the form:

$$U = \frac{C^{1-\sigma} - 1}{1-\sigma} \quad \text{v\u011di} \quad \sigma \geq 0, \sigma \neq 1 \tag{5}$$

where  $C$  is consumption,  $1/\sigma$  is interchangeable elasticity and  $\rho$  is the discount rate. The capital accumulation made through investment comes from savings from after-tax income and consumption.

Call  $\phi$  is the share of the share of the expenditure  $G_1$  in the total government expenditure. Then

$$\dot{K} = (1 - \tau)Y - C - \delta K \tag{6}$$

in which  $\delta$  is the rate of the capital discount.

The optimal problem is established when the households maximize their life cycle benefits by choosing the level of drainage through the periods  $C$ , depending on the rate of capital accumulation.

$$\text{Max}_C \int_0^{\infty} e^{-\rho t} \frac{C^{1-\sigma} - 1}{1-\sigma} dt$$

$$\dot{K} = (1 - \tau)Y - C - \delta K$$

By combining Equations (1) and (2), the production function of the form is determined.

$$Y = A^{1/\alpha} \tau^{(1-\alpha)/\alpha} (\phi^\beta (1-\phi)^{1-\alpha-\beta})^{1/\alpha} K.$$

Then, the Halminton function:

$$H = \frac{C^{1-\sigma} - 1}{1-\sigma} + \varphi \left( A^{1/\alpha} (1-\tau) \tau^{(1-\alpha)/\alpha} (\phi^\beta (1-\phi)^{1-\alpha-\beta})^{1/\alpha} K - C - \delta K \right)$$

$$\frac{\partial H}{\partial C} = 0 \Rightarrow C^{-\sigma} = \varphi \tag{7}$$

$$\dot{\varphi} = \rho \varphi - \frac{\partial H}{\partial K} = \rho \varphi - \varphi (1-\tau) \tau^{(1-\alpha)/\alpha} - \delta \varphi \tag{8}$$

Take the time derivative of Equation (7)

$$-\sigma \frac{\dot{C}}{C} = \frac{\dot{\varphi}}{\varphi} \tag{9}$$

By combining Equations (8) and (9), we obtain the growth rate of consumption.

$$\gamma = \frac{\dot{C}}{C} = \frac{1}{\sigma} \left( A^{1/\alpha} (1-\tau) \tau^{(1-\alpha)/\alpha} \phi^{\beta/\alpha} (1-\phi)^{(1-\alpha-\beta)/\alpha} + \delta - \rho \right) \tag{10}$$

In the equilibrium growth state, all the consumer variables  $C$ , the capital  $K$  and the output  $Y$  increase at the same rate. It can be seen in Equation (10) that the economic growth rate depends on the tax rate, or, also, that a share of the government expenditures depends on the total output and a share of the government expenditures depends on the total government expenditures  $\Phi$ .

When the size of government spending is concerned, it is clear that government spending has two opposite effects on economic growth. The positive impact originates from the goods and services the government provides (a higher government spending will provide more public services that increase the marginal productivity of capital and thus boost economic growth). The section showing the negative impact of taxation (an increase in the taxes that

reduces after-tax income leads to reduced savings and a decrease in investment in capital and thus slows down economic growth).

The structure of government spending is determined by the composition of expenditure as a proportion of the total government expenditure. An assessment is made of the impact that government spending has on the effectiveness of each component of government spending. The composition of government spending is determined to be effective depending on the share of its impact on economic growth. Take the derivative of the economic growth rate under  $\varphi$

$$\frac{d\gamma}{d\phi} = \phi^{\beta/\alpha} (1-\phi)^{(1-\alpha-\beta)/\alpha} \left( \frac{\beta}{\alpha} \phi^{-1} - \frac{1-\alpha-\beta}{\alpha} (1-\phi)^{-1} \right) \quad (11)$$

If  $d\gamma/d\phi > 0$  as the share of government spending increases, that will increase economic growth. Then, the component of government spending is called effective for economic growth. On the contrary, if  $d\gamma/d\phi < 0$ , then the share of government spending increases, the economic growth rate decreases, and the component of government spending is consequently called ineffective for economic growth.

$$\frac{d\gamma}{d\phi} > 0 \quad \Leftrightarrow \quad \frac{\phi}{1-\phi} < \frac{1-\alpha-\beta}{\beta}$$

It can be seen that the effectiveness of each component of government spending depends on (1) the relative weight between this and other government spending components, and (2) the relative proportion between them. The intensity factor uses the inputs of the components of government spending in the production function. The composition of government spending is determined to be effective when its relative share of the expenditure component is less than the ratio of the factor of intensity using the inputs between the two components of expenditure.

## Variables

Regarding the independent variables, they are theoretically driven (Table 1).

**Table 1** The variables

Variables	Explanation
Dependent variable	
The growth of the GDP per capita	The growth of the GDP per capita
Independent variables	
FD: The growth of subsidies/GDP	FD: The Growth of the government subsidies per GDP
The growth of own revenue	The growth of the own revenue of the province
Automatic stabilizers	The automatic stabilizers of the fiscal policy
The direct tax rate	The direct tax rate per total revenue
The indirect tax rate	The indirect tax rate per total revenue
The rate of export-import revenue	The rate of export-import revenue per total revenue
The log of non-tax revenue	The log of non-tax revenue
Domestic revenue/central revenue	Domestic revenue per central revenue
The growth of investment per GDP	The growth of investment per the GDP of the province
Production expenditure	The production expenditure of the province
Central expenditure	Central expenditure
FDI per capita	FDI per capita
The technology gap	The technology gap compared to Ho Chi Minh city
CPI	CPI
The administrative level	The administrative level: Central Province: 1; 0 otherwise
The region	The region (6 regions)

Source: Author

## Data

The data used for the regression analysis have mainly been obtained from the Ministry of Finance (MoF), the World Bank, the Asian Development Bank and the GSO data. In addition, the observations with the missing values for the employed variables are excluded. Finally, the used dataset is an unbalanced panel data with 628 observations, with the descriptive statistics in Table 2.

## EMPIRICAL RESULTS AND DISCUSSION

### Regressions

In this section, the results of the simple and multiple

regressions regarding the impact of the fiscal policy in Vietnam at the provincial level are analyzed. In general, the output is presented stepwise for firm fiscal decentralization (FD), the fiscal factors, and the context factors in order to facilitate comparisons with each other (Table 3).

Adding central government spending to localities does not appear to be economically viable. The results of the analysis indicate that central government subsidies for unplanned expenditures by local governments do not only appear to have had the negative effects on fiscal decentralization, but also on economic growth. Locally, while many localities often have to borrow from the state budget, there are some localities that lend this money, so that they cannot recover the amount of up to VND 3,200 billion (Labor Newspaper 2008).

**Table 2** The descriptive statistics of the fiscal variables

Variables	Obs.	Mean	Std. Dev.	Min	Max	Source
The growth of the GDP <i>per capita</i>	630	1.915.742	1.394.837	-3.449.465	1.750.587	GSO
FD: The growth of the subsidies/GDP	630	5.932.826	4.484.662	-8.422.443	6.490.244	MoF
The growth of own revenue	628	3.367.285	1.589.821	-8.162.682	2.723.698	MoF
Automatic stabilizers	691	5.149.146	2.986.202	.9949532	1.774.037	MoF
The direct tax rate	693	1.881.201	2.080.891	0	2.177.335	MoF
The indirect tax rate	689	1.684.971	1.735.476	.0540735	1.057.244	MoF
The rate of export-import revenue	691	1.022.463	1.546.504	0	964.258	MoF
The log of non-tax Revenue	693	7.301.263	1.383.952	2.815.409	1.173.506	MoF
Domestic revenue/central revenue	693	.0090291	.0082562	.0004358	.0504733	MoF
The growth of investment per GDP	630	.9231978	3.738.582	-7.755.204	2.339.768	MoF
Production expenditure	693	7.941.014	.7621969	614.975	1.039.565	MoF
Central expenditure	693	1.336.722	.5147656	1.247.876	1.405.704	MoF
FDI <i>per capita</i>	693	2.698.958	5.021.977	0	4.942.017	GSO
The technology gap	693	-.0339105	4.405.962	-19	37	GSO
CPI	689	1.095.896	6.331.265	99.8	130.7	GSO
The administrative level	693	.0793651	.270503	0	1	GSO
The region	693	3.264.069	1.825.745	1	6	GSO

Source: Author

**Table 3** The effects of the fiscal policy on growth in Vietnam in the period 2006-2015, the OLS model

	(1)	(2)	(3)	(4)	(5)
	FD	Automatic stabilizers	Revenues-Taxes	Expenditure Structure	Context
FD: The growth of subsidies/GDP	-0.0899*** (0.029)	-0.0915*** (0.029)	-0.0866*** (0.030)	-0.0784*** (0.027)	-0.0590** (0.024)
The growth of own revenue	0.0049 (0.003)	0.0051* (0.003)	0.0026 (0.003)	-0.0031 (0.003)	0.0016 (0.003)
Automatic stabilizers		0.0283 (0.019)	-0.0563 (0.057)	0.3124*** (0.065)	0.1548*** (0.058)
The direct tax rate			-0.4405 (0.436)	-0.7629* (0.414)	-0.5832 (0.463)
The indirect tax rate			-0.0125 (0.086)	-0.0596 (0.085)	-0.0497 (0.067)
The rate of export-import revenue			0.1731* (0.099)	-0.1677** (0.085)	-0.0480 (0.065)
The log of non-Tax Revenue			-0.6459 (0.666)	0.1447 (0.810)	0.5477 (0.744)
Domestic revenue/central revenue			395.5550*** -143.396	-1.33e+03*** -217.090	-716.0049*** -203.205
The growth of investment per GDP				-0.0648*** (0.019)	-0.0571*** (0.019)
Production expenditure				11.813 -1.133	14.044 -1.038
Central expenditure				-20.7403*** -2.402	-11.0895*** -2.660
FDI per capita					0.0060 (0.021)
The technology gap					0.7265*** (0.125)
CPI					0.7291*** (0.070)
The administrative level					-4.1069* -2.262
The region					-0.2060 (0.317)
The constant	19.5378*** (0.578)	18.0950*** (0.912)	23.4128*** -4.097	287.2106*** -28.747	74.7736** -35.035
The observations	628	628	628	628	628
R <sup>2</sup>	0.083	0.086	0.122	0.260	0.396

The standard errors in parentheses

\* p<.10, \*\* p<.05, \*\*\* p<.01

An asterisk (\*), (\*\*), (\*\*\*) denotes the statistical significance at least at the 10%, 5%, and 1% levels, respectively. Model (1) presents the effects of Fiscal decentralization (FD) on the Growth of the GDP per capita of the province without the effect of the other factors. Model (2) presents the effects of FD on the growth and effect of Automatic stabilizers. Model (3) evaluates how the previous effects change under the effect of Revenues-Taxes. Model (4) investigates how these effects change under the effect of the Expenditure Structure. Model (5) presents the effects of the fiscal policy on growth under the context effect.

The results of the other explanatory variables in the model are the same as it was expected by the author. The export, human capital accumulation, the growth of the labor market growth, the growth of the financial market, inflation, education and employment are also the important factors affecting the local economic development of the 63 provinces. The city of Vietnam. The reform of the financial and monetary market in Vietnam during the period 2002-2007 has had a positive impact on local economic growth. Therefore, the monetary and financial market reform should be continued in order to promote the economy in the long run and to effectively absorb foreign investment as well. So, in the future, using financial systems to monitor the revenues and expenditures of local governments will help accelerate economic growth and improve the quality of fiscal decentralization locally.

Although the decentralization of the management of the fiscal policy is practicable for developing countries such as Vietnam, the central government should pay close attention to the investment activities in the localities. In the early stages of economic development, the central government should undertake strategic investment projects so as to ensure the macroeconomic stability of the state, continue to refine the local civil servants that are ineffective and the quality workforce in order to ensure that a contingent of civil servants can effectively manage the fiscal policy and meet the expectations of the people. Large projects and projects of a national strategic nature must be attended and supervised by local residents. Finally, the central government continues to reform its financial and monetary markets in order to ensure the distribution and monitoring of local government spending and expenditures. Consequently, wasteful spending and corruption in expenditures on capital construction will be reduced.

In addition to this, the Fixed Effects-FE and Random Effects-RE methods that are considered to be effective and optimal are used in this paper to a greater extent than the traditional methods such as the OLS. The selection of the optimal methods is performed by doing the Hausman test and the Breusch and Pagan test.

After evaluating and satisfying the tests such as the Hausman test and the Breusch and Pagan test done in order to ensure an accurate estimation (Table 4), the Random Effects (RE) method is the optimum method of choice. The RE estimation method provides us with the following results.

## CONCLUSION

The paper presents several contributions. The research provides an analysis of the effects of the fiscal policy on economic growth at the provincial level, bridging the gap in the recent research studies that are mostly focused on the national level. In addition, the findings will be supportive of the amending of annual and five-year provincial development planning in Vietnam. In addition, the investigation is emphasized by a comprehensive specification of fiscal decentralization, fiscal tools, the provincial-specific, regional and macroeconomic factors. Moreover, both the OLS model, with a robust option, and the Fixed Effects model are employed in order to help provide the unbiased estimates of the explanatory variables. As a further matter, the data cover the provinces in all the regions in the strongest period of economic globalization in Vietnam, from 2006 to 2015, which will help suggest an updated policy implication for Vietnam.

Generally speaking, the findings confirm the hypothesis that the fiscal policy in Vietnam supports provincial economic growth. The results encourage fiscal decentralization in terms of a reduction in the state subsidies intended for the province. There are the pieces of evidence that automatic stabilizers increase provincial economic growth in Vietnam. The findings have also confirmed that, in terms of indirect tax, the fiscal policy can successfully increase revenue, rather than it can be done by direct taxation. In addition to the said, the Vietnamese government should reduce the total budget expenditure at the central level so as to save the resource in order to sustainably develop its economic growth.

**Table 4** The effects of the fiscal policy on growth in Vietnam in the period 2006-2015, the random model

	(1) FD	(2) Automatic stabilizers	(3) Revenues- Taxes	(4) Expenditure Structure	(5) Context
FD: The growth of the subsidies/GDP	-0.0899*** (0.012)	-0.0915*** (0.012)	-0.0866*** (0.012)	-0.0784*** (0.011)	-0.0590*** (0.017)
The growth of own revenue	0.0049 (0.003)	0.0051 (0.003)	0.0026 (0.003)	-0.0031 (0.003)	0.0016 (0.003)
Automatic stabilizers		0.0283 (0.018)	-0.0563 (0.055)	0.3124*** (0.065)	0.1548*** (0.048)
The direct tax rate			-0.4405 (0.372)	-0.7629** (0.347)	-0.5832* (0.338)
The indirect tax rate			-0.0125 (0.102)	-0.0596 (0.098)	-0.0497 (0.053)
The rate of export-import revenue			0.1731 (0.109)	-0.1677 (0.107)	-0.0480 (0.050)
The log of non-tax revenue			-0.6459 (0.595)	0.1447 (0.727)	0.5477 (0.554)
Domestic revenue/central revenue			395.5550** -155.197	-1.33e+03*** -229.582	-716.0049*** -183.974
The growth of investment per GDP				-0.0648*** (0.013)	-0.0571** (0.022)
Production expenditure				11.813 -1.309	14.044 (0.979)
Central expenditure				-20.7403*** -2.288	-11.0895*** -2.375
FDI per capita					0.0060 (0.013)
The technology gap					0.7265*** (0.110)
CPI					0.7291*** (0.059)
The administrative level					-4.1069* -2.314
The region					-0.2060 (0.251)
The constant	19.5378*** (0.550)	18.0950*** -1.091	23.4128*** -3.863	287.2106*** -28.001	74.7736** -30.310
The observations	628	628	628	628	628
R <sup>2</sup>					

The standard errors in parentheses

\* p<.10, \*\* p<.05, \*\*\* p<.01

An asterisk (\*), (\*\*), (\*\*\*) denotes the statistical significance at least at the 10%, 5%, and 1% levels, respectively. Model (1) presents the effects of Fiscal decentralization (FD) on the growth of the GDP per capita of the province without the effect of the other factors. Model (2) presents the effects of FD on growth and effect of Automatic stabilizers. Model (3) evaluates how the previous effects change under the effect of Revenues-Taxes. Model (4) investigates how these effects change under the effect of the Expenditure Structure. Model (5) presents the effects of the fiscal policy on growth under the context effect.

Source: Author

The government should launch a comprehensive master plan for a medium and long-term fiscal and monetary policy, in which the balance-of-payments and public investment balances should be calculated in conjunction with the research. The total means of payment and credit growth. In the time of the need for restructuring investment today, the Government needs to have specific studies for each sector of public investment that can reasonably allocate state capital. In addition, the government needs to closely monitor public investment so as to ensure the effectiveness of these funds.

Besides, the paper has some limitations that a further research study may eliminate. The other control variables, such as monetary supply, the credit flow, and the total capital. A further research study could investigate a longer period of time in order to facilitate the comparison between the periods of time with different fiscal policies.

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## THE ANATOMY OF PENSION FRAUD IN NIGERIA: ITS MOTIVES, THE MANAGEMENT AND FUTURE OF THE NIGERIAN PENSION SCHEME

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The study determined how the administration of the Pension Scheme could be perked up in Nigeria through effective management that would reduce fraudulent practices apparent in the scheme. By following the precept of library research via the survey design, a 5-point Likert Scale questionnaire was designed to educe primary information about pension matters from a sample of 435 knowledgeable respondents. The collected data were presented and analyzed. Three hypotheses were formulated and tested based on Multiple Regression Analysis models with the aid of Minitab version 17. The findings show that, despite the provisions of the Act (the Pension Reform Act - PRA), intents for committing Pension Fraud have not reduced to a significant extent. Also, the accumulated assets of pension funds have not been adequately diversified into profitable investment alternatives. Therefore, we recommend that, among other things, amendments should concertedly be made to the PRA to at least discourage acts of pension frauds by instituting severe punitive measures for culprits, while simultaneously inculcating moral ethics among public servants in Nigeria.

**Keywords:** National Pension Commission, pension funds, pension fraud, Pension Reform Act, pension fund administrators, pension fund custodians

JEL Classification: G23, G28, H55

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### INTRODUCTION

The development of a viable and workable pension scheme in Nigeria has always been clamored not only by pensioners, but also by notable stakeholders and the general populace. This is the reason why the

Government of Nigeria decided to adopt the structure of the Chilean-Styled Pension Scheme as a way of dealing with the challenges posed by the previously adopted defined benefit scheme. According to Y. Demola (2008), this decision of the Federal Government of Nigeria has changed the funding structure of the pension scheme in the country from the usual Pay-As-You-Go (PAYG) to the Contributory Pension Scheme (CPS).

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The CPS came in force through the enactment of the Pension Reform Act (PRA) of 2004, which again was revised by the PRA, 2014 (Onyeonoru, Matthew & David, 2013; Adeniji, Akinnusi, Falola & Ohunakin, 2017). G. Mesike and A. Ibiwoye (2012) avers that the design of the CPS is such that the associated risk/burden of retirement financing was shifted from entirely that of the Government to that majorly of individuals. Experts believe that the CPS is presumably better than the old pension scheme, except for the incidence of fraud and mismanagement. No doubt, various models and pension scams have evolved over the years given the changes evident in pensions and their attendant schemes (The Pension Regulators, 2015).

In fact, the argument has been that an insight into the pension affairs of some Ministries, Departments, and Agencies (MDAs) clearly indicates the evidence of the pension fraud that has negatively affected the success of the CPS. The perpetrators of such pension frauds are partly the management, upon whom such funds have been entrusted. Their motivation for indulging in a pension scam may not be different from the same motivation identified with the other forms of frauds. K. Tasker (2012) observes that pension fraudsters feel that they have a need which is either a real financial need or a perceived need, such as a desire for material goods. While fraud and/or pension scams continue with a varying and alarming magnitude, it is believed that, if uncontrolled, their effect on the overall success of the CPS will be detrimental. It is on the basis of the said that this study attempts to address the issues of pension fraud and how the strategic management of pension funds and possible fraud reduction could guarantee a viable and formidable scheme in the country. Specifically, this study attempts to:

- determine the effect of the Pension Reform Act (PRA) and its provisions on the motive for committing a pension fraud in Nigeria;
- measure the degree of the diversification of the Pension Fund Assets (PFA) into profitable investment opportunities;
- ascertain whether the anti-fraud measures provided by the PRA are effective in significantly reducing pension fraud in Nigeria.

Given the specific goals of this study, the following hypotheses were designed and subsequently tested:

Hypothesis One:

H<sub>O1</sub>: The provisions of the PRA have not reduced to a significant extent the motive for perpetrating a pension fraud in Nigeria.

H<sub>A1</sub>: The provisions of the PRA have reduced to a significant extent the motive for perpetrating a pension fraud in Nigeria.

Hypothesis Two:

H<sub>O2</sub>: PFAs are not adequately diversified into profitable investment opportunities.

H<sub>A2</sub>: PFAs are adequately diversified into profitable investment opportunities.

Hypothesis Three:

H<sub>O3</sub>: The anti-fraud measures provided by the PRA are not effective in significantly reducing pension fraud in Nigeria.

H<sub>A3</sub>: The anti-fraud measures provided by the PRA are effective in significantly reducing pension fraud in Nigeria.

Given the aforementioned, this study relies on a survey design to generate relevant data for the analytical purpose; and the testing of the hypotheses is based on the multiple regression technique via Minitab 17.0. The remaining part of this paper deals with a conceptual and literature review, the anatomy and overview of the pension fraud/pension scam in Nigeria, the theoretical framework, an empirical review, the methods employed in the study, the results, the findings and the discussion, whereas the concluding part presents the recommendations.

## CONCEPTUAL AND LITERATURE REVIEW

### The Meaning of "Pension"

The word "pension" has majorly occupied the minds of researchers and public/civil servants in

Nigeria. According to J. O. Odia and A. E. Okoye (2012), a pension occurs in a system where persons pay into identified schemes (the pension scheme) the proportions of their earnings/entitlements during their years of active service/work life. Such contributions provide earned income (or a pension) on retirement. In his definition, F. O. Ogwumike (2008) affirms that pensions are regular payments by employers to their respective employees after retirement, which usually is expected to continue till the death of such employees. According to T. M. Fapohunda (2013), a pension is the amount jointly set aside by both employers and their employees so as to ensure that workers are not financially stranded in their old age (i.e. after retirement). There are instances where pensions are payable to pensioners' next of kin subsequent to the pensioners' death, for an identified time frame though.

Similarly, O. I. Eme, O. A. Uche and I. B. Uche (2014a) see a pension as periodic income or annuity payments made at or after the retirement of the employees who may have become eligible for such benefits through their respective age, earnings and/or services. It is in view of these definitions that the Auditing Practices Board - APB (2011) categorized pension schemes into two main types: Occupational Pension Schemes (OPS) and Personal Pension Schemes (PPS). The OPSs are the schemes run by employers for the benefit of their employees, and, from an employee's viewpoint, are linked with employment; on the other hand, however, the PPSs are the schemes or individual arrangements intentionally designed by individuals. The APB (2011) further sub-divided the OPS's into three viz: Defined Benefit (or Earnings Related) Schemes, Defined Contribution (or Money Purchase) Schemes, and Hybrid Schemes. According to the APB, the Defined Contribution Pension Scheme refers to any pension scheme whose arrangement is such that an individual member's benefit would basically be determined with reference to the contributions paid into the scheme by such a member, and increased or decreased over time by an amount that succinctly reflects investment return on those contributions. The applicable CPS in Nigeria is a form of this type of scheme.

## **The Anatomy of Pension Fraud**

Fraud connotes all deliberate acts designed to deceitfully and intentionally extort, distort, omit, misrepresent or conceal material facts for personal gains. It is what E. I. Okoye (2016) defined as an enemy to productivity. Fraud also refers to intentional acts designed to pervert the truth and take possession of the financial benefits and resources that belong to others or the inducement of parties to part with their valuables, belongings, legal rights and financial resources (Vasiu, Warren & Mackay, 2003; Okoye & Akenbor, 2009; Okoye, 2016). Explicitly, fraud connotes all multifarious channels of human ingenuity designed to intentionally obtain advantage over others through falsehood, tricks, concealment, deception, dissemblance and the containment of the truth deployed to cheat others (Okoye, Okafor & Ijeoma, 2009; Nenyiaba & Okoye, 2015). Fraud is usually employed with the intent of dishonesty aimed at depriving others from their rights to properties, financial resources and the like, thus making it a crime to humanity and punishable by laws when perpetrators are found culpable.

Owing to growth in pension funds over time, in addition to the multiplicity of complaints about retirees' accrued and unpaid pensions in different states of the federation, a lot of concerns have been raised and stakeholders have wondered continuously about what may probably have led to situations where after retirement the pensioners' entitlements remained unpaid over a number of years. Experts (Omah, Anifowose & Ogundina, 2013; Nweke, 2015) have argued that fraud seems to be prevalent in the administration and management processes of the operational pension schemes in the country over the years. In his study, K. B. Olayinka (2010) notes that some risks are associated with pension schemes, their management and administration. Such risks may occur either in the short or long run. Prominent among the several forms of the risks associated with pensions are believed to be related to the management of pension funds and may be in the guise of the poor management of the PFAs, misappropriation and other forms of corrupt practices.

A. Owojiri (2008) states that in the administration of a PF the ability of individual managers to identify and manage all identified associated risks will determine the level of effectiveness and efficiency in the operation of PFs. In line with this, E. Davis (1993) argues that a prudent diversification and indexation of the accumulated PFs, both in the foreign and the domestic markets, appear to be important in reducing any risks associated with PFs.

Additionally, T. M. Fapohunda (2013) believes that a viable investment of PFs will ensure a prompt and regular payment of retirees' and pensioners' entitlements. Similarly, good investment decisions will reduce the embezzlement and/or mismanagement of PFs by fraudsters or incompetent administrators of such funds.

However, given the belief that the creation of regulatory bodies would help in establishing ethical standards and reduce fraud in the management of PFs and other related matters, the Federal Government of Nigeria established the Economic and Financial Crimes Commission (EFCC) in 2003. Sadly, the coming of the EFCC neither put an end to nor reduced the existence of fraud in Nigeria, especially not so in the pension industry. Also, despite the several provisions and anti-fraud measures of the Act of 2004 (PRA, 2004) and its subsequent revision (PRA, 2014) with the main aim of protecting PF assets the effective functioning of Nigeria's contributory pension scheme to date is yet to be guaranteed. In their study, S. R. Sipe, C. T. Metrejean and W. Donaldson (2015) state that, although the proper underlying framework for preventing and detecting pension fraud exists, there is yet a need for regulators to increase their efforts. Undoubtedly, numerous scandals have trailed Nigeria's pension scheme in recent times, so the need for the proper and efficient management of such a scheme to at least prevent further pension scams/frauds cannot be overemphasized (Fapohunda, 2013).

### **An Overview of Pension Fraud in Nigeria**

Nigeria has no doubt witnessed the notable and alarming cases of the outrageous acts of fraud that have led to multiple litigations, along with the arrest

of several public office holders. The most alarming of them all is the highly canvassed "MAINAGATE". Noteworthy is the fact that prior to the alleged pension fraud of A. A. Maina, several other cases had surfaced on the front pages of national dailies since 2005. Succinctly, over N273 billion have been looted through pension scams in Nigeria between 2005 and 2011. According to E. Akinkuotu and I. Onuba (2016), the Nigerian anti-graft agency (EFCC) arrested a N. Mayshak with her 3 accomplices (P. Iyogun, Y. Youssoufou and R. Imonikhe) over a N2.5 billion fraud. Investigations according to the EFCC revealed that N. Mayshak, who was the Director General (DG) of the Pension Transitional Arrangement Directorate (PTAD), had misappropriated approximately N2 billion from the balances of sums in the pensions' accounts of different government establishments/parastatals, which, among others, included the Nigeria Prisons, the Nigerian Custom and the Immigration Services, respectively. Additionally, a take-off grant of about N500 million intended for the PTAD was said to have been embezzled by the DG of the PTAD through a procurement fraud within her 3-year tenure.

In another streak, I. Omah, A. D. Anifowose and J. A. Ogundina (2013) highlight the menace of pension fraud in the country, which they see as the concomitant debacle given the brigade of the enlisted ghost pensioners that misrepresented genuine pensioners for the purpose of siphoning the pension funds in Nigeria over the years. Several reports of the EFCC had revealed the involvement of highly placed government functionaries in multiple embezzlements and pension scams. There are cases where the directors, deputy directors, heads of service, and even clerks, drivers and domestic staff of some of these government functionaries masterminded the diversion and lodgment of billions of pension funds through illegal bank accounts.

Interestingly, the Government had to set up the Pension Reform Task Team (PRTT) headed by A. A. Maina. At its onset, the PRTT uncovered the cases of pension scams, and working closely with the EFCC, efforts were made to recover some of the loots from various pension fund accounts. However, around mid-2010, there were indications that even the PRTT themselves had become fraudulent by having partaken in the squandering of over N2 billion,

allegedly spent on obtaining the biometrics of the pensioners of the office of the Federation's Head of Service. As of 2011, other revelations indicated that the head of the PRTT (A. A. Maina) had been accused and indicted of awarding phony contracts and questionable spending binge (Omah, Anifowose & Ogundina, 2013).

As noted by allAfrica (2012), reports from various committees set up to investigate the allegations against A. A. Maina and his PRTT further revealed that ₦1.6 billion had been spent as the running cost for police pensions, whereas the amount appropriated for that purpose was ₦80 million. Also, ₦830.8 million was purported to have been spent to pay the pensions for June 2010 through the issuance of cheques rather than via the agreed e-payment system. There were allegations of the dubious and questionable enrolment of retirees in the pensioner payroll. Additionally, about ₦234 million was spent on pensioners' biometrics, which was completed about 90% at that point; yet, no files were created, no document or data were made available as a piece of evidence for the captured pensioners to that effect. Again, without resort to the country's Embassy/High Commission, about ₦17 million was said to have been spent on further biometrics and the verification of the pensioners residing outside the country (Pensioners in Diaspora - PID), whereas the available records reveal that as at that time, the so-called PIDs were not up to 30 persons.

U. Awom (2012) disclosed that the further reports of the Senate's *ad-hoc* committee set up to probe the management/administration of Nigeria's pension funds were revealing. There were indications of massive fraud and dubious collaborations intentionally designed to loot billions of naira. A further observation was that banks were handy collaborators in the unauthorized and illicit opening of the Government's accounts, changing/amending the existing signatories, transferring funds, depositing the Government's funds and the copious deprivation of financial transactions. Specifically, the same A. A. Maina that was commissioned to protect the pension funds was found to be deeply involved in the theft, confiscation, diversion and malicious

spending binge of the pension funds. To perfect his ordeal, O. Agbedo (2017) reported that A. A. Maina had been purported to have used a number of staff and members of his team (PRTT) along with their associates and contractors to unethically receive payments for the biometric enrolment and the non-existent contracts. The sums had also been paid and received for inflated contracts, only to ultimately be remitted to A. A. Maina, based on prior agreements and arrangements.

Through a complex web, A. A. Maina was accused of having laundered billions of naira along with his family members, account officers, associates and other corporate entities/contractors. In a letter of EFCC addressed to the office of the Attorney General of The Federation (AGF), the PRTT under the leadership of A. A. Maina spent a whopping sum of N5,761,150,608.44 on the alleged fictitious contracts, in addition to the N829,902,260.40 paid to ghost workers. Additionally, about N1,365,821,942.91 was looted under the auspices of collective allowances, whereas N4,192,825,310.99 was said to have been stolen under the guise of payments to the Pension Boards of various states. As noted by O. Agbedo (2017), the above sums are not inclusive of the N2,290,593,322.35 claimed to have been paid to the National Union of Pensioners and the N253,390,300 paid to the Association of Federal Public Service Retirees without a clear piece of evidence of the payments and the receipts. Given these and other indictments, A. A. Maina was removed and suspended from office, and a series of investigations, along with those of the other suspects, have been launched into his activities by concerned and relevant agencies.

### **Fraud Perpetrated Against the Pension Scheme**

According to the KPMG (2005), the typical examples of frauds perpetrated against the pension scheme include: Beneficial Fraud - This is where the members of the scheme or their relatives claim or continue to benefit beyond their entitlement; Third Party Fraud - This includes a theft from the scheme's bank accounts by the presentation of altered or false cheques; Trustee

Fraud - Trustees themselves steal from the scheme or misuse its assets; Staff Fraud - This is where the staff or officials charged with the responsibilities of managing the scheme engage in fraudulent acts, such as creating fictitious pensioners and/or beneficiaries and making pension payments to themselves through the accounts of such fictitious pensioners. Others include: Employer Fraud, and Trust Busting (Pension Liberation).

In furtherance of the foregoing, ACCA (2003) provides good examples of frauds within identifiable pension schemes, such as: Misappropriation (of funds and assets); Non-payment of contributions by the employer; Borrowing by the employer. This could be done directly or through using assets as collaterals for borrowing; Buying or selling of assets by trustees without the required mandate or authority.

### Motivations for Fraud

According to KPMG (2005), fraud risk in pension schemes is not likely to be driven by the dire need to attain certain financial targets, but rather for personal financial gain. Such motivations as observed by CIMA (2009) are typically based on greed. Personality and temperament are the likely motivations for fraud generally, and pension frauds in particular. CIMA (2009) also observed that individuals might be tempted, especially when confronted with ruins and predicaments beyond their immediate financial control. All such motivations for fraud are generally not different from what is obtainable as regards occupational fraud, which pension fraud stands as a notable example of. In this light, experts (Osisioma, 2009; Okoye, 2016) have identified several motivations for occupational frauds and abuses to include a desire to live beyond one's means, an overwhelming craving for personal gains, an excessive personal debt, a proximate alliance with customers, a poor pay compared to the job schedule, an uncontrollable desire for gambling and other social activities, undue pressure from the family and peers, etc.

### The Theoretical Framework

The Theory of Differential Association (DAT) provides an appropriate theoretical base for this study. DAT was developed by Edwin H. Sutherland in order for him to explain why individuals commit various crimes/fraud (Sutherland, 1939). The basic assumption in this theory is that by interacting with others, people tend to appreciate and learn the attributes, values and techniques of, approaches to, and motivations for criminal behaviors. The Differential Association thus predicts that individuals are bound to choose or opt for criminal paths where the equilibrium of the definitions of misdemeanor or wrongdoing exceeds the balance of honesty or law abiding. Given the antecedents of pension frauds and scams in Nigeria, we observed that the motive/drive for such frauds/scams may have been learnt through exposures and interactions with earlier culprits. The fact that the act is inborn to some is not overruled. More so, the arguments have been that the traits of pension frauds in the country were bred by the weaknesses or gaps inherent in the provisions of the PRA of 2004 and its subsequent revision/update in 2014. With the above, this study is driven by the tenets of DAT.

### An Empirical Review

The studies of the PRA of 2004 and its subsequent revision of 2014 that led to the establishment of the Contributory Pension Scheme (CPS) abound. There are also studies of the various forms of fraud in the country, though with little emphasis on pension fraud, which is the crux of this study. In this section, the studies of the CPS and pension frauds/scams have been reviewed.

In a study by I. Omah, A. D. Anifowose and J. A. Ogundina (2013), an exploratory examination was done with respect to pension fraud and the supra-administrative system of pensions in the country. The survey method was used to obtain a public opinion through the questionnaires specifically designed for the purpose of the study. The analyses of the findings indicate, *inter alia*, the dominance of fraud managers in the acclaimed corridors of power. The researchers

therefore called for the rehabilitation/restructuring of pension administration in Nigeria.

A. S. Iyortsuun and K. T. Akpusugh (2013) explored how the lifestyle of employees could effectively be managed after retirement. The data obtained from secondary and primary sources were sought. Through the survey design, the disproportional stratified method of sampling was employed to select the required sample of the study. The descriptive and inferential statistics were based on the results of the computed simple percentages and the chi-square ( $X^2$ ) statistical test for the hypothesis. The findings led to the conclusion that a myriad of challenges like fraud, corruption, inefficiency, governance, regulatory challenges, etc. had scuttled the success of the country's ongoing pension reform.

T. M. Fapohunda, (2013) conducted a study of the management of the pension systems in Nigeria by examining the attendant features and prospects *vis-a-vis* the challenges of the existing schemes since they form the important aspects of retirement planning. Following the businographic design, the study relied on the data obtained from secondary sources (official publications, paper clippings and the documentations of the relevant agencies and authorities). Among other things, the findings were indicative of the fact that sharp practices like fraud had impinged the success of pension management and administration in the country, whereas, as he noted, for reforms in pension to be remarkable or successful, stakeholders would need to be sincere and committed to the objectives of the reform agenda of pension schemes.

By employing a survey design, E. Nwagwu, (2014) examined how the new CPS could be managed through transparency/accountability. The study specifically sought to know whether transparency/accountability was maintained in managing the consolidated pension fund evident in the new CPS. In total 478 questionnaires were administered in the south-eastern part of the country to the employees and pensioners of Federal Universities, Pension Funds Custodians (PF.Custods), Pension Funds Administrators (PF.Admins) and the officials of the

National Pension Commission (PENCOM), who had randomly been selected for the study. Based on their specific objectives, the hypotheses were formulated and tested by the student T-test statistics. Overall, the findings indicated that until then, in managing pension funds, transparency/accountability had been maintained by the administrators and custodians of pension funds in Nigeria. The study, therefore, recommends that, among other things, licensed operators should ensure that all pension funds are insured so as to guarantee safeguard in the case of an economic crash.

O. I. Eme, O. A. Uche and I. B. Uche (2014b) did research in the popular police pension scam that was investigated by the Senate of the Federal Republic (Nigeria). The study specifically sought to detail the background information about the scam, the investigations and the findings. It discovered that debauched public officers massively laundered, embezzled, squandered and diverted public pension funds into accounts of private individuals and their associates without being indicted and/or halted. The researchers thus suggest a reversion to the earlier position of keeping the pension funds of MDAs with the CBN in order to minimize the recurrent abuse of such funds by pension officials through unauthorized lodgments with deposit money banks.

## METHODS

The survey method is the method adopted in this study. The study's population consists of 435 accountants, auditors, finance officers, pensioners, the members of the personnel/officers of PENCOM, the officials/administrators and custodians of pension funds and the officials/civil servants of the selected institutions/establishments in Anambra State, Nigeria. The sample size was determined by using the Taro-Yamane method of the sample size determination and a sample size of 417 was calculated for the study. The data utilized were basically those assembled from a primary source through a well-structured questionnaire, designed by applying the

conventional 5-point Likert scale. The assembled data were collated, presented and analyzed via descriptive statistics (tables, percentages, and frequencies) and inferential statistics (the test of the hypotheses). The statistical technique adopted in testing all the formulated hypotheses was the Multiple Regression Analysis with the aid of Minitab Version 17. The acceptable hypothesis is that in which R<sup>2</sup> (the coefficient of determination) lies between ninety five to one hundred percent (95-100%), and *vice versa*.

**RESULTS AND DISCUSSION**

In this section, the results obtained after having tested the hypotheses were presented together with the relevant discussions.

**The Test of the Hypotheses**

In testing the formulated hypotheses in this study, the general model for multiple regression analysis was followed as stated below:

**General Regression Analysis: Yield (Y) versus X1, X2, X3**

Hypothesis One - Regression Model:

$$\text{Yield (Y)} = -33.4147 + 1.05808 X1 - 1.36237 X2 + 1.72301 X3$$

**Table 1** Summary of Model

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$$R\text{-Sq} = 91.19\% \quad R\text{-Sq}(\text{adj}) = 90.34\% \rightarrow R\text{-Sq}(\text{pred}) = -54.58\%$$


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Source: Authors, the result output from Minitab Ver. 17

The indications accounted for in Table 1 reveal that R<sup>2</sup> was 91.19% (Adj R<sup>2</sup> = 90.34%), meaning that the independent variables have a below 95% explanatory ability of explicating the behavior of the dependent variable. Similarly, the F-Value in the regression model is 13.4719, whereas the F-Values for the independent variable were 18.5827, 1.0640 and 1.0738, respectively (Table 2).

**Table 2** Analysis of Variance (ANOVA)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	3	42454.4	42454.4	14151.5	13.4719	0.197047
X1	1	41282.2	19520.0	19520.0	18.5827	0.145115
X2	1	44.2	1117.6	1117.6	1.0640	0.490136
X3	1	1128.0	1128.0	1128.0	1.0738	0.488666
Error	1	1050.4	1050.4	1050.4		
Total	4	43504.8				

Source: Authors, the Results of the Analyzed Field Survey Data (2015) by using Minitab Ver. 17

Furthermore, given the regression model, since the coefficient of determination (R<sup>2</sup>) of the variance is 91.19% < 95%, the conclusion is that the provisions of the PRA may not have reduced to a significant extent the motive for perpetrating pension fraud in Nigeria. This is more visible in the p-values of 0.197047, 0.145115, 0.490136 and 0.488666, respectively (Table 2), which in all of the cases is greater than 0.05. With this result, the alternate hypothesis is rejected, whereas the null hypothesis implying that the provisions of the PRA may not have reduced to a significant extent the motive for perpetrating pension fraud in Nigeria is accepted.

Hypothesis Two - Regression Model:

$$\text{Yield (Y)} = 11.7215 + 1.139 X1 - 0.851003 X2 + 0.565115 X3$$

**Table 3** Summary of Model

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$$R\text{-Sq} = 91.83\% \quad R\text{-Sq}(\text{adj}) = 91.31\% \rightarrow R\text{-Sq}(\text{pred}) = -66.73\%$$


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Source: Authors, the result output from Minitab Ver. 17

The suggestions presented in Table 3 bring to light the fact that R<sup>2</sup> was 91.83% (Adj R<sup>2</sup> = 91.31%), meaning that the independent variables have a below 95% explanatory ability of explicating the behavior of the dependent variable. Similarly, the F-Value in the regression model is 15.0143, whereas the F-Values for the independent variable were 2.2267, 0.0362 and 0.0206, respectively (Table 4).

**Table 4** Analysis of Variance (ANOVA)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	3	26451.5	26451.5	8817.18	15.0143	0.186960
X1	1	26371.8	1307.6	1307.63	2.2267	0.375866
X2	1	67.7	21.3	21.27	0.0362	0.880271
X3	1	12.1	12.1	12.08	0.0206	0.909329
Error	1	587.3	587.3	587.25		
Total	4	27038.8				

Source: Authors, the Results of the Analyzed Field Survey Data (2017) by using Minitab Ver. 17

Furthermore, given the regression model, since the coefficient of determination ( $R^2$ ) of the variance is  $91.83\% < 95\%$ , the conclusion is that Pension Fund Assets (PFAs) may not have been adequately diversified into profitable investment opportunities in Nigeria. This is more visible in the p-values of 0.186960, 0.375866, 0.880271 and 0.909329, respectively (Table 4), which in all of the cases is greater than 0.05 (sig. level). With this result, the alternate hypothesis is rejected, whereas the null hypothesis that PFAs are not adequately diversified into profitable investment opportunities is accepted.

Hypothesis Three - Regression Model:

$$\text{Yield (Y)} = -1.14617 + 0.352241 X1 + 0.486815 X2 + 0.175307 X3$$

**Table 5** Summary of Model

R-Sq = 85.85% R-Sq(adj) = 83.39% → R-Sq(pred) = 69.60%
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Source: Authors, the result output from Minitab Ver. 17

The Table 5 reveals an  $R^2$  of 85.85% (Adj  $R^2 = 83.39\%$ ), meaning that the independent variables have a below 95% explanatory ability of explicating the behavior of the dependent variable. Similarly, the F-Value in the regression model is 7.69386, whereas the F-Values for the independent variable were 0.21303, 0.44607 and 0.07492, respectively (Table 6).

**Table 6** Analysis of Variance (ANOVA)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	3	13153.0	13153.0	4384.32	7.69386	0.257651
X1	1	12555.4	121.4	121.39	0.21303	0.724714
X2	1	554.9	254.2	254.19	0.44607	0.625128
X3	1	42.7	42.7	42.69	0.07492	0.829916
Error	1	569.8	569.8	569.85		
Total	4	13722.8				

Source: Authors, the Results of the Analyzed Field Survey Data (2017) by using Minitab Ver. 17

Furthermore, given the regression model, since the coefficient of determination ( $R^2$ ) of the variance is  $85.85\% < 95\%$ , the conclusion is that the anti-fraud measures provided by the PRA may not have been effective in significantly reducing pension fraud in Nigeria. This is more evident in the p-values of 0.257651, 0.724714, 0.625128 and 0.829916, respectively (Table 6), which in all of the cases is greater than 0.05 (sig. level). With this result, the alternate hypothesis is rejected, whereas the null hypothesis that the anti-fraud measures provided by the PRA may not have been effective in significantly reducing pension fraud in Nigeria is accepted.

## CONCLUSION

The study of the anatomy of pension fraud in Nigeria x-rays the concept of pension and pension fraud/scam and analyzes the various fraud schemes perpetrated against the pension scheme in Nigeria. The efforts were devoted to finding probable reasons for such fraudulent schemes and the manners in which pension fraud could be curtailed through the effective management of pension funds. By adopting the survey design, the data obtained were accordingly subjected to analysis and the results were very revealing. From the analyzed data and the reviewed literature, it was observed that the existing pension schemes in Nigeria may not have proven to be successful due to

the rampant and alarming cases of pension fraud that have remained non-grasped to date.

The outcome of this study has thus contributed to knowledge by proving that fraud has consistently remained a bottleneck to efficiency in the management of pension funds in Nigeria. Most importantly, it was observed that, despite the much canvassed efforts of several Nigerian Governments in reforming the pension schemes and their subsequent revisions in the country, the provisions of the current PRA may not have significantly reduced the intent/motive for fraud in the management/administration of pensions in Nigeria. Sadly, public officials engaged by the Federal Government to fight pension fraud in the process have grossly involved themselves in various pension scams involving billions of naira. The situation is consequent upon the fact that the anti-fraud measures/provisions stipulated in Nigeria's PRA are not strong enough to reduce an increasing and incessant level of pension fraud in the country.

Interestingly, the evidence obtained from the test of the hypotheses further reveals that PFAs have not been judiciously diversified into other investment alternatives yet, although the provisions of the PRA envisage that pension funds' assets belong to investable assets. Though the effective management of pension funds may not be an easy task to perform, the officials involved in such management are expected and ought to be rational decision-makers and managers. When not properly invested, the perils of fraud are bound to exist. More so, where the existing and potential motivating factors are not dealt with, pension fraud persists. Therefore, if fraud is reduced or even eliminated from the process of managing pension funds, Nigeria will have a good pension scheme of her dream.

This study, however, is limited by the scope, as the analysis carried out was based on the primary data obtained from the stakeholders in the south-eastern part of the country. In view of this, we suggest that future researchers should attempt to synergize with the National Bureau of Statistics (NBS) and the other relevant statutory bodies so as to obtain secondary

data on a broader scope. By means of multivariate and correlation analyses, efforts could be made to determine the magnitude of pension fraud in Nigeria and thus establish whether there is a correlation between the management of pension fraud, the PRA and a reduction and/or increase in the cases, the amounts and the magnitude of pension fraud/scam in the country as a whole.

The following recommendations have been put forth:

- Additional provisions and subsequent revisions must urgently be added and made, respectively, to the existing PRA. Such provisions and/or revisions must specifically be tailored for the purpose of reducing to a significant extent the opportunities and drivers of pension frauds by instituting severe punitive measures for culprits. The provisions should also be able to reduce to a significant extent the intent for committing pension fraud, while simultaneously inculcating moral ethics among public servants in Nigeria.
- Administrators (PF.Admins) and Custodians (PF.Custods) tasked with the management of pension funds are thus encouraged to be rational investors in their investment decisions concerning PFAs by investing in different portfolios that are worthwhile to invest in, as an adequate diversification of PFAs into profitable investment opportunities will minimize the risk of PFAs exposure to fraud.
- Since the current anti-fraud measures have not successfully reduced pension fraud to a significant extent, it is thus suggested that PENCOM should again recommend the National Assembly to pass into law the implementation of additional anti-fraud punitive measures, such as life imprisonment, outright killing, the permanent denial/refusal of the right to any political position and permanent banishing from oversea vacations and travelling, as these will bring about fraud reduction and will also serve as a deterrent against potential pension fraudsters.

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**Review paper**

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## MODEL FOR THE SUPPLY CHAIN MANAGEMENT BASED ON THE INTERVAL TYPE-2 FUZZY NUMBERS AND THE TOPSIS METHOD

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The Performance improvement that leads to an increase in business efficiency, both for the enterprises integrated in the supply chain and the entire supply chain, represents one of the basic strategic management problems. A solution to this problem, among other things, can be obtained by measuring and improving the performance of the supply chain, which simultaneously represents the basic purpose of this research study. The relative importance of performances and the values of their key performance indices are assessed by decision-makers. Their assessments are described by linguistic variables, which are modelled by interval fuzzy numbers type-2. The relative importance of performance is obtained by defining the fuzzy matrix of the relative importance of each pair of performances. The weight values of performances are calculated by means of the eigenvector method. Performance values are calculated by using the fuzzy middle-value operator. The rank of the enterprises, with respect to all of the considered performances as well as their weights, is determined by applying conventional TOPSIS. The ranking of the enterprises integrated in the supply chain can be marked as the main result of the research. On the basis of the obtained rank, appropriate measures can be taken to improve the performance of those enterprises that are rated the worst by respecting all the observed performances. The proposed model has been tested on the real life data from the automotive supply chain operating in Central Serbia.

**Keywords:** supply chain performance, interval type-2 fuzzy numbers, fuzzy AHP, TOPSIS, management measures

JEL Classification: C69, L62

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### INTRODUCTION

Supply chain (SC) management represents one of the most important issues, both in the practical and the

theoretical domains. The considered issue is very complex and consists of a number of sub-problems. One of the sub-problems that has a critical impact on the effectiveness and competitive advantage of the SC is measuring and continuously improving the performance of the SC. This issue is especially important for the automotive industry SC that may

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significantly contribute to the sustainable economic development of each country, especially in developing countries. The automotive industry can be seen as a potential stimulus for entrepreneurship by creating new markets and developing a number of the jobs that require higher skills and knowledge. In other words, the enhancement of the efficiency and effectiveness of the SC business in the automotive industry leads to the development of the region which the SC exists in, as well as the development of entire countries.

The subject matter of the research conducted in this paper is the evaluation and ranking of the enterprises involved in the LS, respecting the LS performance. The evaluation of the SC performances and their Key Performance Indicators (KPIs) can be obtained based on decision-makers' assessments. They base their assessments on their knowledge, experience, and evidence data. Decision-makers use linguistic statements to describe the values of the existent uncertainties. It is a well-known fact that it is far easier for decision-makers to express their knowledge and experience in a natural language than to map them into a scale of measures. The concept of the linguistic variable has been introduced by L. Zadeh (1975), and it was defined as the variable whose values are words, and not numbers. The modelling of linguistic variables can be carried out by applying various theories, such as the probability theory, the theory of fuzzy sets (Zimmerman, 2001), and the theory of rough sets (Pawlak, 1998). As is well known, the modelling of uncertain data by random variables requires a large number of relevant data from the records. Due to a rapid and continuous change in the environment, to provide enough accurate data can be said to be almost impossible. The rough set theory (Pawlak, 1998) can be efficiently used to analyze uncertain and incomplete information modelled by a closed interval. This can be identified as the main advantage of the rough sets theory in relation to the fuzzy sets theory (Zimmerman, 2001), in which uncertainties are described by the function of the distribution of possibilities, although, by comparing the rough sets theory and the fuzzy sets theory, the fuzzy sets theory can be said to have advantages in the modelling of inaccurate and vague data (Zhai, Khoo & Zhong, 2009). In this paper, all uncertainties

are modelled by applying the interval type-2 fuzzy numbers that represent a special case of generalized type-2 fuzzy sets. It should be emphasized that generalized type-2 fuzzy sets require huge and complex mathematical, and therefore do not reflect bigger changes in describing and modelling the uncertainties that exist in real problems.

The main objectives of the research study presented in this paper are to rank companies within the supply chain, whereas the derived objectives of the research are to identify the performance of the SC and its KPIs, the modelling of uncertainties in the relative importance of performances and the values of their KPIs by means of interval type-2 triangular fuzzy numbers (Chen & Lee, 2010; Kahraman, Öztayşi, Sarı & Turanoğlu, 2014; Zhang & Zhang, 2017), determining the weights of performances by applying the relative importance of performances, determining the ranks of the enterprises that are integrated in the SC by using the TOPSIS method and undertaking appropriate management initiatives in order to improve the performances of the enterprise, which is further propagated so as to increase the effectiveness of the business SC and its competitive advantages.

The basic hypothesis set out in this paper may be expressed as follows: the priority of the measures that should lead to the improvement of the performances of the enterprises integrated in the SC can be based on the ranking of the considered enterprises.

In literature, a large number of developed methods can be found for measuring and improving the performances of the enterprises which different economic activities are carried out in. However, there are almost no papers that consider the problem of assessing the enterprises that are connected in the SC with the respectability of the SC performances.

Motivation for the research originates from the above-mentioned fact and the assumptions that the application of precise methods for the evaluation of the enterprises integrated in the SC can provide more accurate results, on the basis of which measures for improving the business operations of the SC are defined.

The paper is organized in the following manner: a brief review of the relevant literature is provided in Section 2. The representation of the SC performances and their KPIs is shown in Section 3. The modelling of the existing uncertainties and the proposed algorithm are accounted for in Section 4. The proposed procedure is illustrated by the data obtained in the automotive SC industry that operates in a real environment. The conclusions are presented in Section 5.

## LITERATURE REVIEW

A brief review of the literature related to the discussed problem is given in this section. As is known, SC management is based on the determination, measurement, and the improvement of the performances of SCs and their KPIs. A. D. Neely, M. Gregory and K. Platts (1995) suggest that the continuous monitoring of performance values and taking measures based on the performance values can lead to the increased effectiveness and efficiency of SC management.

In the traditional SC management approach, management teams are commonly focused only on a single performance, most often on costs. By measuring and improving only one SC performance, it is not possible to achieve the improvement of all or at least the majority of the strategic goals defined at the SC level. In literature, there are numerous and diverse approaches proposed for solving the problem of determining the SC performances and its KPIs. Some authors believe that by determining the performance of any organizational system it is possible for the SC to be based on the results of the best practice (Coccoa & Alberti, 2010). J. Anitha (2014) believes that the identification of the performances should be based on the analysis of the data obtained by a survey. The validity of the results (in this case, it is a set of the SC performances) can be confirmed by applying a regression analysis. B. M. Beamon (1999) grouped all SC performances into the three groups: the performance resources, outputs and flexibility. Respecting the requirements of ISO 9001: 2008 and the results of good practice in (Nestic, Djordjevic,

Puskaric, Zahar Djordjevic, Tadic, & Stefanovic, 2015; Tadić, Đorđević, Erić, Stefanović, & Nestić, 2017), the production SC performances are defined. In the paper (Ramesh & Kodali, 2012), the results obtained from the numerous literary sources were summarized, and a list of performances for the lean production SC was proposed. In this paper, the SC performance is determined according to the recommendations defined in the Supply-Chain Operations Reference (SCOR) (Bolstorff & Rosenbaum, 2003) model, and they are described in Section 3. It is a well-known fact that performance values can be obtained by measuring or that they may be based on the decision-maker's decision.

As is known, performance values can be obtained by measuring or they can be based on the decision-maker's assessment. Decision-makers can use pre-defined measuring scales to reflect their stands onto a set of real numbers. In literature, many measuring scales are used, such as the standard scale of measures in (Coccoa & Alberti, 2010). The mapping of assessment onto a set of linguistic statements instead of a set of precise numbers is far closer to the human way of thinking and, therefore, is more precise. Bearing this fact in mind, many authors suggest the use of linguistic expressions to describe performance values (Nestić *et al*, 2015). The modelling of linguistic expressions in the paper (Nestić *et al*, 2015; Tadić *et al*, 2017) is based on the theory of fuzzy sets (Zimmeramn, 2001; Dubois & Prade, 1980). In other words, these linguistic expressions are modelled by applying triangular fuzzy numbers. In (Nestić *et al*, 2015), the task of the assessment of the relative importance of each performance is set as a fuzzy group decision-making problem. The aggregated value of the decision-maker's assessments was obtained by using the fuzzy weighted aggregation operator (FOWA) that is widely used in literature (Merigó & Casanovas, 2008). The overall value of each performance is calculated as a product of relative importance and the estimated value, and is described by the triangular fuzzy number based on the fuzzy algebra rules (Dubois & Prade, 1980).

The numerous performance measurement methods developed in different mathematical and logical

frameworks can be found in literature. These methods have been developed so as to measure the performances of the organizational systems that differ between themselves in their size, the economic branch which they belong to, the way of connection, and so on. Furthermore, a brief retrospective of some of the performance measurement methods is shown.

The most widely used method for measuring performances in the enterprises in which different economic activities are carried out is the Balanced Scorecard (BSC), developed by S. R. Kaplan and P. D. Norton (2008). By applying this approach, it is possible to determine performance values in different perspectives. In this way, a balance between long- and short-term goals, as well as that between financial and non-financial performances, is possible to establish. The BSC approach makes the transformation of strategic goals into a performance set possible. It is necessary to apply the BSC approach at each level of management in order to achieve better results of performance measuring (Behery, Jabeen, & Parakandi, 2014). In this manner, goal setting, setting priorities for the achievement of the goal and the allocation of the resources are significantly simpler compared to the other methods for performance measurement presented in literature. With the use of the BSC approach it is possible for managers to relatively easily maintain or improve the defined management strategy.

M. Hakimollahi, S. J. Naini, M. Bagherpour, S. Jafari and A. Shahmoradi (2012) have developed a method for measuring the performances based on the BSC approach with the fuzzy-interferential mechanism. The KPI performance values defined in each BSC perspective are determined by applying the fuzzy if-then rules. The assessment made by experts of the KPIs values was determined based on their knowledge and experience. In (Nestić *et al*, 2015) the rank of KPIs at the level of all of the considered processes, simultaneously respecting all the enterprises, was obtained by using the continuous fuzzy numbers comparison method (Baas & Kwakernaak, 1977; Dubosi & Prade, 1980).

Many authors suggest that the determination of performance values can be defined as the task of

multi-criteria decision-making (Saranga & Moser, 2010; Feili *et al*, 2011). The estimates of the relative importance of KPIs at the level of each performance and their values were obtained by conducting a survey in (Feili *et al*, 2011), involving decision-makers from different enterprises belonging to the same industrial branch. The decision-makers responded to the questions defined in the survey by using the predefined linguistic expressions, modelled with triangular fuzzy numbers. The aggregated value of the decision-makers' assessments was calculated as the geometric mean of the assessments that were obtained from all of the experts participating in the survey. The weighted aggregate values of the KPIs within each performance were calculated as weight and assessment value products. The KPIs priority at the level of each performance was obtained by using the fuzzy Analytical Hierarchical Process (AHP), developed in (Chang, 1996). H. Saranga and R. Moser (2010) suggest the use of the Data Envelopment Analyses (DEA) method for determining performance values. In (Tadić *et al*, 2017), uncertainties in the relative importance of performances and their values are described by the linguistic expressions modelled with a triangular fuzzy numbers. The fuzzy pair-wise comparison matrix of the relative importance of performances was set. The processing of uncertainty was carried out by using the extended analysis method, developed in (Chang, 1996). The normalized performance values were obtained by applying the linear normalization procedure (Shih, Shyur & Lee, 2007). The elements of the weighted normalized fuzzy decision matrix were calculated as a calculated weight and an assessed performance product. The fuzzy positive ideal solution, the fuzzy negative ideal solution and the coefficient of approximation, on the basis of which the performance ranges were determined, were calculated as they were with the conventional Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), developed in (Yoon & Hwang, 1981).

According to the requirements of ISO 9001: 2015, it is necessary to perform the continuous improvement of business processes. This is achieved, among other things, by improving the performance of the processes themselves. In this way, the appointed business goals can be almost fully realized. Performance

improvement is achieved by applying the appropriate management measures that are either defined in the standard by the quality system procedures implemented in enterprises or the same may be defined by decision-makers, on the basis of their own knowledge and experience. In the papers analyzed in this section, the priority of the measures corresponds to the priority of the enterprises integrated in the SC.

By comparing the proposed model with the models that have been developed and shown in this paper, the differences can be noted and they are further discussed. On the basis of the obtained results, it is possible to clearly see the advantage of the model developed in this paper, in relation to the papers published in literature.

Performance determination is a task of great importance because it affects the entire decision-making process. In this paper, SC performances are determined on the basis of literature (Bolstorff & Rosenbaum, 2003) and it can be assumed that the performance list is more consistently defined than in the other applied methods presented in (Coccoa & Alberti, 2010; Anitha, 2014; Nestić *et al.*, 2015).

The relative importance of KPIs and their values are assessed by decision-makers by using the predefined linguistic expressions (Feili *et al.*, 2011; Nestić *et al.*, 2015). The use of linguistic variables can be said to allow decision-makers to better express their opinion, rather than use a scale of measures, as presumed in (Kaplan & Norton, 2008; Coccoa & Alberti, 2010). Uncertainties in the relative importance of performances or KPIs, as well as their values, are described by the interval type-2 fuzzy numbers (Chen & Lee, 2010; Kahraman *et al.*, 2014; Zhang & Zhang, 2017). It is assumed that the interval type-2 fuzzy numbers can better describe uncertain and imprecise data (Chen & Lee, 2010) when it is impossible to determine the shape of the distribution of the possibilities function of the type-1 fuzzy number in the exact way (Castillo & Melin, 2012). Based on these assumptions, the modelling of uncertainty in this paper was performed in an improved way than it is the case in the papers found in literature (Feili *et al.*, 2011; Nestić *et al.*, 2015). It is closer to the human way of thinking to express the relative importance of performances by applying

the fuzzy matrix of pairs, rather than by applying the direct estimation method (Nestić *et al.*, 2015). In this paper, the pair-wise fuzzy matrix of the relative importance of the performances was set (Feili *et al.*, 2011). Also, in the proposed method, the consistency of the decision-maker's judgment was carried out by the defuzzification of the interval type-2 phase numbers in the first step (Kahraman *et al.*, 2014), and then in the second step, the method of the eigenvector was applied, as defined in the conventional AHP method (Saaty, 1990), so as to verify the consistency of the decision-makers' judgments. The developed procedure presents one of the differences between the proposed method for determining the weight of the performances and the methods presented in (Feili *et al.*, 2011). The management measures to be taken in order to improve the performances of enterprises and the SC are based on the ranking of the enterprises. In this paper, as in all of the analyzed papers found in literature, management measures are considered to be defined by decision-makers based on their knowledge and experience. In the paper (Nestić *et al.*, 2015), the application of the genetic algorithm determines the optimum value of improvement for the selected performance, which provides an opportunity for decision-makers to better select the management initiatives. The main disadvantage of the proposed method is the lack of a procedure for determining the optimum value of performance improvement.

## SUPPLY CHAIN PERFORMANCE

In this paper, the problem of the ranking of the enterprises integrated in the SC with respect to their performances is considered. The SC is assumed to consist of one focal organization and a larger number of the enterprises that can be viewed as the focal organization providers. Such a structure is common for the automotive industry SC. Within this assumption, it can be said that almost all the products used in the assembly process within the focal organization are produced in providing enterprises. The effectiveness of each enterprise's processes affects the efficiency of the final assembly process, as well as the realization of both the operational and the strategic

objectives of the automotive industry SC. Formally, the considered enterprises can be represented by a set of indices  $E = \{1, \dots, e, \dots, E\}$ . The total number of the companies considered is  $E$ , whereas each enterprise index is denoted as  $e, e = 1, \dots, E$ .

The degree of the achievement of the SC business objectives can be determined based on the value of the performances of the enterprises integrated in the SC. The SC performances are defined in appropriate standards or models (Bolstorff & Rosenbaum, 2003). In this paper, the SC performances are defined by SCOR (Bolstorff & Rosenbaum, 2003), which is widely used in literature and in practice. In addition, the SC performances are briefly described, and they also represent the performances of the enterprises that are integrated in the considered SC.

## Complexity

The concept of complexity has been studied in the framework of the graph theory (Bezuidenhout, Bodhanya, Sanjika, Sibomana & Boote, 2012), the SC theory (Pathak, Day, Nair, Sawaya & Kristal, 2007), and other theories. Hence, there is no unique definition of the complexity of the SC term. C. Y. Cheng, T. L. Chen and Y. Y. Chen (2014) implicated that the SC complexity was influenced by a number of factors, such as the size, the degree, and the intensity of the relationships between entities. Quite minor changes in complexity are known to lead to a reduction in the degree of the accomplishment of the placed business goals. The complexity value at the level of each SC entity can be determined based on the estimated values of the KPIs of the SC complexity.

In this paper, the KPIs are determined according to L. Xu, Y. Li, K. Govindan and X. Xu (2015), and they are as follows: (1) the complexity of the environment, (2) the complexity of the production process, (3) operational complexity, and (4) the complexity arising due to the integration of the entities. The value of the complexity of the environment can be assessed with respect to the data on the demand variability. Taking into consideration the information about the complexity of receiving and storing both raw materials and semi-

finished products, the complexity of technological procedures and the methods of the quality control of the processes, semi-products and products, it is possible to estimate the value of the complexity of the production process. The value of operational complexity can be determined by respecting the data on complexity, regarding the processes of production planning and control, internal transport, quality control methods, necessary knowledge and skills, and others. The complexity that arises from the integration of the SC entities is influenced by the number of such entities, the number of the hierarchical levels of each entity, and the links that exist between the entities within the SC.

## Uncertain Demand

In recent decades, in almost all SCs, it has been possible to see that the deviation between a planned quantity and real demand has been on an increase. These deviations have appeared due to the many changes that have been occurring: (a) in SCs, according to T. Maiti and B. C. Giri (2016), which occur due to the lack of relevant information about the changes related to production and demand costs over time; and (b) in the environment, e.g. the development and rapid application of new technologies, customer demand changes, and so forth. Uncertain demand leads to many difficulties in planning the production of the enterprises associated with the SC (Felfel, Ayadi & Masmoudi, 2016).

A number of KPIs have been considered in literature, on the basis of which the value of uncertain demand can be determined. In this paper, the KPIs of uncertain demand are determined according to C. Y. Wong and S. Boon-itt (2008), and they are as follows: (1) customer uncertainty, (2) technological uncertainty, (3) the economic situation, (4) market competitiveness, and (5) law regulation. The decision-makers have based their assessments regarding the first KPI values on the pieces of information related to the types and quantities of the products required by customers, changes in delivery times, and the delivery flexibility. Every complete SC can be said to be characterized by a lack of reliable information which decision-makers

can assess the value of customers' uncertainty on. The uncertainty of demand can be significantly reduced if the SC is customer-, rather than product-oriented (Frohlich & Westbrook, 2002). Technological uncertainty is mostly affected by the technological level of a company. It is known that the higher the technological level, the lower a technological uncertainty. This also applies vice versa. The assessment of the economic situation (Bolstorff & Rosenbaum, 2003) is related to the market growth, the gross domestic product, the unemployment rate, the mortality rate, and so on. The value of the market competitiveness can be estimated by taking into consideration the price of a product by a competitive SC, the time of the delivery of the final products, and the degree of the innovation of competitive SCs (Pal & Kumar, 2008). The business of the enterprise in the SC must be in accordance with valid legal propositions.

## Quality

Predicting demand and determining the product quality are based on the requirements that come from an environment that is rapidly and continuously changing. In order to meet all the requirements, it is necessary that the quality management system should be integrated in any enterprise that is part of the SC. In this way, it is possible to achieve an improvement in the production process in each company, and therefore in the SC as well.

In literature, different KPIs classifications of the considered performances can be found (Bolstorff & Rosenbaum, 2003; Sadikoglu & Zehir, 2010). In this paper, those KPIs that are defined in (Bolstorff & Rosenbaum, 2003) are adopted: (1) the capability, (2) the critical success factors, (3) the strategic components, and (4) the operational components. Many researchers suggest that capacity assessment depends not only on a product quality, but also on the reliability of the delivery, the trust that exists between the focal organization and the enterprise, etc. The value of the critical success factors is assessed according to the results of the integration related to external stakeholders (Kuei & Madu, 2001), as well as to the quality of leadership in the SC (Kupers,

2000). The values of a KPI, which is designated as a strategic component, are assessed with respect to organizational culture and technology management. The assessment of the value of the operational component is based on the information about the extent to which the demand of the focal organization and the volume of the production of the networked enterprises differ, which the company development policies are, and so on and so forth.

## Added Value

Added value is defined as the difference between the price of the product and the cost of production. In recent years, the management of many SCs considers this to be one of the most important SC performances (Presutti, 2003). Based on the results from literature, it can be concluded that the added value of almost every product varies very much over time, and that these variations occur primarily due to changes in production costs.

The KPIs of this performance are defined according to the literature data: (1) the average value of the income of the stakeholder, (2) an increase in the profit, (3) the utilization of the property in possession, (4) communication within the SC and with customers, and (5) the SC's social responsibility.

## MODELING OF UNCERTAINTIES

This section presents the method for the modeling of uncertain and imprecise data in the relative importance of the performances and their values at the level of the considered enterprises. The interval fuzzy set of the type-2 is represented by the function of the distribution of possibilities. The upper and lower functions of the interval type-2 fuzzy set are the functions of the distribution of the possibilities of the fuzzy set defined in (Dubois & Prade, 1980; Zimmermann, 2001). The parameters of this function are the shape, granulation, and domains. The distribution of the functions of opportunities is determined on the basis of subjective assessments made by decision-makers, and the same should

reflect the knowledge of such decision-makers of the uncertainties involved. In literature, trapezoidal and triangular interval type-2 fuzzy numbers for the description of numerous and varied uncertainties (Chen & Lee, 2010; Kahraman *et al*, 2014; Zhang & Zhang, 2017) are the most commonly used ones. Granulation is defined as the number of the fuzzy sets that are associated with each considered uncertainty. Some authors (Lootsma, 1997) believe that the decision-maker can use up to seven linguistic statements to describe uncertainty. In this paper, the relative importance of performances can be described by the five linguistic expressions and their values at the level of each enterprise by the application of the seven linguistic expressions modeled by the interval type-2 triangular fuzzy numbers. The domains of these fuzzy numbers are defined at a closed interval in a set of real numbers.

#### The Selection of Appropriate Linguistic Expressions to Assess the Relative Importance of Performances and the Values of Their KPIs

Respecting the type and the size of the problem, it was assumed that the real value of each pair of the SC performances can be adequately described by applying the five linguistic expressions modeled by the interval type-2 triangular fuzzy numbers in the following way:

very low importance -  $\tilde{W}_1 = ((1,1,3.5;1), (1,1,2.5;0.75))$ ,

low importance -  $\tilde{W}_2 = ((1,2,4;1), (1.5,2,3.5;0.75))$ ,

medium importance -  $\tilde{W}_3 = ((1,3,5;1), (2,3,4;0.75))$ ,

high importance -  $\tilde{W}_4 = ((2,4,5;1), (1.5,4,4.5;0.75))$  and

the highest importance -  $\tilde{W}_5 = ((2.5,5,5;1), (3,5,4,5;0.75))$ .

The domains of these interval type-2 triangular fuzzy numbers are defined on a set of real numbers within the interval [1-5]. Value 1, or Value 5, indicates that the performance  $p$  has the same relative importance, i.e. the highest importance, in relation to the performance  $p'$ ,  $p, p' = 1, \dots, P$ , respectively.

The overlapping of the defined interval type-2 triangular fuzzy numbers used for the modeling of the relative importance of the SC performances is higher because there is insufficient knowledge of their priority.

The KPI values for each of the considered performances are described by applying the seven linguistic expressions modeled by the interval type-2 triangular fuzzy numbers, as is shown below:

very small (VM) -  $((1,1,2.5;1), (1,1,2;0.6))$ ,

small (M) -  $((1.5,3,4.5;1), (2,3,4;0.6))$ ,

almost middle (GS) -  $((2.5,4,5.5;1), (3,3.5,5;0.6))$ ,

middle (S) -  $((3.5,5,6.5;1), (4,5,6;0.6))$ ,

gotovo visoka (GV) -  $((4.5,6,7.5;1), (5,6,7;0.6))$ ,

high (V) -  $((5.5,7,8.5;1), (6,7,8;0.6))$  and

very high (VV) -  $((7.5,9,9;1), (8,9,9;0.6))$ .

The domains of the interval type-2 triangular fuzzy numbers used for the modeling of the performance values at the level of each enterprise are defined by a respectable standard measuring scale (Saaty, 1990). The value 1, i.e. value 9, indicates that the performance  $p$ ,  $p = 1, \dots, P$  has the smallest, i.e. the highest value, respectively.

#### Constructing the Fuzzy Pairing Matrix for the Comparison of Performances

In literature, a large number of papers can be found, in which the relative importance of the attributes in terms of which the alternatives are given by the fuzzy matrix of the relative importance of the attributes (Tadić *et al*, 2016). It is assumed that this way is closer to the human way of thinking than to a direct assessment. In this paper, the pair-wise fuzzy matrix of the relative importance of the performances is set, according to which the SC enterprises are evaluated. The relative importance of each pair of the criteria is assessed by the strategic management

that makes a decision by consensus. The elements of this matrix are defined as the relative importance of the performance  $p$ ,  $p = 1, \dots, P$  compared to the performance  $p'$ ,  $p' = 1, \dots, P$ ,  $p \neq p'$ . The values of these elements are described by the previously defined linguistic expressions modeled by the interval type-2 triangular fuzzy numbers (Chen & Lee, 2010):

$$\tilde{W}_{pp'} = \left( \left( \tilde{X}_{pp'}^U; \mu_1(X_{pp'}^U), \left( \tilde{X}_{pp'}^L; \mu_2(X_{pp'}^L) \right) \right) \right).$$

Type-1 triangular fuzzy numbers are marked as:

$$\tilde{X}^U = (a_{pp'}^U, b_{pp'}^U, c_{pp'}^U) \text{ and}$$

$$\tilde{X}^L = (a_{pp'}^L, b_{pp'}^L, c_{pp'}^L).$$

The reference points of the interval type-2 triangular fuzzy numbers are denoted as:

$$a_{pp'}^U, b_{pp'}^U, c_{pp'}^U, a_{pp'}^L, b_{pp'}^L, c_{pp'}^L.$$

The distribution function of the higher or lower interval type-2 triangular fuzzy numbers is denoted

as  $\mu_1(\tilde{X}_{pp'}^U)$ , i.e.,  $\mu_2(\tilde{X}_{pp'}^L)$ , respectively.

If the relative importance of the performance  $p'$  is greater than the relative importance of the performance  $p$ , then the value of the element to the pair-wise fuzzy matrix of the relative importance of the performances can be described as:

$$\tilde{W}_{pp'} = (\tilde{W}_{p'p})^{-1} = \left( \left( \frac{1}{c_{pp'}^U}, \frac{1}{b_{pp'}^U}, \frac{1}{a_{pp'}^U}; \min(\mu_1(\tilde{X}_{pp'}^U)), 1 \right), \left( \frac{1}{c_{pp'}^L}, \frac{1}{b_{pp'}^L}, \frac{1}{a_{pp'}^L}; \min(\mu_2(\tilde{X}_{pp'}^L)), 1 \right) \right).$$

Based on the experience and results of good practice, it can be argued that decision-makers make mistakes in assessment. Therefore, it is, firstly, necessary to determine the consistency of the assessment made by strategic managers. In the first step, the pair-wise fuzzy matrix of the relative importance of the performances is mapped onto the pair-wise fuzzy matrix of the relative importance of the performances whose values are precise numbers. The representative

scalars of the interval type-2 triangular fuzzy numbers were obtained using the defuzzification procedure (DTriT), developed by C. Kahraman *et al* (2014), so that

$$W_{pp'} = \frac{\frac{(c_{pp'}^U - a_{pp'}^U) + (b_{pp'}^U - a_{pp'}^U)}{3} + a_{pp'}^U + \alpha \cdot \left[ \frac{(c_{pp'}^L - a_{pp'}^L) + (b_{pp'}^L - a_{pp'}^L)}{3} + a_{pp'}^L \right]}{2}$$

where  $\alpha$  denotes the maximum value of the distribution function of the possibilities for the lower interval type-2 triangular fuzzy number.

In the second step, the consistency of the pair-wise fuzzy matrix of the relative importance of the performances is determined by applying the eigenvector method (Saaty, 1990). Decision-makers' assessments are assumed to be consistent if the coefficient of consistency (C.I.) is less than 0.1.

### The Proposed Algorithm

Step 1. Construct the fuzzy comparison matrix of the pairs of the relative importance of the performances,

$$\left[ \tilde{W}_{pp'} \right]_{P \times P}, \text{ and determine the weight of the}$$

performance  $p$ ,  $W_p$ ,  $p = 1, \dots, P$ :

$$W_p = \frac{\tilde{r}_p}{\sum_{p=1}^P \tilde{r}_p} \tag{1}$$

where:

$$\tilde{r}_p = \left( \left( \sqrt[p]{\prod_{p=1}^P a_{pp'}^U}, \sqrt[p]{\prod_{p=1}^P b_{pp'}^U}, \sqrt[p]{\prod_{p=1}^P c_{pp'}^U}; \mu_1(b_{pp'}^U) \right), \left( \sqrt[p]{\prod_{p=1}^P a_{pp'}^L}, \sqrt[p]{\prod_{p=1}^P b_{pp'}^L}, \sqrt[p]{\prod_{p=1}^P c_{pp'}^L}; \mu_2(b_{pp'}^L) \right) \right) \tag{2}$$

The performance weight is described by the interval type-2 triangular fuzzy number.

Step 2. Assess the KPI values of each performance at the level of each enterprise,

$$V_{jep}, j = 1, \dots, J_p; e = 1, \dots, E; p = 1, \dots, P \tag{3}$$

Step 3. Determine the aggregated performance  $p$  value:

$$\tilde{z}_{ep} = \frac{\tilde{V}_{jep}}{J_p} \quad e = 1, \dots, E; p = 1, \dots, P \quad (4)$$

Step 4. Construct the decision matrix,

$$\left[ \tilde{d}_{ep} \right]_{E \times P}, \text{ so that:}$$

$$\tilde{d}_{ep} = \tilde{w}_p \cdot \tilde{z}_{ep} \quad (5)$$

The decision matrix values are described by the interval type-2 triangular fuzzy number, based on the multiplication rule defined in (Mendel & Liu, 2017).

The representative scalar of the interval type-2 triangular fuzzy number,  $\tilde{d}_{ep}$  is obtained by applying the defuzzification procedure (Kahraman *et al*, 2014),  $d_{ep}, e = 1, \dots, E, p = 1, \dots, P$ .

The decision matrix can be written as:

$$\left[ d_{ep} \right]_{E \times P} \quad (6)$$

Step 5. Determine the Positive Ideal Solution (PIS),  $d_p^+, p = 1, \dots, P$  and the Negative Ideal Solution (NIS),  $d_p^-, p = 1, \dots, P$  while respecting the type of the performance:

a) for the beneficial type:

$$d_p^+ = \max_{e=1, \dots, E} d_{ep}, \quad d_p^- = \min_{e=1, \dots, E} d_{ep} \quad (7)$$

b) for the cost type:

$$d_p^+ = \min_{e=1, \dots, E} d_{ep}, \quad d_p^- = \max_{e=1, \dots, E} d_{ep} \quad (8)$$

Step 6. Calculate the Euclidean distance from PIS,  $y_p^+$  and NIS,  $y_p^-$  for each decision matrix element value:

$$y_p^+ = \sum_{p=1}^P (d_p^+ - d_{ep})^2 \quad \text{and} \quad y_p^- = \sum_{p=1}^P (d_p^- - d_{ep})^2 \quad (9)$$

Step 7. Calculate the coefficients of the approximation that is associated with each enterprise, according to the procedure developed in the conventional TOPSIS method (Yoon & Hwang, 1981)  $k_e$ :

$$k_e = \frac{y_p^-}{y_p^- + y_p^+} \quad (10)$$

Step 8. Assort the coefficients of the approximation into a decreasing set. The rank of the enterprise is determined by the  $k_e$  values. The enterprise with the highest associated value  $k_e$  is the considered to be the first-ranked.

### An Illustrative Example

The automotive industry SC that has been the subject matter of discussion, which exists in Central Serbia, includes the focal enterprise (in which the process of the assembly of the final product is realized) and the nine big enterprises (in which the components are built, which are later installed in the final product). It should be emphasized that the revenue generated by the automotive industry SC has a major impact on the gross domestic product of each country, especially developing countries. SC performances are defined on the basis of literature recommendations (Bolstorff & Rosenbaum, 2003). To assess the relative importance of the performances, as well as their values, appropriate questionnaires were sent to the SC's strategic management, as well as the management teams (the production manager, the quality manager, the financial manager and the supply manager) involved in the SC, respectively. The decision-makers were asked through the questionnaire to select one of the predefined linguistic expressions in order

to assess the relative importance of each pair of the performances, and the value of each performance. All decision-makers may be assumed to have made decisions by consensus.

The fuzzy matrix of the relative importance of the pairs of the performances at the SC level is defined as follows (Step 1 of the developed Algorithm):

$$\begin{bmatrix} ((1,1,1;1),(1,1,1;1)) & 1/\tilde{W}_1 & 1/\tilde{W}_3 & 1/\tilde{W}_4 \\ \tilde{W}_1 & ((1,1,1;1),(1,1,1;1)) & 1/\tilde{W}_2 & 1/\tilde{W}_3 \\ \tilde{W}_3 & \tilde{W}_2 & ((1,1,1;1),(1,1,1;1)) & 1/\tilde{W}_2 \\ \tilde{W}_4 & \tilde{W}_3 & \tilde{W}_2 & ((1,1,1;1),(1,1,1;1)) \end{bmatrix}_{4 \times 4}$$

The mapping of the fuzzy pair-wise matrix of the comparison of the relative importance of the performances in the pair-wise matrix of the comparison of the relative importance of the performances is performed by applying the defuzzification process, DTriT (Kahraman *et al*, 2014), in order to determine the consistency of the assessment of the strategic managers:

$$\begin{bmatrix} 1 & 0.681 & 0.422 & 0.301 \\ 1.468 & 1 & 0.473 & 0.422 \\ 2.369 & 2.114 & 1 & 0.473 \\ 3.322 & 2.369 & 2.114 & 1 \end{bmatrix}, C.I. = 0.258$$

Using the expressions (1) and (2), the weights of the considered performances are calculated. The procedure shown in Step 1 of the Developed Algorithm is illustrated in the case of calculating the weight of the performance, which is denoted as complexity ( $p = 1$ ).

$$\begin{aligned} \tilde{r}_1 &= ((0.327, 0.536, 0.841;1), (0.386, 0.536, 0.759;0.75)) \\ \sum_{p=1}^4 \tilde{r}_p &= ((0.327, 0.536, 0.841;1), (0.386, 0.536, 0.759;0.75)) + \\ &+ ((0.473, 0.639, 1.268;1), (0.518, 0.639, 0.955;0.75)) + \\ &+ ((0.707, 1.316, 2.115;1), (0.963, 1.316, 1.749;0.75)) + \\ &+ ((1.189, 2.213, 3.162;1), (1.456, 2.213, 2.817;0.75)) = \\ &= ((2.696, 4.704, 7.386;1), (3.323, 4.705, 6.2780;0.75)) \end{aligned}$$

$$\begin{aligned} \tilde{w}_1 &= \frac{((0.327, 0.536, 0.841;1), (0.386, 0.536, 0.759;0.75))}{((2.696, 4.704, 7.486;1), (3.323, 4.705, 6.280;0.75))} \\ &= ((0.327 / 7.486, 0.536 / 4.704, 0.841 / 2.696;1), \\ &((0.386 / 6.280, 0.536 / 4.705, 0.759 / 3.323;0.75)) \\ \tilde{w}_1 &= ((0.044, 0.114, 0.312;1), (0.061, 0.114, 0.228;0.75)) \end{aligned}$$

In the same way, the weight of the other considered performances are obtained, and they are:

$$\begin{aligned} \tilde{w}_2 &= ((0.063, 0.136, 0.470;1), (0.082, 0.136, 0.287;0.75)) \\ \tilde{w}_3 &= ((0.094, 0.279, 0.784;1), (0.153, 0.279, 0.526;0.75)) \\ \tilde{w}_4 &= ((0.161, 0.471, 1.173;1), (0.232, 0.471, 0.848;0.75)) \end{aligned}$$

The estimated KPI values (Step 2 of the developed Algorithm) are accounted for in Table 1.

**Table 1** The estimated value of the KPIs at the level of each enterprise

	Enterprise								
	e=1	e=2	e=3	e=4	e=5	e=6	e=7	e=8	e=9
Complexity	GS	M	GS	M	M	GS	M	GS	GS
	GV	S	GV	S	S	GV	S	GV	GV
	S	S	GV	S	S	GV	S	GV	GV
	GV	S	V	GV	GV	V	GV	V	V
Uncertain demand	M	M	M	M	VM	VM	VM	VM	VM
	M	M	M	M	VM	VM	VM	VM	VM
	GS	GS	M	M	M	M	M	VM	VM
	M	M	M	M	M	VM	VM	M	M
Quality	VM	M	M	VM	VM	VM	M	VM	M
	V	V	VV	V	V	V	V	VV	VV
	VV	VV	VV	VV	V	V	VV	V	VV
	VV	VV	VV	V	VV	V	V	V	V
Additional value	V	VV	VV	VV	V	VV	V	V	V
	VV	VV	V	V	VV	VV	VV	VV	VV
	V	VV	V	V	V	V	V	VV	VV
	V	V	V	V	V	V	VV	VV	V
	V	V	GV	V	V	GV	V	V	V

Source: Authors

The aggregated performance values are calculated according to the expression (3) and they are presented in Table 2.

The weighted performance values at the level of each enterprise are calculated according to the expression (5). The multiplication process of the two interval triangular fuzzy type-2 numbers is illustrated by the following example:

$$\begin{aligned} d_{63} &= ((5.7, 7.2, 8.4; 1), (6.2, 7.2.8; 0.6)) \cdot \\ &\cdot ((0.094, 0.279, 0.784; 1), (0.153, 0.279, 0.526; 0.75)) = \\ &= ((0.54, 2.01, 6.59; 1), (0.95, 2.01, 4.21; 0.6)) \end{aligned}$$

The fuzzy decision matrix (Step 4 of the developed Algorithm) is shown in Table 3

The PIS and NIS values are calculated according to the decision matrix (Step 5 of the developed Algorithm) and shown in Table 4.

The values of the approximation coefficient and the rank of the considered enterprises are obtained according to the developed Algorithm (Step 6 to Step 8) and accounted for in Table 7.

**Table 4** The decision matrix PIS and NIS

	p = 1	p = 2	p = 3	p = 4
e = 1	0.6443	0.5827	2.3937	3.5967
e = 2	0.6153	0.6430	2.4763	4.5957
e = 3	0.7673	0.6070	2.5593	3.4340
e = 4	0.7673	0.5713	2.3937	3.5967
e = 5	0.6443	0.4267	2.3103	3.7187
e = 6	0.7673	0.3670	2.3103	3.5210
e = 7	0.6443	0.4267	2.3103	3.9320
e = 8	0.7673	0.3670	2.3937	4.5957
e = 9	0.7673	0.4267	2.3937	3.7187
PIS	0.6153	0.3670	2.5593	4.5957
NIS	0.7673	0.6430	2.3103	3.4340

Source: Authors

**Table 2** The aggregated performance values

	p = 1	p = 2	p = 3	p = 4
e = 1	((3.25,4.75,6.25;1), (3.75,4.62,5.75;0.6))	((1.6,2.8,4.3;1), (2,4,2.8,3.8;0.6))	((6.5,8,8.75;1), (7,8,8.5;0.6))	((5.9,7.4,8.6;1), (6.4,7.4,8;0.6))
e = 2	((3,4,5,6;1), (3.5,4,5,5;0.6))	((1.7,3,2.4,7;1), (2.2,4,3.2,4.2;0.6))	((7,8,5,8.87;1), (7.5,8.5,8.75;0.6))	((6,7,8,2,8.8;1), (7.2,8.2,8.6;0.6))
e = 3	((4.25,5.75,7.25;1), (4.75,5.75,6.75;0.6))	((1.5,3,4,5;1), (2,3,8,4;0.6))	((7.5,9,9;1), (8,9,9;0.6))	((5,3,6,8,8,3;1), (5.8,6.8,7.8;0.6))
e = 4	((4.25,5.75,7.25;1), (4.75,5.75,6.75;0.6))	((1.4,2.6,4.4;1), (1.8,2.6,3.6;0.6))	((6.5,8,8.75;1), (7,8,8.5;0.6))	((5.9,7.4,8.6;1), (6.4,7.4,8;0.6))
e = 5	((3.25,4.75,7.25;1), (3.75,4.75,5.75;0.6))	((1.2,1.8,3.3;1), (1.4,1.8,2.8;0.6))	((6,7.5,8.62;1), (6.5,7.5,8.25;0.6))	((6,3,7.8,8.7;1), (6.8,7.8,8.4;0.6))
e = 6	((4.25,5.75,7.25;1), (4.75,5.75,6.75;0.6))	((1.1,1.4,2.9;1), (1.2,1.4,2.4;0.6))	((6,7.5,8.62;1), (6.5,7.5,8.25;0.6))	((5.7,7.2,8.4;1), (6.2,7.2,8;0.6))
e = 7	((3.25,4.75,7.25;1), (3.75,4.75,5.75;0.6))	((1.2,1.8,3.3;1), (1.4,1.8,2.8;0.6))	((6,7.5,8.62;1), (6.5,7.5,8.25;0.6))	((7.1,8.6,8.9;1), (7.6,8.6,8.8;0.6))
e = 8	((4.25,5.75,7.25;1), (4.75,5.75,6.75;0.6))	((1.1,1.4,2.9;1), (1.2,1.4,2.4;0.6))	((6.5,8,8.75;1), (7,8,8.5;0.6))	((6.7,8,2,8.8;1), (7.2,8,2,8.6;0.6))
e = 9	((4.25,5.75,7.25;1), (4.75,5.75,6.75;0.6))	((1.2,1.8,3.3;1), (1.4,1.8,2.8;0.6))	((6.5,8,8.75;1), (7,8,8.5;0.6))	((6,3,7.8,8.7;1), (6.8,7.8,8.4;0.6))

Source: Authors

**Table 3** The fuzzy decision matrix

	p = 1	p = 2	p = 3	p = 4
e = 1	((0.14,0.54,1.95;l), (0.22,0.53,1.31;0.6))	((0.1,0.38,2.02;1), (0.19,0.38,1.09;0.6))	((0.61,2.23,6.86;1), (1.07,2.23,4.47;0.6))	((0.95,3.49,10.09;1), (1.48,3.49,6.78;0.6))
e = 2	((0.13,0.51,1.87;1), (0.21,0.51,1.25;0.6))	((0.11,0.44,2.21;1), (0.18,0.44,1.21;0.6))	((0.66,2.37,6.95;1), (1.15,2.37,4.61;0.6))	((1.08,3.86,15.23;1), (1.67,3.38,7.29;0.6))
e = 3	((0.19,0.66,2.26;1), (0.29,0.66,1.54;0.6))	((0.09,0.41,2.11;1), (0.16,0.41,1.15;0.6))	((0.71,2.51,7.06;1), (1.22,2.51,4.73;0.6))	((0.85,3.21,9.74;1), (1.35,3.21,6.78;0.6))
e = 4	((0.19,0.66,2.26;1), (0.29,0.66,1.54;0.6))	((0.09,0.35,2.07;1), (0.15,0.35,1.03;0.6))	((0.61,2.23,6.86;1), (1.07,2.23,4.47;0.6))	((0.95,3.49,10.09;1), (1.48,3.49,6.78;0.6))
e = 5	((0.14,0.54,2.26;1), (0.23,0.54,1.31;0.6))	((0.08,0.24,1.55;1), (0.11,0.24,0.8;0.6))	((0.56,2.09,6.76;1), (0.99,2.09,4.34;0.6))	((1.01,3.67,10.21;1), (1.58,3.67,7.12;0.6))
e = 6	((0.19,0.66,2.26;1), (0.29,0.66,1.54;0.6))	((0.07,0.19,1.36;1), (0.09,0.19,0.69;0.6))	((0.56,2.09,6.76;1), (0.99,2.09,4.34;0.6))	((0.92,3.39,9.85;1), (1.44,3.39,6.78;0.6))
e = 7	((0.14,0.54,2.26;1), (0.23,0.54,1.31;0.6))	((0.08,0.24,1.55;1), (0.11,0.24,0.8;0.6))	((0.56,2.09,6.76;1), (0.99,2.09,4.34;0.6))	((1.14,4.05,10.44;1), (1.76,4.05,7.46;0.6))
e = 8	((0.19,0.66,2.26;1), (0.29,0.66,1.54;0.6))	((0.07,0.19,1.36;1), (0.09,0.19,0.69;0.6))	((0.61,2.23,6.86;1), (1.07,2.23,4.47;0.6))	((1.08,3.86,15.23;1), (1.67,3.38,7.29;0.6))
e = 9	((0.19,0.66,2.26;1), (0.29,0.66,1.54;0.6))	((0.08,0.24,1.55;1), (0.11,0.24,0.8;0.6))	((0.61,2.23,6.86;1), (1.07,2.23,4.47;0.6))	((1.01,3.67,10.21;1), (1.58,3.67,7.12;0.6))

Source: Authors

**Table 5** The values of the approximation coefficient and the rank of the enterprises

	$y_p^+$	$y_p^-$	$k_e$	Rang
e = 1	1.0356	0.2285	0.1103	9
e = 2	0.2882	1.1833	0.8041	2
e = 3	1.1959	0.2516	0.5000	3
e = 4	1.0442	0.1964	0.1583	8
e = 5	0.9141	0.3781	0.2714	6
e = 6	1.1136	0.2894	0.2063	7
e = 7	0.7119	0.5487	0.4353	4
e = 8	0.2248	1.1970	0.8419	1
e = 9	0.9073	0.3671	0.2880	5

Source: Authors

## DISCUSSION ON RESULTS

Respecting the results presented in Table 7, it can be concluded that the enterprises (e = 8) and (e = 2) are the most efficient in the considered LS because they are ranked the first and the second, respectively. The enterprise (e = 1) is ranked the last. Since the closeness coefficient value of the enterprise (e = 1) is almost equal to the closeness coefficient value of the enterprise (e = 4) and the enterprise (e = 6), it can be said that the management should simultaneously undertake appropriate measures for improving the performance of the enterprises (e = 1, e = 4 and e = 6), which are ranked the last, the 8<sup>th</sup> and the 7<sup>th</sup>. In all of the three enterprises, the quality performance (p = 3) values and added value (p = 4) have the smallest weighted values. Hence, it can be concluded that it is necessary for the management team to take the first steps that should lead to the improvement of these performances. Improving the quality of the performance (p = 3) can be achieved through the improvement of the supply strategy, the introduction of new leadership concepts,

etc. The improvement of the supply strategy can be realized through the realization of a partnership relationship with the suppliers of repro materials, the introduction of the information systems that may improve communication between all the entities in the SC, the use of inventory management and production systems, etc. An increase in the added value ( $p = 4$ ) of the enterprises ( $e = 1$ ,  $e = 4$ , and  $e = 6$ ) can be achieved by using the lean principle, such as the pull system.

The weighted complexity performance value ( $p = 1$ ) in the enterprises ( $e = 4$ ) and ( $e = 6$ ) is higher than the value of the same performance in the enterprise that is the 1st ranked ( $e = 8$ ). Therefore, the management team should take appropriate measures to reduce complexity in the enterprises ( $e = 4$ ) and ( $e = 6$ ). Complexity reduction can be realized through the improvement of the value-stream map. By determining the value-stream map, it is possible to see all the unnecessary subprocesses and activities of the production process. Their elimination reduces the complexity of the enterprise. The complexity of the SC can also be reduced by applying the method of reengineering processes and products.

## CONCLUSION

The management and improvement of SC performances represents one of the most important management tasks. A solution to this problem should lead to the enhancement of the competitiveness and sustainability of the SC over a longer period of time. By simultaneously improving the performances of all of the SC entities, the effectiveness of the SC will surely increase. Also, if this scenario is applied, there is a great deal of resource usage (time, money, etc.). In order to achieve the enhancement of the effectiveness of the SC, with the least possible use of resources, it is necessary to identify the SC enterprises whose performance needs to be improved. It has been demonstrated that the use of the analytical methods in the evaluation and ranking of enterprises generates more accurate results than the use of intuitive decision-making methods does.

The main contribution of this paper is the development of the model for the evaluation and ranking of the enterprises integrated in the SC respecting the performance of the SC, as well as their weights. Since the SC exists in a rapidly changing environment, the relative importance of the performances and their values are described by the interval triangular fuzzy numbers of the type-2. It can be assumed that this approach in the modeling of uncertain and imprecise data is quite appropriate when there is not enough information about the nature of uncertainties. It has been shown that the ranking of enterprises can be posed as a multiple-criteria decision-making problem. Based on the obtained rank of enterprises, the priority of the enterprises in which performance improvement is to be performed is determined. The priority of the measures in the considered enterprises is determined by comparing the current and the target performance values.

The proposed model was tested on the real data obtained from the automotive industry SC that exists in Central Serbia. This paper makes a contribution to both the theoretical and the practical domains. The modeling of uncertainties and the modifications of the conventional TOPSIS method represent the basic contributions to the theoretical domain. The developed model is flexible in terms of changing the number of performances, their importance and values, and therefore can be applied to solve similar problems that exist in different industrial branches. In the practical domain, the contribution of this work can be identified as a reduction in the resources that need to be spent in order to improve the businesses effectiveness of the enterprises integrated in the SC.

The main limitation of the model is the non-existence of a unique SC performance classification.

Future research should include the development and application of exact methods for determining the improvements of optimal performances. The developed model can also be applied to the SCs of different industrial branches.

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**Review paper**

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## A COMPARATIVE ANALYSIS OF OUTSTANDING CLAIM RESERVES

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The key processes in the business of insurance companies which define the financial viability of their business activities, as the most important element, are the adequate amount of technical reserves. A qualitative assessment of the technical reserves level is the basic support to the management of the key business processes and proper strategic and financial decision-making in order to maximize the viability, profitability, competitiveness, and further development of the company. Based on the data on the operations of an insurance company, within a single line of insurance, different, in practice, most frequently used methods were applied in order to determine the deviation amplitude of the projected amounts from the actual claims. Another direction of research focuses on actuarial practice in non-life insurance companies operating in the territory of the Republic of Serbia. The comparative analysis of the obtained projection points to the fact that the chosen methods, commonly used in actuarial practice in the Republic of Serbia, should be monitored and reviewed. The results of the multidirectional research and detection of the existing problems provide a useful framework and a stimulating mechanism, as well as the guidelines to improve the operations and better positioning of insurance in the commercial and economic environment of the Republic of Serbia.

**Keywords:** technical reserves, outstanding claims reserves, chain indices, loss ratio

JEL Classification: G22

### INTRODUCTION

The key processes in the business of insurance companies (IC) which define the financial viability of their business activities, as the most important

element, are the adequate amount of technical reserves (TR). The TR level enables a critical insight into the numerous aspects of the insurers industry, which can be a useful indicator for a future business strategy. Through legal regulations and international accounting standards, supervisory authorities are focused on the TR level and their mobility in order to respond to the user's requests at any time.

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The importance of an adequate TR calculation in non-life insurance has resulted in numerous studies at the European Union level: H. Müller's Report (1997), G. Manghetti's Report (2000), the KPMG Report (2002), The Report of the Working Group on the Solvency of Non-Life Insurance Companies (European Commission, 2002), who found that the TR level is the main cause of the insolvency of non-life insurance companies, as long as there are many inconsistencies in their quantification. In addition, the existing standards do not provide a clear answer to numerous questions about the quality of the methods for assessing their quantity. "An example of a standard that leaves significant room for a wide range of accounting practices is the IFRS 4, which relates only to the general issues of the accounting treatment of insurance contracts, but does not provide solutions to all problems in this area" (Obradovic, 2014).

The issues of financial security have woven an intricate network of various mathematical, financial, statistical, even medical science contributions, including an extensive deployment of information technologies. The inherent uncertainty of the frequency, number, amount and time horizon of policyholders' claims is still the focus of many researchers. The bibliographies of numerous publications on the mentioned issues, both in the form of books, monographs and scientific papers, were compiled by K. D. Schmidt (2011).

There is a lack of research interests in non-life claim reserves in the domestic academic society. This fact has an impact on the research study published in this paper, which is defined as an analysis of the methodologies of outstanding claim reserves calculation, in the actuarial practice of non-life insurers of the Republic of Serbia (RS).

The primary goal of this paper is a comparative analysis of the results obtained by applying different methods for calculating the most reliable component of the TRs - i.e. reserves for claims incurred but not reported. As long as this technical reserves component is the most discouraged and in the focus of the research in the world actuarial authorities, the goal of the research is the possibility of applying their perceptions in the domestic, underdeveloped insurance market.

In accordance with the research purpose and goals, the general hypothesis:

$H_0$ : The projections of the cumulative amounts of future monetary compensations should be inflationary adjusted, has been tested.

This general hypothesis has also induced an additional hypothesis:

$H_1$ : The methodology required by the supervisory authorities should be reviewed through redesigning the current insurance legislation.

Two types of research had been requested for hypotheses testing. The general hypothesis directed one research direction, oriented towards a comparative analysis of the obtained results of the calculation of reserves for claims incurred but not reported, using the most commonly used methods in the world actuarial practice. Using the specific results of an insurance company's business, in a single line of business with a long development period (from 2006 to 2015), various methods were applied, as well as a comparative analysis of estimated claims with real claim payments in the next business year. The additional hypothesis directed the second research direction towards the methodologies used in domestic insurance companies. The questionnaire with 32 questions related to the methodologies used for calculating particular components of technical reserves was distributed in 2014 to non-life, as well as composite insurance companies operating in RS. Based on the responses received from 11 insurance companies, it was noted that the practice in claims reserves was conducted by the methodology required by the supervisor, with the lack of available staff and, hence, the necessary time for actuarial engagement on a similar research study.

Both research directions were monitored as a quantitative methodology, presented as a technical reserves calculation, as well as a qualitative methodology, through consulting relevant literature and by surveying domestic stakeholders.

This paper is structured into four thematic units. The first part is an introduction to the observed topic,

which contains six subsections, with an overview of the most frequently used deterministic methods of claim projections, along with a review of the relevant scientific results. In the next section, such methods are applied to the paid claims of an insurance company in order to project future payments. In addition to the applied quantitative methodology, through 42 projections of both the dinar and the euro reserves for claims incurred but not reported, the qualitative research methodology was also interpreted and conducted through survey among actuaries in non-life insurance companies. In the concluding observations, the results of both directions of the survey were summarized, as a comparative analysis of the results of the projected claims and the responses in the distributed questionnaire. Identifying the key contributions and limitations of the presented research study, a set of scientific hypotheses have been specified, pointing to a future research direction.

## DETERMINISTIC CLAIMS RESERVING METHODS

With a view to the potential significance of technical reserves and the impact of uncertainties on forecasts, various models have been developed, and these can be generally classified as deterministic and stochastic. Deterministic techniques provide the actuarial assessment of a potential cumulative value of the amounts of future claims paid based on the patterns in claims activities in the previous periods. However, the existing deterministic methods do not provide a concrete measure of the deviation of the obtained forecasting from possible realizations. Being aware of this shortcoming, actuaries apply different prediction models for obtaining multiple estimates of potential losses. However, no matter how wide is the range of these forecasts, questions referring to what amount may represent the optimal estimate or what is a reasonable estimate of dispersion remain open.

The determination of the optimal estimation of reserves is closely linked to absorbing the shortcomings of traditional deterministic techniques. As the Chain Ladder Method is generally the initial

method in reserving, its stochastic modification has been investigated by many authors, including E. Kremer (1982), G. C. Taylor and F. R. Ashe (1983), K. D. Schmidt and A. Schnaus (1996), A. E. Renshaw and R. J. Verrall (1998), Th. Mack and G. Venter (2000), G. C. Taylor (2000), P. D. England and R. J. Verrall (2002). However, the sophistication of stochastic models requires a lot of time and other resources, so that, due to commercial imperative in terms of haste to obtain the desired forecasts as soon as possible, there is still room left for the application of stochastic models in the domain of academic research.

Deterministic methods assume that patterns in claims activities will continue to repeat in the future, which can be forecasted by observing and analyzing the past experiences in certain lines of activities. The most widely used format of displaying and analyzing data is a tabular form, where data can be systematized by: the number of claims incurred, the number of claims paid, the amount of reported claims or the amount of paid claims. Since the primary focus of an actuary, i.e. the person responsible for forecasting the amount of reserves, is on the potential payments that may occur in the next accounting period, it is recommended that a focus should be put on the analysis of the amounts of claims paid in the previous accounting periods, which may be annual, semi-annual or quarterly. Data in one table-type relate to the same year which the claim was incurred in, whereas the columns represent how many accounting periods have passed since the claim occurrence until the moment of the claim payment. Amounts in columns correspond to the same period of delay, whereas the sums paid in the same calendar year are represented along a diagonal line.

The random variable  $X_{ij}$  is the amount of the claims incurred in the year  $i$  and paid within  $j - 1$  development years from the date on which the claim occurred. The table includes the values of the observable data, where  $i + j \leq n + 1$ , which is why this table is also called the run-off triangle. Actuarial studies related to the losses rating and reserving use run-off triangles with individual amounts of claims paid in a given observed period  $X_{ij}$  and the cumulative losses  $S_{ij}$  incurred in the year  $i$  and paid within  $j-1$  development years from the date on which

such damage occurred (Schmidt, 2006), i.e.:

$$S_{i,j} = \sum_{k=1}^j X_{i,k}, \quad i = 1, 2, \dots, n, \quad j = 1, 2, \dots, n-i+1 \quad (1)$$

The traditional, deterministic methods of claim reserving can be grouped into two large families: the method of chain indices and the methods based on calculating loss ratios.

### The Methodological Framework of Chain Indices Methodology

Generally, all forecasting models using the chain indices method are based on the following steps: determining the chain indices, selecting the average development factor and calculating the cumulative development factors, selecting the tail-factor and obtaining projections for the claims and reserves in the next accounting period (Faculty and Institute of Actuaries, 1997).

The basic idea behind the Chain Ladder Method is that there is regularity in claims loss settlement according to the periods of delaying the settlement of claims. Hereby, the amounts of claims paid in successive development periods are compared, i.e. a rise in the percentage of cumulative payments is observed. The quotient of two adjacent amounts in the accident year represents the chain index (age-to-age factor, development factor, link ratio) (Schmidt, 2006):

$$f_{i,j} = \frac{S_{i,j+1}}{S_{i,j}}, \quad \text{where } i=1, 2, \dots, n, \text{ and } j=1, 2, \dots, n-i. \quad (2)$$

Based on these assumptions, the amount of claims that may be reported is calculated by way of the expected value of conditional probabilities (Dahl, 2003):

$$E[S_{i,j+1} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] = S_{i,j} \cdot r_j \quad (3)$$

where  $r_j$  is the selected development factor (DF) among all of the obtained factors  $f_{i,j}$  for the development

period  $j$ . If both sides of the previous equation are divided by  $S_{i,j}$  it follows that:

$$E[S_{i,j+1} / S_{i,j} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] = r_j. \quad (4)$$

As the amounts  $S_{i,j}$  and  $S_{k,l}$  are independent for  $i \neq j$  and  $j \neq l$ , the development factor  $r_j$  does not depend on the accident year. Forecasting the amount of  $S_{i,j}$  for  $j \geq n-i+2$  is based on the following result, which is also mentioned by P. Dahl (2003):

Lemma 1: If  $E[Z]$  is finite, then  $E[Z] = E[E[Z|X]]$ .

Starting from Assumption 3, by applying Lemma 1, we obtain:

$$\begin{aligned} E[S_{i,j+k} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] &= E[E[S_{i,j+k} | S_{i,1}, S_{i,2}, \dots, S_{i,j+k-1} | S_{i,1}, S_{i,2}, \dots, S_{i,j}]] = \\ &= E[S_{i,j+k-1} \cdot r_{j+k-1} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] = E[S_{i,j+k-1} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] \cdot r_{j+k-1} = \\ &= E[E[S_{i,j+k} | S_{i,1}, S_{i,2}, \dots, S_{i,j+k-2} | S_{i,1}, S_{i,2}, \dots, S_{i,j}]] \cdot r_{j+k-1} = \\ &= E[S_{i,j+k-2} \cdot r_{j+k-2} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] \cdot r_{j+k-1} = E[S_{i,j+k-2} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] \cdot r_{j+k-1} \cdot r_{j+k-2} = \\ &= S_{i,j} \cdot r_{j+1} \cdot r_{j+2} \cdot \dots \cdot r_{j+k-1} \end{aligned}$$

Therefore:

$$\begin{aligned} E[S_{i,j+k} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] \\ = S_{i,j} \cdot r_{j+1} \cdot r_{j+2} \cdot \dots \cdot r_{j+k-1} \end{aligned} \quad (5)$$

This result points to the procedure of obtaining all of the values of  $S_{i,j}$  for each  $j \in (n-i+2, \dots, n)$ .

The necessary reserves that the company determines are calculated as:

$$R_i = E[S_{i,n}] - S_{n-i+1}, \quad i=1, 2, \dots, n \quad (6)$$

Formula (5) points to the fact that the choice of the average development factor  $r_j$ , for each development period, is very important for obtaining the desired forecast.

A run-off triangle is not complete until all the claims, at least in the oldest origin year, are paid; therefore, cost settlement for any particular year is unknown. In this respect, actuaries complete the chain indices derived from the available data in the run-off triangle, i.e. they use the remainder coefficient or the tail factor which predicts development beyond the last phase of the development for which a chain index can be calculated. Research related to determining the tail factor (TF) has resulted in numerous papers and methods; the Working Party of the American Association of Actuaries Casualty Actuarial Society - CAS (2013) presented their view in the paper "The Estimation of Loss Development Tail Factors: A Summary Report", CAS Tail Factor Working Party. The mentioned paper identifies a number of the methods grouped into 6 main classes: Bondy-Type Methods, Algebraic Methods, Benchmark-Based Methods, Curve-Fitting Methods, Methods Based on the Remaining Open Counts and Methods Based on the Peculiarities of the Remaining Open Claims.

The methods belonging to the group of Bondy-Type Methods are the most widely used in practice due to their simplicity; however, the resulting tail factor, obtained by their application, may be understated for "long-tail" lines. M. Bondy's Original Method (1960), justifies the use of the last link ratio as a predictor of future claims development (Boor, 2006), i.e.  $f_{i,n+1} = f_{i,n}$ . As the TF is determined for each origin year, the designation  $i$  can be omitted from the subscript, while each chain index is observed in the form  $f_j = 1 + v(j)$ , where  $v(j)$  represents the development portion of the remainder coefficient. The numerous modifications of Bondy's original method have been developed. One of these assumes that the development portion of the chain index is reduced by 50%, i.e.  $f_{j+1} = 1 + 0.5v(j)$ , while alternative methods suggest that the development portion of the last index should be multiplied by two or squared, i.e.  $f_{j+1} = 1 + 2v(j)$  or  $f_{j+1} = 1 + v^2(j)$ . Weller generalized the method in 1989 by using the average of the three most recent developments, whereas the Fully Generalized Bondy Method considers TF as:  $f_n = (f_{n-1})^{B/B-1}$ , where  $B$  stands for the Bondy exponent and the number ranges between 0 and 1 (CAS Tail Factor Working Party, 2013).

Algebraic methods focus on the relationships between the losses paid and incurred. Their main advantage is that they are based solely on information in the loss triangle. One of the most representative methods in this group is the Sherman-Boor Method or algorithm (Sherman & Diss, 2005; Boor, 2006), whose application has been becoming more and more popular in actuarial practice in recent years. A possible approach to estimating TF is the assumption of the existence of the geometric relationships between the chain indices, depending on the development period until the claim is paid. The most commonly used method is the method of determining the exponential rate of "decay", which uses chain indices  $f(d_j)$  for calculating cumulative or incremental paid losses. Here, each chain index is treated as a function of the development portion, i.e.  $f(d_j) = 1 + v(d_j)$ , assuming that the development portion  $v(d_j)$  "decays" at a constant rate  $r$ , i.e.  $v(d_{j+1}) = v(d_j)r$  (Boor, 2006). The process consists of defining the exponential curve for development portions  $v(d_j)$ . The decay constant  $r$  can be estimated by using a linear trend in the values of the natural logarithm of development portions, and then the TF for the development age  $d$  can be estimated as:

$$T(d) = 1 + v(d) \cdot \sum_{m=1}^{\infty} r^m.$$

C. L. McClenahan (1975) initiated the technique of determining the theoretical curve, assuming that incremental paid losses "decay" at a constant monthly rate  $p$ , but after a few months  $a$ , in which there were no payments. Following the exponential trend of the development periods of the chain indices and the corresponding amounts in cash, their monthly rate of decay  $r$  is determined, based on which the TF is obtained by using the formula:

$$T = \{12 \times (1 - p)\} / \{12 \times (1 - p) - p^{m-a-10} \times (1 - p^{12})\}.$$

Skurnick simplified this method (Boor, 2006) by observing the annual rate of decay in incremental payments that is proportional to the most recent payment, while for each accident year, the appropriate rate of exponential decay and the corresponding TF

are calculated as:  $T = \frac{1 - r}{1 - r - r^y}$ , where  $y$  marks the

number of the development years which the TF will be applied to.

Determining the TF is still the focus of many researchers, because the value of TF significantly affects the projections of future payments to be made on claims in the following years. Due to appropriate assumptions, there is no single method that can produce accurate results; however, by testing the obtained results using different methods, one can obtain the most optimal coefficient of further developments in the payment of claims.

### Chain Ladder Method (CLM)

The Chain Ladder Method is a representative method among that numerous projection methods that use chain indices. The CLM is most commonly used in actuarial practice, both by domestic and foreign ICs. P. D. England and R. J. Verrall (2002) note that the main objective of all deterministic methods is a comparative analysis of the results obtained by applying the CLM. However, J. N. Stanard (1985), P. Narayan and T. V. Warthen (1997), G. Barnett and B. Zehnwrirt (2000) and G. C. Taylor (2000) focus their research on the key assumptions and examine the comparative adequacy of this method in terms of different lines of insurance.

The main characteristic of the CLM is the “original” weighting. Starting from the fact that every quotient in the column is weighted by the claim from which it originated, this method uses original weights, therefore the development factor is obtained as follows (Schmidt, 2006):

$$r_j = \frac{\sum_{i=1}^{n-j+1} S_{i,j}}{\sum_{i=1}^{n-j+1} S_{i,j-1}}, j=1,2,\dots,n-i \quad (7)$$

### The Methods Based on the Loss Ratio Calculations

The projections of payments to be made by an IC in future accounting periods are based on assumptions;

therefore, each result obtained must be accepted with some caution. A lack of the methods based on TF is reflected in the most recent accident years because their development period to ultimate payments is very long. For this reason, the development factors derived from the past experience are relatively high and subject to numerous fluctuations, which are quite uncertain at the given moment. An alternative approach, which is relatively easy to use, is to calculate the loss ratio which indicates the share of the total claims paid (in %) in the premiums earned by the insurer. The essence of the adequate application of the concept of a loss ratio is that premiums should correspond to the risk exposure period. Therefore, if you use the run-off triangles that contain claims given by the accident years, then the amount of the final payments is to be compared with the premiums earned (Schmidt, 2008). In the case of presenting the data according to the years of the inception of the insurance coverage, the indicative measure is a written premium. The simplest approach is to, based on the previous loss rates and earned premiums, determine the aggregate monetary amount of future payments, which, when reduced by the amount of the payments made thus far, gives the amount of necessary reserves (Saluz, Gisler & Wüthrich, 2011). The application of this method is characterized by a greater stability of the results, especially for a small series or a new insurance line. The main shortcoming is that it relies too much on *a priori* information, simultaneously ignoring the payments that have already been realized.

### The Average Cost per Claim Method

The Average Cost Per Claim Method assumes that the average amount of claims and their number for each development year are in a constant relation with the total number and amount of claims for the year observed. The application of this method is based on the use of the data concerning the number of the claims filed and the amount of claims incurred. This method can be applied both to paid and reported claims, where the number of such claims must correspond to the type of the amounts used. In addition, if the amounts of claims paid are

used, they should be compared with the number of claims settled, whereas the number of reported claims should be compared to the amount of incurred claims. By dividing cumulative claim amounts by claim numbers, the amount of the average cost per reported claim is obtained. These costs are then projected to the finite amounts of individual costs in each development year by using the grossing-up factors. The same procedure is used to generate the final number of expected claims to be filed, which when applied as a multiplier to the expected average claim amount, gives the projection of the amount of the total liabilities of an IC. The necessary reserve is obtained by subtracting the obtained amount in respect of the amount of claims paid.

This projection can be very useful, because the analysis of the experience with respect to the amount and number of claims makes it possible to review the trends in the filing of damages and their liquidation, as well as the average amount of claims. The method itself can provide satisfactory answers, especially in the case of organizational or external fluctuations; it can also help in the detection of the adequacy of other actuarial projection techniques. It can be applied to the data aggregated by the year of origin, the accident, the respective year of inception or the calendar year. Although this method can be applied to all lines of insurance, it is most commonly used regarding the "long tail" lines.

### The Bornhuetter-Ferguson (BF) Method

Bornhuetter-Ferguson's method combines the Average Cost Per Claim with the Chain Indices Method. The initial, realistic assumption is that the total loss for each year of operation can be divided into the respective past and future portions that are subjected to a separate analysis. The first part of the evaluation, which relates to the claim payments made, is known or adequately evaluated, taking into account the reserves for incurred but not reported claims. Uncertainties contained in future payments to be made will not be estimated by applying the same pattern of historical payment realizations; they will be estimated by using a more general estimator,

based on the loss ratio for a given line of insurance. By summing up the two estimates, a more sensitive assessment of the possible final payments and therefore the necessary reserves is obtained.

If we analyze the amounts of cumulative payments,  $S_{i,j}$  which are actually the variables that are independent of the year of origin  $i$ , the assumption of the BF method is that there are the parameters  $\alpha_1, \alpha_2, \dots, \alpha_n$  and the rates  $\beta_1, \beta_2, \dots, \beta_n$ , where  $\beta_n=1$  (because the development for the first year of origin is concluded), which are used for projecting the future and past portions of the aggregate payments, therefore (Mack, 2006),  $\forall i : 1 \leq i \leq n, \quad \forall j : 1 \leq j \leq n - 1$ :

$$E[S_{i,1}] = \alpha_i \cdot \beta_1, \text{ and}$$

$$E[S_{i,j+k} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] = S_{i,j} + (\beta_{j+k} - \beta_j) \cdot \alpha_i \quad (8)$$

Since  $S_{i,j}$  represent cumulative amounts, thus  $\alpha_i$  is a cumulative TF. According to (8), it follows:

$$E[S_{i,j}] = \alpha_i \cdot \beta_j \quad \text{and} \quad E[S_{i,n}] = \alpha_i. \quad (9)$$

Starting from the relation  $\forall i : 1 \leq i \leq n, \quad \forall j : 1 \leq j \leq n - i + 1$ , we obtain:

$$E[S_{i,n} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] = S_{i,j} + E[S_{i,n} - S_{i,n-i+1}],$$

this, according to the basic assumptions, implies the following:

$$\begin{aligned} E[S_{i,n} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] &= \\ &= S_{i,j} + (\beta_n - \beta_{n-i}) \cdot \alpha_i = \\ &= S_{i,j} + (1 - \beta_{n-i+1}) \cdot \alpha_i \end{aligned} \quad (10)$$

The BF projection is written as (Schmidt, 2008):

$$E[S_{i,n}] = S_{i,n-i+1} + (1 - \beta_{n-i+1}) \cdot \alpha_i \quad (11)$$

where  $\beta_{n-i+1}$  is an *a posteriori* estimation and  $\alpha_i$  is an *a priori* estimation of ultimate losses.

As the CLM assumes that:

$$E[S_{i,n} | S_{i,1}, S_{i,2}, \dots, S_{i,j}] = E[S_{i,j}] \cdot \prod_{k=j+1}^{n-1} r_k = E[S_{i,1}] \cdot \prod_{k=1}^{n-1} r_k,$$

We obtain:  $E[S_{i,j}] = E[S_{i,n}] \cdot \prod_{k=0}^{n-1} r_k^{-1}.$

If this result is compared with (9), it is evident that:

$$\beta_j = \prod_{k=j+1}^{n-1} r_k^{-1} \tag{12}$$

Thus, (11) is now written as:

$$E[S_{i,n}] = S_{i,n-i+1} + \left( I - \frac{I}{\prod_{k=n-i+1}^{n-1} r_k} \right) \cdot \alpha_i \tag{13}$$

This relation points to a significant difference between the BF method and the CLM - the method of choosing estimators. For the CLM, we have (Schmidt, 2008):

$$\begin{aligned} E[S_{i,n}] &= S_{n-i+1} \cdot \prod_{k=n-i+1}^{n-1} r_k = \\ &= S_{n-i+1} + S_{n-i+1} \cdot \left( \prod_{k=n-i+1}^{n-1} r_k - I \right) = \\ &= S_{n-i+1} + \frac{E[S_{i,n}]}{\prod_{k=n-i+1}^{n-1} r_k} \cdot \left( \prod_{k=n-i+1}^{n-1} r_k - I \right) \end{aligned}$$

therefore:

$$E[S_{i,n}] = S_{n-i+1} + \left( I - \frac{I}{\prod_{k=n-i+1}^{n-1} r_k} \right) \cdot E[S_{i,n}] \tag{14}$$

The difference between (13) and (14) is only in the last member of the estimation: in the CLM, it is obtained

from observable data, whereas the BF method allows  $\alpha_i$  to be any estimator of the ultimate loss development. Therefore, the parameter  $\alpha_i$  is an *a priori* exogenous factor, obtained by some other professional expertise. The application of the BF method is mainly based on the loss ratio, i.e. on the ratio of incurred claims to earned premiums as the  $\alpha_i$  predictors of ultimate losses. Since the loss ratio indicates the historical experience of the IC activities regarding the share of claims (in %) in premiums, this product indicates the likely amount of the expected losses in the next business year. In terms of the CLM, the inverse product of the development factors indicates the percentage of the paid claims in the expected aggregate payment for a given development year, therefore  $1 - 1 / \prod_{k=n-i+1}^{n-1} r_k$  represents the amount (in %) of expected unpaid claims. If the projection of possible losses per development years is calculated using the ratio of claims to premiums, by multiplying this amount and the factor:  $1 - 1 / \prod_{k=n-i+1}^{n-1} r_k$ , we obtain the amount of the necessary reserve (Schmidt, 2008).

In contrast to the method of the expected losses, where projection ignores the actual realization of payments, and the method of chain indices, where full credibility is given to paid claims, the BF method relies on data from the past, but not as the only benchmark for the evaluation of future payments. Concerning the development of losses, the credibility of projections is based on the claims development in most recent experience periods; therefore, the weighting factor of the initial realizations declines (Martínez-Miranda, Nielsen & Verrall, 2013). Incurred but not reported claims will be developed in the future based on the expected payments; incurred payments are not the predictors of a future development; therefore, payment fluctuations in the early stages do not impair the projection of the necessary reserves. This is actually the main argument for the implementation of the BF method for “long-tail” insurance lines, as well as in the case of other insurance lines characterized by significant fluctuations in the realization of incurred payments.

## Stanard-Bühlmann Method

This method, also known as the Cape-Code (CC) Method, was independently developed by J. N. Stanard (1985) and H. Bühlmann (1983), as an improved variation of the BF method. The initial assumption concerning the division of ultimate claims to reported and incurred but not reported claims is retained, as well as the sensitivity of determining the loss ratio. In contrast to the BF method, where the loss ratio is estimated by the person liable for calculating reserves, the CC method determines the expected loss ratio based on the historical experience of the total amounts of reported claims. For each development year, the loss ratio is calculated based on the total reported claims and earned premiums, whereas the expected loss rate for the next development period represents the weighted average of all ratios obtained. Since the expected claims are based on the reported losses, a sufficient volume of data is required, which often limits the application of this method. "A lack of quality data is a critical factor, because with inadequate data no results will be produced, no matter how perfect the model may have been" (Kočović, Mitrašević, Kočović i Jovović, 2011, 2011).

## The Methodology for Calculating Claim Reserves Prescribed by the National Bank of Serbia (NBS)

The Insurance Law of the Republic of Serbia, i.e. the Decision on the Detailed Criteria and the Manner of Calculating Claim Reserves, allows the application of actuarial methods for the calculation of incurred but not reported claim reserves; it also allows to calculate reserves based on the data on resolved and reserved incurred reported but not settled claims without the involvement of annuity claims. Also, the calculation should not include any costs associated with the settlement and payment of claims. According to this principle, the amount of reserves for incurred but not reported claims concerning the self-insured retention of the company for the particular insurance line represents the sum of settled and unsettled reported claims in retention within a certain insurance line,

corrected by the coefficient for the calculation of claims incurred but not reported, i.e.

$$R_t^{IBNR} = a_t \cdot (S_t + R_t)$$

where  $S_t$  stands for the amount of settled (not including annuity) claims in retention in a particular insurance line,  $R_t$  is the amount outstanding (excluding annuities) incurred reported but unsettled claims in retention in the particular insurance line,  $a_t$  the coefficient for the calculation of incurred but not reported claims and  $R_t^{IBNR}$  resulting amount of incurred but not reported claims in the observed insurance line (Službeni glasnik RS, 2007).

The correction coefficient  $a_t$  is calculated on 31<sup>st</sup> December of the current year for those lines of insurance that have been conducting particular insurance activities for more than three years (or at least two years) and the same cannot be smaller than 0.1. It represents the arithmetic mean of the coefficients  $k_t$  calculated for the current and previous two insurance years. The coefficient  $k_t$  for each of the last three or two years is the quotient of: 1) the sum of the amounts of the claims settled during the year and the outstanding incurred reported claims on 31<sup>st</sup> December that have occurred in the previous period and are the first reported in the year for which this coefficient is determined and 2) the sum of the amounts of the claims settled during the year and the outstanding incurred reported claims on 31<sup>st</sup> December of the year for which this coefficient is determined. If insurance activities in a particular insurance line last for less than 2 years, the value of this coefficient is 0.1.

If the incurred claims reserve is calculated by applying some other method, its amount cannot be smaller than the amount obtained by using the above-described method; furthermore, the reserve calculated according to the method presented above must not be smaller than the reserve calculated at the end of the previous year.

## METHODOLOGY AND RESEARCH RESULTS

Standard & Poor's (S & P), one of America's leading financial services companies, calculates the level of TR by applying a comparative analysis of the results obtained by using the following three methodologies: the paid loss development method, the incurred loss development method, and the BF methods. According to their analysis, the triangulation techniques based on paid and incurred losses produce the most appropriate results when using the five-year weighted average of DF that best reflect the balance between stability and reliability in developing factors (Standard & Poor's Ratings Services, 2008).

The results of the research carried out by the global network of consulting and audit firms - KPMG at the EU level (2002) - show that a comparative analysis of the reserving results obtained by means of various actuarial methods is the generally accepted way to minimize the deviations of proposed projections from the actual realization of payments. In almost all European countries, the methods based on the run-off triangles proved to be the most effective and in terms of cumulative paid claims in the previous business years the CLM was the method most commonly used. Beside the mentioned method, one of the following methods is also simultaneously used: the Loss Ratio Method, the Average Cost per Claim Method or Bornhuetter-Ferguson's method. In Spain, it is even prescribed by the law that at least two methods must be used when determining reserves; furthermore, the selected methods must include data for at least five preceding years.

All of the mentioned studies have initiated research in the applied practices in non-life ICs operating in Serbia's economic environment. According to the results of the survey which was carried out on 11 non-life insurance companies (2 of which are in private and the remaining 9 in foreign ownership), the actuaries follow the Decision on the Detailed Criteria and the Manner of Calculating Claim Reserves (NBS) and the CLM when projecting the uncertain amounts of future claim reserves. Hence, the focus of this research is directed towards the application of various deterministic methods in order to determine whether

their choice is the most appropriate or whether some other method provides better results closer to payment realizations in 2016.

In the line of business with a long development period, the claim payment data of an insurance company were used in this research. The projections of the potential amounts of future payments were done by using the triangulation methods applying the development triangles for paid and incurred losses in the period from 2006 to 2015 in order to make it possible to compare the results with the realizations of these amounts in 2016. Additionally, all the projections obtained by using the run-off triangles, the BF and the CC methods calculated amounts in dinars (RSD) and euros, respectively. Currency conversion was done at the official exchange rate applicable on 31<sup>st</sup> December.

Loss development triangles are formed based on the cumulative amount of payments as per accident year and payment delay periods of 12 to 120 months. For each development year, the chain indices were selected and obtained as follows: 1) conservative mean-value, i.e. the selection of the highest chain index value in the observed development period; 2) the arithmetic mean of all the chain indices as per columns for each year of claims development; 3) the arithmetic mean of the last three chain indices in each column; 4) the arithmetic mean of the last five chain indices in each column; 5) the median of the indices, i.e. the arithmetic mean of the indices that remains after eliminating the highest and the lowest index values in each column; 6) the geometric mean obtained by applying GEOMEAN, a function contained in the *Microsoft Office Excel 2007* software, i.e. as  $\sqrt[n]{f_1 \cdot f_2 \cdot \dots \cdot f_n}$ , where  $f_1, f_2, \dots, f_n$  are chain indices, and 7) the weighting means obtained by using CL weights.

Among the many techniques used for determining the tail factors, the following methods were used: Bondy's method, which carries out the selection based on the last calculated chain index for the year that has the longest claims development period and the two more modifications of this method, where the development portion of the last chain index is squared or doubled,

respectfully; Sherman-Boor’s method; Method of Exponential Approximation; McClenahan’s method and Scurnick’s method.

The tail factors were determined for each of the seven mentioned ways of obtaining the development factor by using all the seven methods and the projection of future payments for incurred but not unreported claims was done for the development period from 2006 to 2015. So, 49 projections were obtained only for the chain-ladder based methods. The results of the projections were compared with the real payments in 2016, for all the claims that occurred from 2006 to 2015, but which had not been reported in that period. In the chain-ladder based methods, the amount the closest to the actual payments was the method where the development factors were obtained over a medial average, with the tail factor determined by using the Bondy method. In addition to the chain index methods, the amount of these potential payments by the expected cost method, the BF and the CC methods was obtained. The results of the projected incurred but not reported claims in the EUR currency are given in Table 1, while the same results in the RSD currency are accounted for in Table 2.

**Table 1** The comparative analysis of the projection methods (in EUR)

Method	Projected amount of reserves for claims
Chain Index Method	12312428
Average Cost per Claim Method	13141133
CL Method with Bondy ROC	12356404
Bornhutter–Ferguson Method	12359573
CapeCod Method	12232147
Realization in 2016: 11728866	

Source: Authors

**Table 2** The comparative analysis of the projection methods (in RSD)

Method	Projected amount of reserves for claims
Chain Index Method	1 578 908 008
Average Cost per Claim Method	1 527 416 691
CL Method with BondyROC	1 623 425 309
Bornhutter–Ferguson Method	1 659 685 804
Cape Cod Method	3 058 845 966
NBS Methodology	1 892 155 950
Realization in 2016: 1 344 383 096	

Source: Authors

The second direction of the research is focused on actuarial practice in the non-living ICs operating in the territory of the RS. The questionnaire containing 32 questions, focused on the calculation of the individual components of technical reserves, was distributed to the insurance companies only engaged in non-life insurance and composite insurance companies in order to detect divergence in the applied methodology.

The following questions were posed in the mentioned questionnaire: 1. Which line of non-business is presented in your insurance company’s portfolio? 2. Are technical reserves calculated by a qualified actuary? 3. How many years of experience does the person responsible for technical reserves calculations have? 4. What percentage of the working hours during the year does this person spend on TR calculations? 5. Which types of TRs are calculated? 6. Unearned premium reserves are calculated by using: a) the pro-rata temporis method; b) the 1/24 method; c) the quarterly method; d) the same-rate method; 7. Please, explain how you use the method selected that was used in the previous question. 8. Which method is used for an RBNS estimation: a) the estimation of each separate claim; b) the average method; c) by using

tables; c) the claim ratio method? 9. Please, explain how you use the method selected that was used in the previous question. 10. Which method is used for an IBNR estimation: a) the flat methods based on paid and RBNS claims; b) the claim ratio; c) the chain ladder; d) by using another method (specify which)? 11. Please, explain how you use the method selected that used in the previous question. 12. If you use the chain ladder method, then explain the methodology used for the calculation of development factors. 13. How many development years are presented in the claim triangles? 14. Do you calculate the tail factor and how? 15. Which data are presented in the claim triangles: a) paid claims; b) paid claims including costs; c) the sum of paid claims and RBNS? 16. Which data are presented in the claim triangles: a) the occurred claims; b) the reported claims; c) the paid claims? 17. Do you think that the expected inflation should be used in calculations? 18. Are the claims paid by the reinsurer included in the claim triangles? 19. How much is the average deviation of the projected reserves and the real paid claims? 20. Do you calculate the adequacy of the projected reserves? 21. How do you calculate adequacy? 22. Which method is used for claim costs reservation: a) the method of the claim costs ratio; b) by using another method? 23. Please, explain how you use the method selected that had been used in the previous question. 24. Do you use statistical methods for TR projections? 25. Specify which statistical methods you have used and how useful their application has proved to be? 26. Would you like to use statistical methods and how frequently? 27. Which method is used for premium rates calculations: a) the class method, b) the method of premium rate estimations, c) experientially, d) by using another method (specify which)? 28. Please, explain your using of the method selected that had been used in the previous question. 29. Are premium rates corrected, how often and in what manner? 30. Which percentage of technical premiums are variable costs? 31. Which percentage of gross premiums is a reinstatement? 32. Do you have any suggestion about the calculation of technical reserves?

The distributed questionnaire was completed by 11 ICs, of which the 2 domestic ones solely engaged in non-life insurance, and 9 foreign companies, of

which the 7 companies only offer non-life insurance, whereas the 2 companies offer both non-life and life insurance.

In 81.82% of the surveyed ICs, the authorized actuaries are liable for calculating reserves; however, in 45.45% of these companies, the actuaries have less than 5 years of experience in the field of reserving. The actuaries employed in domestic ICs have over 6 years of work experience; yet about 10% of their working day is spent on calculating reserves, which is inadequate concerning the contribution that due to their experience and practice can be provided in terms of the development and amendments of the existing laws and regulations in this field. The situation in other ICs differs from one IC to another – their actuaries spend from 5% to as much as 50% of the working time on the calculation of reserves; the work experience of their actuaries varies from 3 to 6 years in terms of reserving tasks. The methodology applied by the employees regarding the valuation of certain components of the reserves is in line with the regulations prescribed by the National Bank of Serbia. Reserves for incurred but not reported claims until the end of the accounting period are determined by the actuaries in several ways: 88.89% of the actuaries follow the Decision of the NBS and its prescribed methodology, 33.33% apply the Expected Loss Method and 77.78% apply the Chain Ladder Method (CLM). The actuaries employed in domestic ICs apply the NBS methodology and the CLM when calculating reserves. They also apply different methods for the selection of the development factors: three actuaries use weighted averages, two use median values, whereas one actuary (employed in a domestic IC) uses both methods plus the arithmetic factors for the last three accident years.

The question: “Do you enter the liabilities borne by the reinsurer in the run-off triangles?” divided the insurers, both the foreign and the domestic ones; 5 actuaries do not register the amounts handled by reinsurers, whereas 4 insurance companies, quite unjustifiably, use these amounts when calculating the amounts of claims paid. The transfer of risks underwritten to a reinsurance company eases the insurers’ liabilities in terms of future payments and

their responsibilities concerning the payment of such claims. These different approaches concerning the data entered in the run-off triangles make a great difference in practice when quantifying the amounts of reserves. The use of reinsured amounts in the run-off triangles is by all means unjustifiable and should be restricted by law, since such practice is motivated by the wrongful obtaining of tax reliefs. Until the Solvency II Directive, which prohibits the use of these amounts in the projections of future cash flows, comes into force in Serbia, it is necessary that the NBS and its auditors and supervisors who monitor the activities of ICs should react and regulate these matters.

All the actuaries position the amounts in the run-off triangles according to the accident year and the development year; however 28.57% of the surveyed actuaries also enter the amounts payable by reinsurers. However, divergence is present in practice both with the foreign and the domestic insurers. When asked about the statistical methods they apply in terms of reserving, one actuary employed in a domestic IC answered that he applied the methods of correlation analysis, standard deviations and other methods, while the other actuaries do not apply statistical methods, but are willing to include statistical and stochastic projection methods. The encouraging fact is that the intellectual potentials of the hired actuaries strive towards the scientific soundness of the methods they use, which should be more than enough reason for competent internal and external bodies to mobilize their energy and efforts and provide continuous training opportunities in order to achieve the greater preparedness of our insurance market for harmonization with the complex new regulations implemented in the European Union.

Quantifying the costs of settling, reserving, estimating and liquidating claims in an unstable business environment faced with an increasing unfair competition in the race to win over new customers is not an easy task to do. An insight into the balance sheets and the income statements of the non-life insurance companies operating in the RS confirms the necessity to introduce more reliable methods and be more cautious when projecting the amounts of reserves. The reports on the audit of these companies,

i.e. the auditor's opinion, also confirm our conclusion. At the end of 2013, while supervising the operation of the ICs and analyzing the individual items from their balance sheets, the auditors found that five insurers (AS Insurance, DDOR Novi Sad, Millennium Insurance, Sava Insurance and Triglav Insurance) had inadequate reserves. In the aforementioned ICs, the costs of insurance in the individual insurance lines significantly exceed the expense loading (the balance sheets, the income statements and the auditor's opinion are available on the website of the NBS for all the ICs operating in the territory of the RS). However, according to the information provided in the completed questionnaires, 10 actuaries calculate these costs according to the Decision on the Detailed Criteria and the Manner of Calculating Claim Reserves (NBS).

## CONCLUSION

Inherent uncertainty with respect to both the occurrence and the amount of claims in non-life insurance reflects most on the projection of the amounts of technical reserves. Numerous scientific papers and studies are directed towards obtaining the best assessments of their amounts. However, there have almost been no empirical research studies regarding the topic in national academic/actuarial papers. This fact gives special relevance to this paper, which consists of the two directions of the empirical analysis.

- The results of the quantitative analysis, conducted in the previous section of the paper, imply the following conclusions:
- The calculations based on the loss triangles in the euro amounts indicate that in the methods based on the chain indices, the slightest deviation of the projection from the claims paid in 2016 is caused by implementing the development factors obtained via median value, with the remainder coefficient according to Bondy's method;
- The comparative analysis of the obtained projection of the euro amounts regarding the claims incurred but not reported indicates that

the most appropriate forecasting of payments in the following year is obtained by using the CC method, where the deviation from the actual realization is 4.29%, whereas the Average Cost per Claim Method provides the over-reserving of 12.04%. Bondy's method with its median value - as the best projection method concerning the triangulation methods - deviated about 5% from the actual realization of the incurred loss payments.

In the projections of the reserves conducted in the RSD amounts, the Cost per Claim Method produces the slightest deviation (+13.615%) from the incurred losses paid in 2016, whereas the projection performed by applying the Decision of the NBS has resulted in the over-reserving of 40.745% on the account of claims incurred but not reported.

In terms of non-life ICs, the realization of the loss payments is the highest in the first year of insurance coverage; in many other lines of insurance, insurance coverage is short-term. So far, these arguments have been sufficient for the regulators monitoring the activities of the ICs operating in the EU territory; therefore they do not insist on inflation-adjusted projections. The instability of market conditions, as well as a high inflation, present in the Republic of Serbia as well as in other developing countries, point to the need for the implementation of adjustments for inflation when projecting future payments to be made on claims. The projection of the amount of the technical reserves in the selected insurance company for one insurance line, as well as a comparative analysis of the obtained results, indicate that the application of the deflated data results in minor deviations between the expected and the realized payments. The best method of projecting amounts in RSD resulted in the over-reserving of 13%, whereas the projections in the euro amounts differ about 5% from such realizations, which confirms the basic hypothesis and points to the fact that inflation should not be neglected even in the short-term lines of insurance.

By analyzing the responses to the questions from the distributed survey, what was observed was an

insufficient number of the actuaries hired to calculate the technical reserves amounts since their practical perception can be the best ground for the further monitoring of the given topic. The suggestions regarding the current situation and the directions of correcting the technical reserves calculation, accompanying the responses to the questions in the survey, indicate a detected lack of current regulations and a necessity for passing a detailed rulebook and the best possible model of calculating TRs, followed by mitigating the excessive rigidity of local regulations with respect to reserving incurred claims.

The comparative analysis of both directions of the research study has confirmed the additional hypothesis since the best methods detected in the quantitative research were not used in the actuaries' practice in the Republic of Serbia. The practitioners' perceptions and suggestions of the current situation and the directions concerning the correction of the calculation of technical reserves point to the insufficiency of the existing regulations and the necessity for establishing more detailed regulations and a better model for the calculation of TRs, including the mitigation of excessively rigid local regulations applicable to claim reserving.

An undeniable quality of the paper is reflected in the presentation of the numerous methods used to calculate reserves with respect to claims incurred but not reported, as well as the implementation of the various methods used for determining the remainder coefficient since the conducted research study has proved to have a significant effect on the amount of projected reserves.

Being aware of the fact that all the projections were made based only on a single line of business operation of an insurance company, the authors believe that the obtained results provide both the base and the incentive for similar empirical research studies. Simultaneously, this suggests the possible directions of further researching efforts. The intention to use the concrete, historical operating results to analyze the adequacy of the applied techniques in all non-life insurers could not have been realized due to the protection and confidentiality of their data.

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## THE USE OF GEOGRAPHIC INFORMATION SYSTEMS IN PUBLIC SERVICES

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With the further development of information and communication technology and a growing use of smart phones, the significance of Geographic Information System - GIS will indisputably continue to grow. This is supported by the fact that in the last decade geotechnology has been identified as one of the fastest growing technologies, along with biotechnology and nanotechnology. Even though GIS is increasingly being utilized in the Republic of Serbia, it appears that its use with some providers of public services is mainly deduced to showing spatial data with quite limited possibilities for a further analysis - which represents the essence of the use of GIS. The paper uses the examples of good practice in the sphere of the health system, public safety, rescue services and local government. The covered examples show that the use of the analytical component of GIS in everyday activities of the mentioned public services can make their work not only more transparent to the public, but considerably more efficient as well. This way, the analytical component of GIS enables decision-makers to improve the management of frequently limited available resources, while proving a higher level of the service quality to citizens as the final users.

**Keywords:** geographic information system (GIS), health system, emergency response, local government

JEL Classification: L80

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### INTRODUCTION

As J. T. Coppock and D. W. Rhind (1991, 21) suggest, there are rather few written traces on the beginnings of the geographic information system (GIS). Nevertheless, the first modern use of GIS

can be associated with the Canadian government efforts made in the mid-1960s (Haklay, Antoniou, Basiouka, Soden & Mooney, 2014, 11). This endeavor included the census of Canadian land resources in order to understand how the land was used at that time, and also to have a better idea on how to use inventoried land in the future. The mentioned project is considered to be the first GIS project, whereas the first use of the term GIS is associated with the project's director R. Tomlinson (Longley & Batty, 2003, 2). Interestingly enough, this GIS project did not

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have any capacity to visualize the data, but only to show alpha-numeric outcomes in the form of a table. In spite of this shortcoming, this approach utilized by R. Tomlinson and his team was soon recognized by the Harvard Laboratory for Computer Graphics - which has designed and developed a multi-purpose GIS platform - creating in that way the foundation for the development of the first GIS software based on a synergy between a digital map and data.

However, according to P. Longley, M. Goodchild, D. J. Maguire and D. W. Rhind (2001, 11) the main driving force for a further development of GIS occurred during the 1980s, when the hardware prices went down enough to support significant development of GIS software. At that time, a decent computer system - rather modest compared to modern computers - could have been purchased for about \$250,000, and the appropriate software was available at the price of about \$100,000. Even at these prices, the benefits of GIS significantly overcame the costs. With a further decline in prices, computers became more available, whereas the GIS software market was growing at a steady pace, as a logical result of the fact that there was a growing community of those who understood the benefits of GIS.

Nowadays, the implementation of GIS is quite disseminated - ranging from its application in cadaster bureaus to the very sophisticated business applications intended for the needs of analyzing customers and their demographic characteristics. Therefore, it should not come as a surprise that defining GIS is not an easy task to do. Commonly, it can be heard that GIS has as many definitions as applications. Yet, one of the frequently used definitions suggests that GIS represents an organized set of hardware, software and processes devised to allow the saving, editing, managing, handling, analyzing, modeling and visualizing of spatially referenced data, with an objective to solve complex issues in planning and management (Voerkelius, Glavina, Specht-Mohl & Schilcher, 2008, 14).

Although GIS is used at an advanced analytical level by some scientists and practitioners - mainly those whose work is connected to geography and related

disciplines - it seems that scientific and practicing communities in the Republic of Serbia (RS) are relatively modestly conversant with the means of the implementation of the analytical capabilities of GIS when providing public services. The search of SCIndeks (Serbian Citation Index) reveals that there are only a few papers that deal with utilizing the analytical aspects of GIS in the context of providing public safety services, whereas such an advanced use of GIS is almost non-existent when speaking of the other types of public services. Therefore, the main objective of this paper is to highlight the analytical component of GIS as the tool that has an outstanding potential to improve the efficiency of some very important public service by using a set of the examples of good practice in the different fields of providing public services.

The next section of the paper will discuss the most frequent uses of GIS in RS today by the providers of public services. Thereafter, a number of the examples of good practice with respect to the analytical aspect of GIS in the domain of public health, public safety, rescue service, as well as local government are presented. In the final section of the paper, the most important implications, the shortcomings of the paper and new directions for further research will be stressed.

## THE USE OF GIS IN THE REPUBLIC OF SERBIA

Even though the intensive utilization of GIS in developed countries is related to the 1980s, the more substantial use of GIS in RS has been occurring in the last 15 years. Certainly, the assumptions of an extensive use of GIS in RS existed during the 1990s (Jovanović, Đurđev, Srdić i Stankov, 2012, 172), which is supported by the fact that a course entitled "Geographic Information Systems" already existed within the Department of Spatial Planning at the Faculty of Geography - University of Belgrade. Unfortunately, the economic isolation of RS, among other negative effects, resulted in a delayed implementation of GIS on a greater scale in our country. Upon the lifting of the

economic embargo, the most important providers of GIS software solutions significantly stepped up their presence in the Serbian market. That mainly resulted in the education of a wider auditorium of potential users and a better understanding of the capabilities that GIS offers in different fields.

Nowadays, GIS has become a tool that is mainly used in everyday work of many city cadasters and city planning bureaus throughout RS. Recognizing the benefits of GIS, many cities have commenced the implementation of their own "city GIS" projects. For the most part, "city GIS" involves web platforms with digital maps, with the option of showing different sets of thematic maps, as well as a certain level of interaction with available maps. In most cases, "city GIS" includes the maps of administrative units, streets and the address system, roads, natural resources, general urban plans, cadaster data and, in some instances, even the air quality in certain parts of the city.

At the national level, in compliance with the Infrastructure for Spatial Information in Europe Initiative (INSPIRE) guidelines, the Republic Surveying Authority has established the National Spatial Data Infrastructure (NSDI). The main goal of the NSDI is to create an integrated system of spatial data, while allowing users to access with ease various types of spatial data, regardless of whether its source is of a local, national or global character (Vlada Republike Srbije, 2010, 1). This certainly is a big step forward towards conducting various analyses or providing location-based services, especially if we speak of delivering a large number of different public services.

Nevertheless, an impression is that some providers of public services in RS either do not fully understand the importance of GIS for their everyday activities or simply do not have adequate human/technical resources for integrating GIS in their activities - in the majority of the cases it is a combination of both factors. Namely, if we speak of health services, public safety, or rescue services, it can be implied that the use of GIS for analysis or decision-making is at best very limited, with certain exceptions. On the other

hand, even though the concept of "city GIS" exists in many Serbian cities, it seems that local governments do not recognize the numerous possibilities of GIS in the context of attracting investors or improving the business climate in their communities, thus being unable to create added value for investors through the use of the analytical component of GIS, although the conditions for this exist.

## THE USE OF GIS FOR PUBLIC HEALTH SERVICES

A long tradition of spatial studies in public health goes back to the 19<sup>th</sup> century (Setia, Singh, Mathur, Makkar & Pal, 2017, 2). Numerous recent studies have utilized traditional tools for visualizing, as well as data research methods and their modeling that was taken from statistics and epidemiology. Simultaneously with the studies in the domain of spatial epidemiology, a number of other research efforts that were taking place were less within the paradigm framework common for natural sciences, but more within the context of social sciences, including above all the studies on health disparity and variations by regions that were taking into consideration not only health conditions, but also access to and the quality of the rendered health services. Certainly, what is common for both paths of research is the recognition that space and location are of significant importance.

In the previous years, we witnessed the frequent occurrence of epidemics and pandemics, such as the avian flu or A (N1 H1). Taking into consideration the fact that an epidemic outbreak can be followed in space, the application of GIS becomes apparent in the domain of improving public health and preventing the events that can lead to fatal consequences for the population's overall health, which has resulted in the appearance of geomedicine (Blatt, 2015, 102) and spatial epidemiology.

Spatial epidemiology can be defined as the analysis of the spatial occurrence of disease risks and incidence (Ostfeld, Glass & Keesing, 2005, 328). This type of analysis allows the identification of the

population groups with the relatively high levels of a predisposition for catching certain diseases and can significantly assist in isolating the potential source factors of an illness for further analysis. Spatial analysis can also be of great significance in the case of some types of disease that do not have epidemic roots, such as respiratory diseases and cancer. This is especially true when similar results are being confirmed at different times and in different locations, allowing for implications about the etiology of the given disease (www.who.int, 2017).

One of the good examples is a research study by L. A. Williams, C. M. Ulrich, T. Larson, M. H. Wener, B. Wood, P. T. Campbell, J. D. Potter, A. McTiernan, and A. J. De Roos (2009, 373), who did research in the correlation between living close to streets with heavy traffic and the condition of the immune system. The research focused on obese women in postmenopause - a population particularly at risk if exposed to the polluted air. The results of the study revealed that the women living up to 150 meters away from roads with heavy traffic have 21% fewer cytotoxic lymphocytes in comparison to the women who lived farther away from such roads. The authors of this study conclude that such results can have significant implications for a future policy on the use of the land that is near to heavy traffic spots. On the other hand, the next step that could be taken is that related to creating targeted campaigns focused on informing the population that already lives near heavy traffic locations about the importance of having more frequent health check-ups.

Another interesting use of GIS in the domain of health services is a consequence of the Internet's rapid growth. The dissemination of maps in the web environment can assist decision-makers to a great extent, especially when speaking of the prevention and control of, and reaction to the occurrence of certain diseases. As presented in the previous example, the phenomenon of the disease is closely related to the spatial and temporal factors. The Web-based GIS enables us not only to show data in real time, but also to present new information on a given disease in a dynamic manner. Therefore, it comes as no surprise that in the last twenty years the Internet has become an important medium for the public

health institutions dealing with the overall health conditions, as well as for the general population demanding more pieces of information on the state of public health. It could be stated that the Internet has become the main technology for monitoring public health.

Data on the appearance (and spreading) of diseases are no longer reported exclusively through the official statements made by health institutions, but are more frequently so reported via the less formal channels that include anything from newspaper reports, blogs, chat rooms to the statistical analysis obtained from web searches. All these channels together create a brand new approach to understanding the overall state of public health that can be significantly different from what is presented by traditional means. These less formal means of informing significantly shorten the time needed for disease recognition, preventing the government authorities from covering up information on epidemics, while allowing a faster reaction to epidemic outbreaks.

Nowadays, web applications can search, categorize, filter and visually present on the map all the developments related to an epidemic occurrence and disease spreading in real time. A good illustration is the Health Map that is publicly available on the web portal (www.healthmap.org) for the purpose of informing on public health matters, which uses data from various sources in order to create an overview of the currently active infectious diseases at the global level. The sources from which the Health Map obtains pieces of information on epidemic outbreaks are of different confidence, varying from the information that can be found on Google News and ProMED to the official and credible information that comes from the World Health Organization. This web portal (www.healthmap.org) has over 100,000 users on a daily basis, including government health institutions, physicians and those who are planning international trips. Other similar systems include MediSys, Argus, EpiSPIDER, BioCaster and Wildlife Disease Information Node (Brownstein, Freifeld & Madoff, 2009, 2154).

A particularly interesting application of the GIS-based epidemiology was developed by Walgreens.

Namely, the company has created The Walgreens Flu Index™ that is based on a number of purchased flu medications in over 8,000 Walgreens' stores across the United States. Based on the number of the purchased medications, Walgreens generates the maps on a weekly basis that show which segments of the country's population are the most affected and even more significantly it does so faster than the Center for Disease Control and Prevention, whose main objective is to inform the population about health risks as early as possible.

Nevertheless, in the medical context, GIS is not only used for studying the epidemiology and spread of diseases, but also for representing any system that has a spatial component, including the processes that occur within the body of an individual patient (ESRI, 2008a, 5). This is especially true in the case of the bio-medical imaging that shows organs at a micro level. In that respect, GIS based on vector images can be used successfully to examine the blood flows in micro-vascular networks (Roth & Kiani, 1999, 44).

## THE USE OF GIS BY PUBLIC SAFETY SERVICES

Services dedicated to maintaining public safety (such as the police, the judicial system and other relevant institutions) are faced with numerous tasks and challenges in their daily efforts to protect human lives and property. Given the fact that almost every task they are facing has a spatial component, GIS presents itself as an invaluable resource for the daily activities of these public safety services. The GIS-enabled fast access to data and their processing and visualizing allow for a quick and efficient allocation of the needed resources. For public safety, data on the crime location, an incident, a suspect or a victim are of utmost importance in determining the means and scale of reaction. Furthermore, GIS may be utilized for generating information of critical importance for response units, which have to react at the moment's notice. Nowadays, modern public safety services cannot be imagined without the use of GIS technologies. Response teams are not only able to

react faster to critical incidents, but they are also able to achieve the highest possible levels of efficiency in the use of available resources (ESRI, 2006, 4).

The backbone of every analysis begins with entering the exact locations where human lives and property have been endangered. Based on such data, we can find out a great deal about the type and occurrence of such events. A quite interesting example where GIS has been used to record criminal activities is the CLEAR Map of the Chicago Police Department (CPD). Namely, the CPD has created a web portal that can assist citizens to track the criminal activity in their neighborhoods.

This web-based application is publicly available and allows the citizens of Chicago to search the CPD's database that contains all of the recorded events related to public safety. The application allows the citizens to view the thematic maps categorized by the type of criminal offense. The database itself contains the records of all of the events in the last year that can be searched by the time periods of 90, 180, 270 and 365 days, whereas the data are updated on a daily basis. By utilizing the GIS software and other technologies, the CLEAR Map's database can generate the maps that show almost all different variations of the location where an offense was committed or other relevant pieces of information, where every piece of data can simultaneously be shared with officers in the Command Center, as well as with the citizens, via the web portal. Such visualizations are useful and very effective additions to those rendering public safety services, allowing those in charge to identify, discuss and note the patterns in the domain of public safety.

The true value of one such system in terms of public safety can be seen through the cases in which GIS assists to establish where next crime will occur, based on historic data. One such example is a Los Angeles case dating back in 1998 (Geggie, 1999, 111). Namely, detectives were looking into a series of three robberies, where the offender attacked the victims and robbed them as they were walking to their parked cars. The mentioned attacks occurred in three completely different locations within the range of several kilometers.

The idea was to use the historical data, as well as the way in which the crime was committed, in order to predict the time and the location of the next attack. This was done by mainly relying on the statistical methodology that used the mean values ( $\mu$ ) and the standard deviation ( $\sigma$ ) of the attacks. This methodology took into account the times of the attacks and the locations where they had occurred (shown as dots in Figure 1). Assuming the normal distribution principle, it was determined that there was an 68% probability (i.e. within  $1\sigma$ ) that the next attack would occur between January 25<sup>th</sup> and February 6<sup>th</sup>, in a time period between 20:45 and 23:45, in some of the locations marked with the smaller rectangle. By using the same logic, there was a 95% probability (within  $2\sigma$ ) that the next attack would occur in longer time spans and in the locations that were marked within the larger rectangle, as is shown in Figure 1.

The fourth attack occurred within the expected time and location frameworks that had been predicted based on the first three attacks. Following the fourth

attack, new predictions were made and the police units were distributed in the field with an objective to capture the offender. During the fifth attack, the suspect was spotted, but after the chase the criminal managed to escape. Even though the offender ran away, the objective was partially achieved given the fact that after the last attack there were no similar incidents in that part of the city.

### THE USE OF GIS BY RESCUE SERVICES

Emergency rescue services are responsible for protecting human lives and property, but quite often they are faced with limited resources in the context of the people and equipment. RS is no exception to this rule. Namely, there is a major shortage of firemen - according to the European standards, RS should have about 7,000 firemen in service, but instead there are currently only about 3,100 in service („Koliko Srbiji nedostaje vatrogasaca?“, 2016).

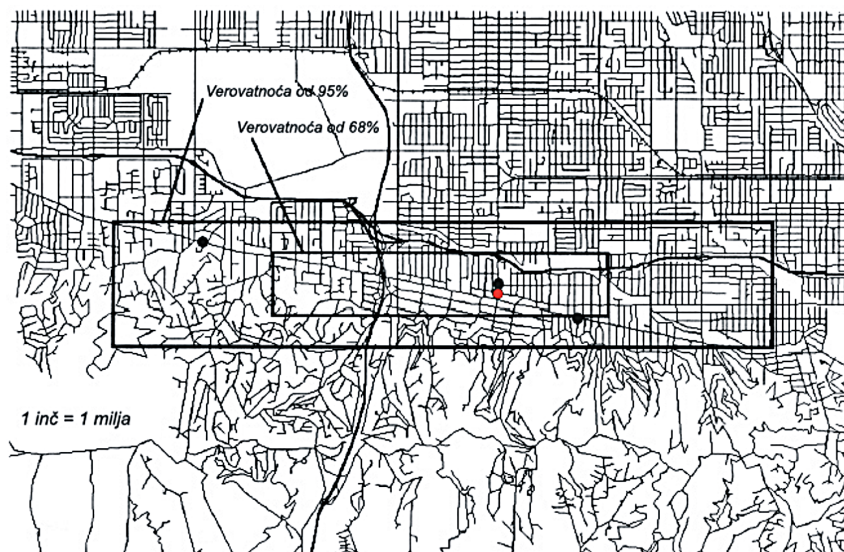


Figure 1 Map of LA where attacks occurred

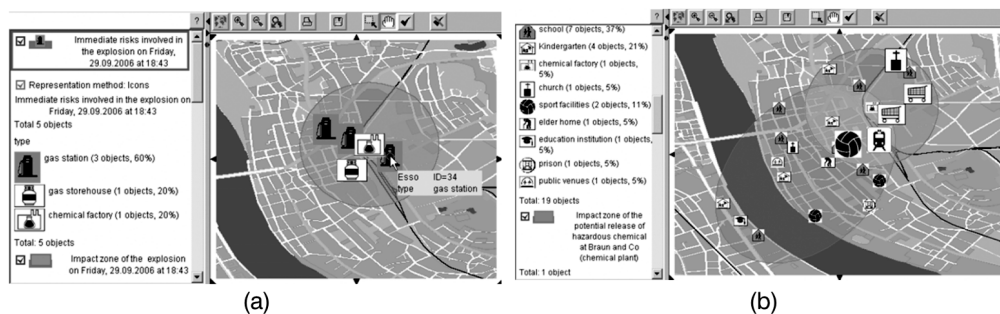
Firefighting is far more than mere reaching the location of fire. Nowadays, firefighting assumes a holistic approach to a given situation and possible scenarios. GIS offers a set of tools for work with tactical, location-based information, such as - what it is in the immediate surroundings that may have an effect on the course of action. In that sense, urban environments pose a special challenge (Forkuo & Quaye-Ballard, 2013, 32). Facilities including schools, shopping malls, warehouses with dangerous substances, factories or gas stations, may additionally complicate intervention in the field and determine its course. Access to such information while the response units are on the way to the location of an accident allows firefighters to secure the area faster and more effectively, taking into consideration possible threats to the population and the units in the field.

Indeed, the incoming information can be “fed” into the GIS application that can provide an overview of the potential threats that are in the immediate vicinity of an accident in real time, as is shown in Figure 2(a). For instance, sparks from a nearby electrical substation can ignite the flammable gases already present in the air, eventually causing an explosion of a larger scale.

The unique value of such an “intelligent tool” for

rescue service is reflected in the fact that it allows those in charge to make an estimate of the number of the people living near the endangered zone. That is possible based on the census data that are already in the GIS database. Although such estimates may not have perfect accuracy, they do enable the planning of certain activities, such as the evacuation of certain city neighborhoods. It is particularly important to stress that such a GIS facilitates the prompt anticipation of events and taking all the necessary measures for minimizing and eliminating the unwanted effects for the local population (Andrienko & Andrienko, 2007, 901), as is seen in Figure 2(b).

Another good illustration is a study by T. J. Cova (1999, 53), who has developed a “tool” that enables local communities to assess the probability of traffic jams during evacuation efforts. The application uses the GIS database that contains information on the dissemination of the population within a community, as well as the streets network. The final result is the “vulnerability map” that points to potential traffic-related bottleneck points during evacuation. Given the fact that the scale of an accident cannot be determined in advance, this method is based on the principle of the worst possible scenario in a given location.



**Figure 2** The potential sources of risk in the immediate surroundings

- (a) The map shows the other potentially dangerous facilities that are in an immediate vicinity;  
 (b) The map shows which objects will be under a direct impact in the case of some of the potential scenarios - specifically, the emission of chemicals from a local factory

Source: Andrienko & Andrienko, 2007, 902

We can assume that a certain neighborhood is threatened by a forest fire and that evacuation is necessary. Furthermore, we can assume that only one vehicle is needed to evacuate the entire family from one household. If the households are located in a dead-end street, then all inhabitants have to use the same street exit. The method used by T. J. Cova (1999) is designed to take into account the entire network of roads/streets so as to determine the bottleneck - the section that will suffer the greatest traffic congestion during evacuation. In the neighborhood with a dense network of roads/streets, traffic will flow towards several exit options, minimizing the bottleneck effect. However, densely populated areas with the limited road/street infrastructure can lead to serious issues during evacuation, if the situation demands the prompt evacuation of the entire area.

Figure 3 shows the map of one part of Santa Barbara, California. The streets are displayed in different colors, depending on the bottlenecks, based on the previously explained method used by T. J. Cova (1999). The streets are assigned different colors, depending on the expected number of the vehicles that should go through the critical bottlenecks during the evacuation effort, taking into consideration the worst possible scenario. The dark-colored locations represent the places where it is estimated that over 500 people will

pass during evacuation, thus creating potentially dangerous standstills, wasting precious evacuation time.

By analyzing such maps, firefighters (and other rescue services) can have an overview of the most critical locations during the evacuation effort and consequently plan to dispatch the units in those spots so as to facilitate the flow of traffic. On the other hand, such analyses allow for the better planning of the traffic infrastructure that can take into account bottlenecks and try to minimize their number.

## THE USE OF GIS BY LOCAL GOVERNMENTS

One of the most frequent uses of GIS can be found in the domain of local government (Campbell & Masser, 1992, 529). City managers make decisions on a daily basis that directly or indirectly have an impact on the quality of the life of every single citizen that works and resides in a given city or community. Nevertheless, citizens are quite aware of the fact that wrong decisions made by local authorities may have a negative effect on the quality of their lives - starting from traffic jams to protecting the natural environment. Therefore, citizens start to demand that decisions made by local governments should



**Figure 3** The map of the street bottlenecks in Santa Barbara, California

be justified and supported by adequate data. In that way, not only will the risk of making wrong decisions be minimized, but non-functional and often financially unjustified projects will be prevented from commencing.

In fact, citizens increasingly demand that the offered actions should result in improved efficiency in solving their problems, generating sustainable value, a further enhancement of the community's development capacities, as well as the better management of the city's infrastructure and resources. Hence, it comes as no surprise that a growing number of local governments (Jacoby, Smith, Ting & Williamson, 2002, 305) and utility companies operating at the city level invest in GIS and in building databases - whose synergy can significantly facilitate decision-making.

The fact is that those who create policies at a local/regional level have a talent for suggesting rather complicated solutions. Prior to the introduction of GIS, the costs of testing such solutions and their evaluation were quite high in terms of money, effort and time. In other words, GIS has enabled the testing of complex solutions through a set of scenarios using data from the real world and their implementation starts only after it has been determined that a particular solution is acceptable for all stakeholders.

The general acceptance of GIS technologies implies the value that this tool has in the process of reaching many important decisions. Indeed, nowadays, GIS is used in almost all aspects of planning a community's development or following the trends occurring within it. City architects and cadasters need as detailed information as possible on the classification of land parcels and available land resources in specific parts of a city or a region. Civil engineering needs to plan a network of roads, define the building of timeframes and forecast all costs associated with road construction. Also, it should not be forgotten that all large-scale infrastructure installations, such as sewage, the water system or telecommunication, demand spatial data in order to establish efficient maintenance or a faster response in the case of issues or when planning to add new users to the existing service network. Numerous public services have

recognized the possibilities that GIS offers. Thanks to GIS, many spatial analyses are conducted in order to attract new and support the existing businesses that, in turn, create new jobs - thus strengthening a city's tax potential, or in order to improve the planning and implementation of large-scale works.

In addition to the said, the synergy between the increasingly more available Internet, on the one hand, and digital maps, on the other, defines the new types and levels of the services that local authorities can offer to their citizens. Generally, the services based on the GIS technologies offered by local governments can be classified into the following three categories: a) the services aimed at business users, b) the services aimed at the local population, and c) the services aimed at other governing bodies. In the next section of the paper, only the first category will be briefly covered.

### **Local Government Services Aimed at Business Users**

These types of services are usually related to fostering economic development, information on land use in certain urban zones, the efficient processing of various requests and the issuance of permits. Potential investors can access all relevant data on a 24/7 basis, locate the city areas where the construction of manufacturing facilities, shopping malls or residential/office buildings is permitted, or have the visualization and analyze the demographic or economic data collected from the last population census for certain city areas.

In the domain of supporting economic development, GIS technology is used dominantly as an efficient way to attract new investors. In fact, the mere existence of GIS in a given city can be said to already be creating a favorable climate and a desirable location for hi-tech companies. However, in order to attract additional capital, or to convince the existing companies not to relocate their production facilities, the GIS of a local government needs to be completely adjusted to the business needs of the investors themselves. For numerous investors, seeking efficiency leads

towards not only finding an optimal location, but also towards obtaining an absolutely transparent picture of a given potential location. Today's investors prefer getting a complete image, taking into consideration the traffic and telecommunication infrastructures, the community's image, the skills of the local labor force, the market size, sustainability and plans for a further development of local communities.

Hence, in order to remain competitive, many cities (and entire regions as well) develop their own GIS infrastructures that should be able to give answers to all of these - and many other - questions to the prospective investors. The Savannah Economic Development Authority (SEDA) represents an example of good practice. SEDA was founded in the mid-1990s, with an objective to improve the living standard of the population that resides in the Savannah and Chatham counties, Georgia, USA, through stimulating economic development by attracting investment capital, generating new jobs and providing an adequate support to the companies that had already been located in that region.

SEDA is certainly aware of the fact that, in the competitive environment that is becoming increasingly tougher on a daily basis, it is impossible to offer prospective investors the papers with a list of available real estate and their square footage. To investors, it is of vital importance to know where the potential site is exactly located - how far from the port, the train station, the highway or the local airport. Above all, investors want to know all of these things even prior to making the initial contact with the local authorities.

Understanding these demands, SEDA has introduced a GIS portal (<http://www.savannahsitesearch.com/>) with a database containing all of the available manufacturing facilities, office spaces and parcels that range between 500 m<sup>2</sup> to 250 hectares. At every moment, SEDA has at its disposal over 150 real estate locations that it can offer investors. SEDA offers its potential clients all the available data via the Internet portal, and much more beyond that. Indeed, through the GIS use, a connection between spatial and non-spatial data has been established, thus creating an

efficient geo-database for managing resources, while shortening the search time. Clients can conduct their search as per available real estate, select the one that matches their need and perform various types of demographic and business analyses (ESRI, 2008b, 2). In addition to this, SEDA has the capability of overlooking all changes in real time and offering its clients the data that are always up-to-date.

A study on the economic impact SEDA had on the development of the local economy revealed that, in the period between 1996 and 2007, in collaboration with the state and local partners, SEDA had helped to create 15,320 new jobs and had generated \$1.8 billion in investments (SEDA Annual Report, 2007). The study also showed that without these jobs mainly attracted by SEDA, the region would not have reached this level of development until as late as 2020.

## CONCLUSION

The main contribution of this paper is reflected in the fact that, in RS, there are only a few studies of the use of analytical GIS in the domain of public services. Through the examples of good practice, the paper stresses an important role that analytical GIS can play for different providers of public services, given the fact that the numerous activities that they perform on a daily basis and the issues that they are faced with both have a pronounced spatial component. On the other hand, it should not be forgotten that, nowadays, providers of many public services are under growing pressure to deliver the best services possible to the general public with the limited time, financial, operational or human resources. In order to do so, they turn to GIS as an indispensable technology that allows those who plan and deliver public services to achieve improved information processing, design better decision-making processes and reduce overall costs, while simultaneously improving the quality of life in their communities.

Certainly, one of the shortcomings of this paper is related to the fact that it does not provide a more precise overview of the current state in terms of the

utilization of analytical GIS among the mentioned providers of public services in RS. Namely, certain assumptions were made primarily on the publicly available data, which does not exclude a possibility that certain types of analytical GIS are carried by the providers of public services addressed in this paper. In fact, this shortcoming provides one possible direction for future research, and that is the study of the level of the integration of GIS and its analytical capacities into the day-to-day activities of the analyzed providers of public services in RS. Such a study would allow for a much better understanding of the current state when the analytical component of GIS is concerned, and identify future steps for a faster adoption of this technology, with the end goal of creating new services and also improving the quality and transparency of the already existing public services for citizens.

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