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## THE IMPACT OF CORPORATE SOCIAL RESPONSIBILITY ON THE FINANCIAL PERFORMANCE IN THE REPUBLIC OF SERBIA

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Original Scientific Paper

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**Under conditions of globalization and increasing market integration, competitiveness is a prerequisite for survival in the global market. The goal is not only to achieve a competitive advantage but to make it sustainable. The most stable and long-term source is reflected in business innovation. Innovative activities encourage companies' development and influence the preservation of market position as well as the company's profitability. The effects of applying the CSR concept can positively influence a company's financial performance. The authors of this paper investigate whether there is a connection between the concept of corporate social responsibility and financial performance in the Republic of Serbia. The paper presents the results of research conducted in the territory of the Republic of Serbia. The research covers 165 large companies during the period November 2019 - August 2021. The data were processed using the Smart PLS program. The research results show that the application of the CSR concept has a positive effect on the financial performance of large companies in the Republic of Serbia.**

**Keywords:** Corporate Social Responsibility; Financial performance; PLS-SEM, Serbia.

### INTRODUCTION

Today, due to the globalization process of the market and economy, the development of information technologies, and knowledge, socially responsible business is getting stronger, so the success of a company's business is conditioned by its socially (ir) responsible activities and practices. Namely, the trend of global business offers a large number of corporations some new opportunities for expanding their activities in hitherto inaccessible markets. For corporations where this kind of growth proves to be successful, it is true that besides generating more profit, they gain greater power that is not only economic but also social (Porter & Kramer, 2019). Precisely, with globalization, which represents a fertile ground for the creation of conglomerates, comes the need to discuss the companies' key role in the development of the well-being of both the economy and society.

Therefore, in their global business, with the intention of achieving socially responsible business, corporations can be involved in community development in several ways. By raising environmental awareness, donations, philanthropic activities, education, scholarships, and volunteering, corporations raise the social standard (Čoćkalo et al., 2015; Sharma, 2019; Sinthupundaja et al., 2019). What is crucial for these conglomerates is to present the mentioned activities to society by promoting their results, to create a better image of themselves and thus getting closer to the population and winning their favor in a very competitive environment (Bošković et al., 2021).

Companies that have a strategic approach to implementing the CSR concept and have built relationships with stakeholders can gain advantages that will allow them to survive and be



successful in a competitive market. These benefits are: improving financial performance; improving reputation; increasing sales, customer satisfaction, and loyalty; strengthening customer relationships and expanding market share; improving competitive advantage, satisfaction, creativity, and employee commitment (Hur et al., 2018; Luo & Bhattacharya, 2006; Ngai et al., 2018; Rettab et al., 2009; Saeidi et al., 2015; Sekulić & Pavlović, 2018; Xie et al., 2017). Future-oriented corporate business gets a new flywheel – the restoration of the natural environment as a business opportunity and obligation. The efficiency and effectiveness of the new green cycle cannot be achieved without educated and aware consumers (demand), in which corporations play a significant role through relations and communication with the public.

The research was conducted in the business environment of the Republic of Serbia on a sample of 165 large companies. The research model is based on the management team of large companies and their perception of the concept of corporate social responsibility and financial performance. The Smart PLS program was used to analyze the relationship between the concept of CSR and financial performance. The obtained research results showed that there is a positive statistical correlation between dimensions of corporate social responsibility and financial performance. The paper is structured in three parts. The first part refers to an overview of the prevailing views on the concept of corporate social responsibility and financial performance. The second part is based on the applied statistical research method, while the third part refers to the analysis of the obtained results, recommendations for future research, and conclusions.

## THEORETICAL BACKGROUND

Many large companies have an important role to play in the business environment in which they operate, as well as in their ability to influence social circumstances. Precisely on that basis, the environment requires transparency of corporations in the performance of their activities. Generating as much income as possible and survival no longer represent the crucial goals of international corporations, but those are reflected in socially responsible business (Lee, 2008; Wu et al, 2020). Based on that, companies gain the loyalty of all the interested parties, i.e. stakeholders; business continuity; importance and influence in society; bringing the company itself to a better position in

the market where it operates and thus strengthening the competitive advantage concerning its main competitors, also, on the company's reputation (Fauzi & Idris, 2009).

Every large company bases its corporate social responsibility on the implementation of new (clean) production processes, to reduce and eliminate the harmful effects on the environment and improve working conditions for the employees. If technological development is at the center of general development, then it must be affirmed and encouraged, noting that the technology should be used sensibly and for common good, which is not always the case (Asif, et al., 2013). Corporate social responsibility of companies is most often based on the ideology and beliefs of the top managers themselves. In this regard, the vast majority of the companies have an individual ethical code of socially responsible business, created according to their needs, which is often based on a very similar ideology, i.e. on improving the general well-being of the society and environmental protection (Aleksić et al., 2020; Gupta et al., 2017; Berber et al., 2021).

Large companies that apply the concept of corporate social responsibility suffer certain pressures from society, the employees, and the local community in which they operate, which influences the conception of a socially responsible business policy. The integration of certain business activities within the activities of organizations is often done based on research (Lindgreen et al., 2009). In this regard, the organization conducted an internal survey concerning the well-being of the working environment. By implementing legal regulations that companies must comply with (e.g. minimum wage), to do more responsible business, many companies make provisions like additional health protection, improvement of working conditions and safety at work, improvement of work organization, and care for the employees even outside the work environment (Đervidal-Lekanić et al., 2016; Samy, Odemilin, & Bampton, 2010). In addition, positive CSR activities have a positive effect on the company's employees (Cheema et al., 2020).

The implementation of the CSR concept depends on several factors related to the size of the organization, the market in which it operates, as well as the influence of various interest groups. To achieve the positive effects of social cohesion, it is necessary to establish a correlation between social,

environmental, economic, and philanthropic business policies at the national level (Vukotić et al., 2019).

The application of ethical business should become the "norm" and practice of all companies (small, medium, and large), given that many studies have proven that companies that apply the concept of CSR achieve significant growth in business performance (Morsing & Schultz, 2006).

Generally speaking, the concept of corporate social responsibility implies that the profit achieved by the organization should not be directed only to the employees and the shareholders, but also to other groups of interested parties (stakeholders), who have, with their activities, participated in any way in the creation of financial performance (Carroll, 1991).

The correlation between the financial indicators and the indicators of corporate social responsibility has been the subject of a lot of research in the field of management since the second half of the 20<sup>th</sup> century. Financial indicators presented in the form of ratios, indices, and equations provide insight into the quantified performance of the observed organization (Mali et al., 2022; Tripathi, & Kaur, 2020).

Financial performance plays a significant role in the concept of corporate social responsibility (Grubor et al., 2020; Javed et al., 2020; Scholtens, 2008). So far, a lot of research has been conducted in which it has been proven and confirmed that there is a positive correlation between corporate social responsibility and financial performance.

According to the authors McWilliams and Siegel (2001), it can be concluded that there is a certain level of socially responsible business that will maximize profits, and at the same time satisfy the demand for socially responsible business of interested parties. The measured level of CSR in the research was determined by cost-benefit analysis (McWilliams & Siegel, 2001, p. 125).

The financial result represents one of the most used indicators for determining the strategic value of CSR, and the satisfaction of stakeholders is the key to a company's financial performance (Orlitzky et al., 2003, p. 40). According to the meta-analysis, 55% of 160 respondents to the study believed that there is a positive correlation between the CSR and financial performance, 22% of the respondents did

not answer, while 18% of them were not sure of the answer, and 4% of the respondents gave a negative answer (Rettab et al., 2009, p. 375). Author Orlitzky et al. (2003) conducted another meta-analysis and found similar results (p. 43). The analysis of the mentioned studies gives credence to the widely accepted understanding that socially responsible business would in most cases improve a company's financial performance. Therefore, it could be concluded that in developing economies, the connection between CSR and the company's financial performance depends on the stakeholders' perception of CSR activities.

Author Scholtens (2008) analyzed 289 US companies to determine the correlation between CSR and financial performance, using the data collected from 1991. to 2004. Based on the analysis and the obtained results, it can be concluded that the correlation between CSR activities and the financial performance of the companies is positive (Scholtens, 2008, p. 47).

To investigate the impact of CSR on the business's financial performance: return on investments (ROI- Return on Investment), return on invested funds (ROA- Return on Assets) and return on capital (ROE- Return on Equity) authors (Tanggamani et al., 2018) have used "The Dow Jones Sustainability Index". Based on a sample of 2,500 of the largest companies in the world, it can be concluded that all three indicators had a positive impact on social performance, i.e. on corporate social responsibility (Tanggamani et al., 2018, p. 338). Also, other authors confirm that CSR activities have a positive effect on financial performance (Cho et al., 2019, p. 11; Hafez, 2016, p. 40).

Research conducted on 314 Turkish companies shows that CSR has a positive effect on the financial performance of the business and the competitive advantage of the company. It was found that larger manufacturing companies are somewhat more sensitive to CSR, while in the case of heavy industries less emphasis is placed on CSR activities because, to a certain extent, these activities are far from the public (Ağan et al, 2016, p. 1872).

The interest and practice of socially responsible business in the Republic of Serbia have existed for quite a long time, with the fact that its manifestations and goals were considered in the socio-economic milieu. In the past, socially

responsible business was more oriented toward internal responsibility (responsibility towards employees), while today more emphasized is the so-called external social responsibility, i.e. responsibility towards the environment, that is, towards the selected target groups.

In research conducted on a sample of 53 large companies in the Republic of Serbia, the authors proved a significant positive correlation between the CSR activities related to the employees on the financial results and environmental performance. The obtained results show that corporate social responsibility activities can improve their financial performance in the current year, as well as have significant effects on their financial results in the following year, and vice versa (Grubor et al., 2020, p. 9).

## RESEARCH METHODOLOGY

The research was conducted in large companies operating in the business environment of the Republic of Serbia in the period from November 2019. to August 2021. A total of 165 companies responded to the questionnaire, i.e. one manager from each company who is at the level of top management in the organization responded. Large companies in the Republic of Serbia are considered to be the ones that have more than 250 employees, in this regard the sample size in this research is 29.15% of the total sample (Popović, 2020). The questions in the questionnaire consist of three segments. The first segment of the questionnaire is based on the questions related to the socio-demographic characteristics of the respondents, what economic activity they are engaged in, and the type of market (local, regional, international, or global market). The questions related to the concept of corporate social responsibility represent the second group of questions, divided into six dimensions. The first dimension refers to responsibility towards the community and contains four questions, the questions are presented as Comm1, Comm2, Comm3, and Comm4. The second dimension, responsibility towards the environment, is based on four questions that are marked as Envi1, Envi2, Envi3, and Envi4. The third dimension refers to the responsibility towards the employees, and the questions are presented as HRM1, HRM2, HRM3, and HRM4. The next dimension refers to the responsibility towards the investors, which contains questions marked as Invest1, Invest2, Invest3, and Invest4. The fifth dimension refers to the responsibility towards the

suppliers and contains five questions tagged as Supp1, Supp2, Supp3, Supp4, Supp5, and the last dimension refers to the responsibility towards the customers and contains four questions that are marked as Cust1, Cust2, Cust3, and Cust4. This part of the questionnaire is structured in the form of closed questions on a Likert scale from 1 to 5 (1 - do not agree at all; 2 - do not agree; 3 - neither agree nor disagree; 4 - agree; 5 - completely agree) (Rettab et al., 2009). The third segment of the questionnaire refers to the company's financial performance. The questions and marks in this segment are: Concerning your competitors, rate your business results over the past year related to 1. market share (FinPerf1), 2. rate of profit/profit (FinPerf2), 3. Return on Investment - ROI (FinPerf3), 4. Return on Assets - ROA (FinPerf4), 5. Return on Equity - ROE (FinPerf5) and 6. Growth in sales volume (FinPerf6). All questions in the questionnaire are structured in the form of closed questions on a Likert scale from 1 to 5 (1 - weak or the smallest in the branch; 2 - below average; 3 - average or equal to competition; 4 - better than average; 5 - superior). The questionnaire created has been compiled relying on previous research (Saeidi, et al., 2015).

Based on previously stated theoretical viewpoints and presented research methodology, the authors of this paper propose a research hypothesis that reads:

- H: The application of dimensions of the concept of corporate social responsibility has a positive effect on the financial performance of large companies in the business environment of the Republic of Serbia.

## RESEARCH RESULTS AND DISCUSSION

Based on the mentioned research methodology, the authors of the paper checked and tested the questionnaire, i.e. analyzed its internal consistency. Internal consistency was checked by calculating Cronbach's Alpha (Cronbach's Alpha), composite reliability (CR), and average variance extracted (AVE) for each construct in the model (Bjekić et al., 2021; Grubor et al., 2018; Hair et al., 2019). The variables that were excluded from further analysis of the indicators are those that had values below 0.708. Based on the above, the authors have excluded from the analysis the following indicators: HRM1, Invest3, Cust3, and Cust4. The following figure, Figure 1, shows the research model.



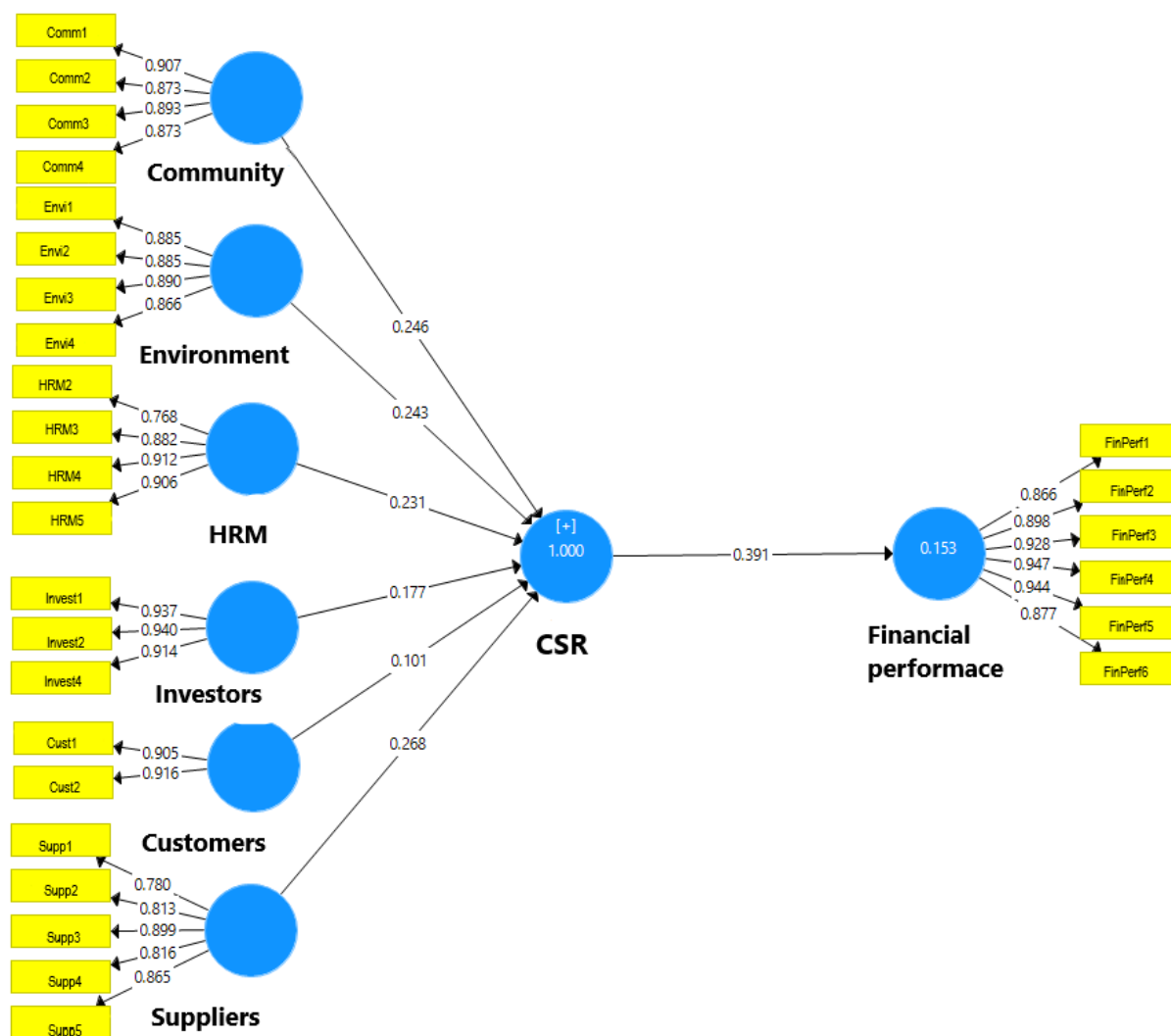


Figure 1: Path coefficient estimates

Table 1: Indicator reliability and construct reliability and validity

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Suppliers	0.891	0.920	0.698
Environment	0.905	0.933	0.777
HRM	0.890	0.925	0.755
Community	0.909	0.936	0.786
Investors	0.923	0.951	0.866
Customers	0.794	0.907	0.829
Financial performance	0.959	0.967	0.829

Table 1 presents the obtained results of internal consistency, related to the assessment of the questionnaire's validity. Internal consistency was performed by calculating Cronbach's Alpha, Composite reliability, and Average variance extracted for each construct of the model.

The analysis of the obtained research results in Table 1 shows that Cronbach's Alpha values are in the range of 0.890 to 0.959. According to previously conducted research by Hair et al., (2017), it is stated that the lower limit of

acceptability is 0.7. The second indicator refers to composite validity, which is measured by different factor loadings for each part in the model, and the values shown in Table 1 are in the range of 0.907 to 0.967. In this regard, the authors conclude that the criterion of composite reliability is met, given that the lower limit of acceptability is 0.7 (Hair et al., 2017). The third indicator shown in Table 1 refers to the analysis of the average extracted variance. By analyzing the data obtained, it can be concluded that the values range from 0.698 to 0.866, given that the lower limit of AVE acceptance is 0.5 (Hair et al., 2017, p. 118). Based on this, convergent validity is satisfied for both constructs in the model.

The criterion of discriminant validity, i.e. Heterotrait-monotrait (HTMT) is the next criterion that will be shown in Table 2. The specified criterion means that all the values are below 0.9, that is, that the defined components are sufficiently different from each other and therefore show different phenomena. HTMT is an indicator that shows that all ratio values below 0.9 are acceptable, that is, it shows that the defined components are sufficiently different from each other and that they show different phenomena (Hair et al., 2019). Based on the results obtained in Table 2, it can be seen that all the values are below 0.9 and that the criterion of discriminative validity using the HTMT criterion is fully met.

Table 2: Discriminant Validity: Heterotrait-monotrait (HTMT)

	Suppliers	Environment	HRM	Community	Investors	Customers	Financial performance
Suppliers							
Environment	0.544						
HRM	0.647	0.700					
Community	0.578	0.760	0.669				
Investors	0.582	0.558	0.433	0.582			
Customers	0.609	0.637	0.505	0.596	0.516		
Financial performance	0.378	0.322	0.359	0.312	0.319	0.214	

The following Table, Table 3, shows the Variance Increment Factors (VIF). The limit of acceptance of the value of the variance increase factor is defined so that the value is less than 3 and then there is no problem with multicollinearity (Knock, 2015). Based on the indicators obtained, it can be concluded that there is no multicollinearity problem between the formative constructs, given that all the values are below 3.

Table 3: Variance inflation factor- VIF

Formative construct	CSR
Suppliers	1.944
Environment	2.442
HRM	2.076
Community	2.337
Investors	1.671
Customers	1.640

Table 4: Mean, Standard Deviation, T-statistics, P-values

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics ( O/STDEV )	P Values
CSR -> Financial performance	0.391	0.390	0.079	4.927	0.000

Table 4. shows the results related to the correlation between the dimensions of corporate social responsibility and financial performance. Based on the obtained results, it can be concluded that there is a positive statistically significant correlation between corporate social responsibility and financial performance (T=4.927; p= 0.000) in large companies in the Republic of Serbia. The obtained results have similarities with previously conducted

research (Cho et al., 2019; Grubor et al., 2020; Hafez, 2016).

Based on the performed analysis and obtained research results, it can be concluded that the hypothesis (H: Application of dimensions of the concept of corporate social responsibility has a positive effect on the financial performance of large companies in the business environment of the Republic of Serbia) is accepted.

## CONCLUSION

Advancement of business towards the global market requires from the company's management team: new skills, techniques, and knowledge, agility in business, decisiveness in making business decisions, as well as readiness to react quickly and solve problems in a dynamic and competitive environment. Relying on their knowledge and experience in the field of motivation and encouraging certain targeted behavior of consumers, companies' managers are increasingly creating positive changes in society, based on the so-called social awards, i.e. on a wider social benefit that extends beyond the usual coordinates in which the company operates. Socially responsible business practices in companies represent a concept according to which the economic entities consciously and voluntarily dedicate themselves to the activities with the aim of having a positive impact on their work, social and natural environment. This behavior is a consequence of the developing awareness of the importance that companies have in modern society. Companies' operations, as well as their effects, go beyond the companies' internal framework of an organization, so an increasing emphasis is placed on companies' activities, which aim to satisfy a wider circle of interested parties.

The primary business goal of every company is profit growth; however, the strategic goals of the company are strengthening the market position through the improvement of business digitization, increasing revenue with innovative business opportunities, increasing efficiency, and maintenance. From the aspect of socially responsible business, companies take as their strategic goals the education of employees through various programs, implementation of the highest standards of this type of business, and contribution to the development of local communities through various supporting activities.

The concept of corporate social responsibility is based on the balance between the economic, social, and environmental goals of companies. The role of CSR can be defined as the organization's intention to contribute to the community in which it operates through its business activities. Accordingly, businesses should concentrate on those CSR activities that demonstrate significant results, ensuring that they only engage in efficient, effective activities. CSR has a significant impact

on the organizational performance of companies, especially financial performance. Financial performance was observed from the aspect of applying financial indicators (profit rate, return on investments, return on invested funds, etc.) concerning corporate social responsibility. The results of this research show that CSR activities are not only a cost for companies but can improve the company's corporate value in the long run.

Based on the previous analysis in this paper, practical implications are based on empirical evidence that unequivocally indicates that there is a positive correlation between the concept of CSR and the financial performance in the Republic of Serbia. The role and importance of dimensions of corporate social responsibility represent an imperative for future business. The limitations of this study are reflected in the sample, in terms of the size of companies, and future research efforts need to be expanded so to include medium-sized companies as well.

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## UTICAJ KORPORATIVNE DRUŠTVENE ODGOVORNOSTI NA FINANSIJSKE PERFORMANSE U REPUBLICI SRBIJI

U uslovima globalizacije sve veće rastuće integracije tržišta, konkurentnost predstavlja preduslov za opstanak na svetskom tržištu. Cilj nije samo ostvariti konkurentsku prednost nego je cilj učiniti je održivom. Najstabilniji i dugoročan izvor ogleđa se u inovativnosti poslovanja. Inovativne aktivnosti podstiču razvoj kompanija, utiču na očuvanje tržišne pozicije kao i profitabilnost kompanija. Efekti primene koncepta KDO mogu pozitivno uticati na finansijske performanse kompanija. Autori ovog rada istražuju da li postoji veza između koncepta korporativne društvene odgovornosti i finansijskih performansi u R. Srbiji. U radu će biti predstavljeni rezultati istraživanja sprovedenog na teritoriji Republike Srbije. Istraživanje je obuhvatilo 165 velikih kompanija u periodu od novembra 2019. do avgusta 2021. godine. Podaci su obrađeni pomoću programa Smart PLS. Rezultati istraživanja pokazuju da primena koncepta CSR pozitivno utiče na finansijske performanse u velikim organizacijama u Republici Srbiji.

**Ključne reči:** Korporativna društvena odgovornost, Finansijske performanse, PLS-SEM, Srbija.



# THE IMPACT OF ENTREPRENEURIAL LEADERSHIP ON INNOVATIVE EMPLOYEE BEHAVIOR: A MULTI-GROUP ANALYSIS COMPARING THE UNITED STATES, SERBIA, AND BOSNIA AND HERZEGOVINA

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**In the research of this paper, the center of events is entrepreneurial leadership as a new concept for the work behavior of associates. This study aims to determine the entrepreneurial self-efficiency and inclination of entrepreneurs towards innovation and creativity of entrepreneurs. The research aims to achieve results that reveal the relationship between entrepreneurial leadership and the work behavior of employees. The study tested 360 individuals - subordinates in small and medium enterprises operating in the United States - California, Serbia - Vojvodina, and Belgrade, and Bosnia and Herzegovina - Republika Srpska. Based on the obtained results, a model was made and hypotheses were tested. It was a big problem to harmonize the results of research from these three regions. Careful processing of the data resulted from these results. The results obtained have a significant effect on innovative entrepreneurship, which again aims to determine whether there is entrepreneurial leadership and in what form. The research found that innovative entrepreneurs mediate between entrepreneurial leadership and the innovative behavior of associates. The results obtained in this study confirm the hypothesis that entrepreneurial self-efficiency has an adequate effect on the connection between entrepreneurial leadership and the innovative behavior of employees in the companies in which they work. The results of this research work are intended to achieve the originality of entrepreneurship and small and medium enterprises dealing with innovation and a challenging business environment. According to the findings of numerous authors who deal with this issue, this research is not the first attempt to develop innovative behavior of employees in entrepreneurial small and medium enterprises, but it certainly has a great impact on increasing the effectiveness of entrepreneurial leadership on innovative behavior.**

**Keywords:** Entrepreneurial leadership; Innovative environmental; Innovative work behavior; Innovative employee behavior.

## INTRODUCTION

Crites et al. (1994) and Breckler (1984) suggest individual creative self-sufficiency and team beliefs about creative efficiency. Crites et al. (1994) in their study examine the reliability of their results. According to the results, Crites et al. (1994) claim that scales can distinguish people whose attitudes differ from the information

obtained. Breckler (1984) assessed individual creativity and formed a model with three components: affect, and behavioral cognition. Breckler (1984) in his research researched and identified five conditions for proper testing of the established model, and effective mediation between entrepreneurial leadership and the creativity of the individual in the team.

Fernald et al. al. (2005) state in their paper observing the overall state of entrepreneurial action and the ability of entrepreneurs as bearers of progress both in each country and in the world. Fernald et al. al. (2005) state in their interesting work that entrepreneurial ventures and the current literature on entrepreneurship devote a significant discussion to the role that entrepreneurs have in their newly created businesses and in new market niches, which they create themselves. Fernald et al. al. (2005) state in their paper that ideas in a special type of people appear so that they become innovators and create a nucleus of new products, which they later refine and thus become visionaries and bearers of the future. When creating a product, they want to create a product that does not exist on the market, they want it not to have a high production cost, so that they have a big profit, at least in the beginning. With all these characteristics of entrepreneurs, whose imperative is to apply good management practice, they apply in their new company. In this paper, Fernald et al. (2005) engage in a very difficult thing and that is the discovery of important abilities whose bearers are entrepreneurs as leaders, the circumstances in which entrepreneurial leaders are created are very changeable and must take care of the survival of their company at all times. Also, Fernald et al. (2005) attempt to essentially create a new style of entrepreneur who is evolving, offering a change from the past and moving into the future. There are new ideas about modern business characterized by the fourth industrial revolution. The role of technology in entrepreneurial leadership is growing and the application of information and communication technologies and the entrepreneurial need for sustainable development of their companies. All these changes and global challenges for entrepreneurial leaders are becoming an important driver of technology development, innovation, and overall economic growth and development.

A review of the literature so far is not relatively new, some authors are controversial in their data on entrepreneurial leadership. Entrepreneurship is according to Sajfert et. al. (2012) studied since Aristotle. According to the authors Sajfert and Čóckalo (2009), entrepreneurship is an internal feature of the open economy, the company's "Natural" organizational form. Entrepreneurship and enterprise cannot be successful without adequate leaders, regardless of who holds these functions - the owner, entrepreneur, manager, or worker in a different or the same person. Sajfert

and Čóckalo (2009) state that in the world of business people, leaders at different levels in companies, especially those who are just planning to start their own business, are future promising entrepreneurs. Sajfert and Čóckalo (2009) state that small business owners often work and operate from remote poorly equipped workshops, a small business owner has to make business decisions most often alone, so he becomes a leader entrepreneur. Sajfert and Čóckalo (2009) state in their work that this is the time of small businesses, i.e. entrepreneurship, in other words, it is the small entrepreneur on whom the whole world is based for the most part bases his hopes for economic development, then we can say that he is a small entrepreneur still a restrained person. Sajfert and Čóckalo (2009) state that the skill of entrepreneurship is a process of directing, where an individual directs himself or a group of people towards goals that he has already achieved or towards goals that he wants to achieve with his like-minded people.

Renko, et. al. (2015) state in their research that entrepreneurial leadership is very interesting for scientists and their research. Renko, et. al. (2015) come to the conclusion, which they present in their work and analysis that papers of this type appear in professional journals on the SCI list, as well as in the popular press, and among doctoral students in doctoral studies. Renko, et. al. (2015) in their research concluded that entrepreneurial leadership has great application in theory and practice and the creation of entrepreneurial opportunities. Authors Renko, et. al. (2015) in their research state the specific circumstances that may affect the success of entrepreneurial leadership, and test the reliability and validity of empirical measures for this construction (ENTRELEAD scale). Renko, et. al. (2015) developed the ENTRELEAD scale for assessing entrepreneurial leadership style, including identifying opportunities, taking risks, proactively, being visionary, and innovatively, and leading leaders in generating ideas. Using this new measuring tool, Renko et. al. (2015) arrive at valid results, that entrepreneurial leadership is predominant among founders rather than among non-founders, indicating constructive validity.

Most people want to do their jobs well. They don't need commands, threats, or ultimatums. What they can use more productively are direction, support, encouragement, and rewards, Haim (2002). Haim (2002) reveals how to increase commitment, competency, and productivity by stimulating each

employee's intrinsic desire to excel. Iqbal et al. (2020) in their research seek to establish the relationship between entrepreneurial leadership and employee innovative behavior and examine the mediating role of affective commitment, creative self-efficacy, and psychological security in this. A study conducted by Chen (2007) tests the view that the innovative ability of a new venture is influenced by the interaction of the leadership of the leading entrepreneur and the creativity of the members of the entrepreneurial team, measured by the creation of patents. Čóckalo et al. (2020) state that youth unemployment rates are high in both developing and developed countries, improving the environment for entrepreneurial activities is a necessity to increase the potential of youth entrepreneurship. Global entrepreneur Sir Richard Branson (2006) has built a business empire and made billions, yet is renowned for his approachability, and ability to challenge and succeed against the odds. *Screw It, Let's Do It: Lessons in life and Business* that have helped him through his business and personal life such as, believe it can be done and that, if others disagree with you, try and try again until you achieve your goal; or that you must love what you do. Malik et al. (2020) conducted a study that focused on the impact of entrepreneurial leadership on employee innovative behavior while using organizational change, employee commitment, and commitment toward change as a mediator. When people start a job for which they are experts, they want to do it with quality. In the workplace, people try to do their job correctly. According to Haim (2002), it is important for employees to be guided by someone, to give them support, and to stimulate them in order to receive rewards. Haim (2002) in his research concludes that employees need to increase their commitment, to be as competent and productive as possible, if in the production process. Every employee should be given a chance to stand out. In their research, Iqbal et al. (2020) seek to establish the possibility for an entrepreneur-leader to be as innovative and creative as possible. A study conducted by Chen (2007) tests the view that the innovative ability of a new venture is influenced by the interaction of the leadership of the leading entrepreneur and the creativity of his members of the entrepreneurial team, measured patent creation. Čóckalo et al. (2020) state in their research conducted in the Central Banat District that it is necessary to create an entrepreneurial environment for youth entrepreneurship. The great leader entrepreneur Sir Richard Branson (2006) is a very direct businessman. His idea is to create a

very profitable airline Virgin Atlantic. As a very creative businessman, he did a very unusual thing. There is a hairdresser on all flights, so passengers can get a haircut without wasting time. Branson (2006) states in his very interesting book: try and try again until you reach your goal; or that you have to love what you do. Malik et al. (2020) conducted a study that focused on entrepreneurial leadership on their innovative behavior and organizational change, employee commitment, and commitment to change as intermediaries.

Fahad et. al. (2020) cite in their comprehensive research a model they have developed that integrates entrepreneurial leadership, instructing people to be innovative and creative in their future work. According to Fahad et. al. (2020) and research, they found out how much influence entrepreneurs have on small and medium enterprises. Fahad et. al. (2020) state that their research, which has been empirically confirmed, has a significant impact on the quality attitude towards innovation, which can benefit the owners of new companies. Sarwoko (2020) stated before embarking on research that many studies test the relationship between leadership and innovative behavior at work. Sarwoko (2020) therefore decided to examine the mediating role of creative efficiency and the relationship that exists between entrepreneurial leadership and innovative behavior at work in start-ups. Sarwoko (2020) states that this research has compensated for the impact of effects on people with new ideas who are innovative and have the ability to realize their ideas and make them a good business. According to Sarwoko (2020), a person who possesses creative self-efficiency is well on his way to achieving great business ventures with innovation. The results obtained by Sarwoko (2020) show that entrepreneurial leadership increases the innovative work behavior of employees. In addition, Sarwoko (2020) argues in their research that entrepreneurial leadership increases creative self-efficacy and leads to increased innovative work behavior of employees.

Tung and Yu (2016) state in their research that there is a great understanding of the impact of entrepreneurial leadership and the great importance of innovation. Tung and Yu (2016) place special emphasis on the ability to look at situations, things, and phenomena from a new point of view and find new, original solutions, i.e. the ability to look at things in a new way. Tung and Yu (2016) state that it is a cognitive process, the development of ideas,

concepts, means, or discoveries that the creator himself and those for whom the product is intended consider new. These are the people who make things different. Tung and Yu (2016) concluded that it is the result of a specific structure and interaction of intellectual abilities, personality characteristics, knowledge, and motivation. Gumusluoglu and Ilsev (2009) state in their research that transformational leaders are people who create exceptional motivation in employees and outstanding achievements in all areas, and possess vision, enthusiasm, and inspiration to focus on higher missions and ideals that go beyond their immediate personal interests. People who see problems in a new way.

According to Gumusluoglu and Ilsev (2009), transformational leaders have self-confidence and confidence in personal abilities and capabilities in achieving exceptional results and achieving a special mission in general. Holzmann and Golan (2016) state that a quantitative expression of how much we want to achieve what we want. According to Holzmann and Golan (2016) business goals are the endpoints towards which activities are directed, the starting and ending point of management. They state that one should take care of the dimensions of creativity in the production environment. Holzmann and Golan (2016) state that every business goal should be clear, they state that vaguely set business goals make it difficult to achieve. Unattainable business goals have a demotivating effect on both entrepreneurial leaders and all employees in the company. Holzmann and Golan (2016) developed a model that explains the initial phase that motivates employees to achieve the basic thing they come to the company for, and that is personal affirmation and earnings. Shin (2015) cites his research that is how much leadership influences creativity. According to Shin (2015), important personality traits related to creativity are tolerance of uncertainty, non-conformism, curiosity, flexibility, etc. He states that creativity requires a specific motivation in which self-actualization, achievement, curiosity, and diversity are the central motives that should be influenced by entrepreneurial leaders.

Santos et. al. (2018) state in their paper that they want to focus on the idea management system (IMS). The competitiveness of the economy largely depends on the ability to introduce ideas. There is an agreement between research and business practice on the great importance of the process of introducing innovations, especially at

the earliest stage when it is necessary to identify business opportunities and the possibility of their realization. In the process of innovation management, many authors emphasize the crucial role of idea management, i.e. the efficiency of the way of creating, collecting, evaluating, improving, selecting, and implementing ideas. Chen, et. al. (2014), state in their research that product innovation is the main topic of their work. According to Chen, et. al. (2014) development and application of new ideas, which people spread over time within the institutional framework. They state that innovation is a new idea, which can be adapted to an old idea. They state that every renovation is shaped to strengthen the position of the company or the company against the competition. Chen, et. al. (2014) instruct us that we need to distinguish the invention from innovation. Chen, et. al. (2014) believe that invention is the act of discovering (inventing) new methods and techniques, i.e. technologies, as well as new products. They state that innovations have the task of materializing discoveries and using the market to bring them to purpose.

Recently, entrepreneurial leadership towards Bagheri and Pihie (2011). It is focused on constant development and change. They believe that entrepreneurial leadership should create and use opportunities for new business ventures, accepting risks in starting a business and improving business performance, as well as finding new potentials and opportunities. Bagheri and Pihie (2011) state that a strategy of constant change and innovation should be constantly developed and implemented. Innovations and their rapid implementation and commercialization are the basic instruments of entrepreneurial leadership. However, as stated by Bagheri and Pihie (2011) in their work there is a problem with the conceptual basis of this developmental area of research.

Bagheri (2017) conducted a study whose main purpose is to investigate the impact of entrepreneurial leadership on innovative work behavior. Bagheri (2017) states in his work three key tasks of entrepreneurial leadership: achieving successful existing business, finding new business potentials, and securing the future of business. Authors Mehmood, et. al. (2019) conducted a study examining the impact of entrepreneurial leadership (EL) on innovative employee behavior (IB) along with the mediating role of psychological empowerment (PE). Findings discovered by Mehmood, et. al. (2019) that the person who



undertakes certain ventures takes on the uncertainty and risk for its effect. Mehmood, et. al. (2019) state that every company needs a leader entrepreneur as the bearer of entrepreneurial initiative. They state that he is always a creative person who is capable of founding a new company.

## LITERATURE REVIEW

### Development of the definition of entrepreneurial leadership

Cunningham and Lischeron (1991) state that entrepreneurial leadership is a very interesting phenomenon that involves setting clear goals, both for the entrepreneur, who is always a creative and capable person who creates opportunities, starts business ventures, bears business risk, but also looks to the future develop a human resources system. Irelan et al., (2003) state in their research that entrepreneurial leadership implies the ability to innovate in the company. They state that successful entrepreneurial leadership is the best combination of talent, knowledge, and abilities of entrepreneurs, to influence others, and very skillfully strategically manage resources. Irelan et al. (2003) state that all ideas and abilities must be supported by capital, to emphasize the need for such behavior in search of opportunities. Gupta et al. (2004) in their research conclude that leadership creates visionary scenarios, which are possessed by only an extremely small number of entrepreneurs. Gupta et al. (2004) state that leaders are the ones who bring together and mobilize the employee support team and who are committed to creating vision and strategic value creation.

Thornberry (2006) in his research states that he came to the conclusion that leadership requires passion, vision, focus, and the ability to inspire others. Thornberry (2006) further states what results he has come to, that entrepreneurial leadership requires all of this, as well as a different way of thinking about a business venture, with adequate capital, to help entrepreneurial leaders identify, develop and seize new business opportunities. Surie and Ashley (2008) cite their model, which they have managed to develop through pragmatism, which combines entrepreneurial leadership and ethics, and state that this merger is not incompatible. A case study conducted in the United States and India states that it is necessary to emphasize pragmatism that will be combined with ethics, in order to achieve sustainable entrepreneurial leadership. Renko, et.

al. (2015) state in their research that entrepreneurial leadership has an impact on the performance of the whole group that needs to achieve the set organizational endeavors, bearing business risks with a view to the future, which necessarily includes identifying and using entrepreneurial opportunities.

Jong (2006) states in his research on innovation, that it is the application of new ideas, which people spread over time, who can innovate and be adapted to the old idea. Jong (2006) warns us to distinguish between invention and innovation. According to Jong (2006), invention means the act of discovering (inventing) new methods and techniques. While innovation means discoveries that materialize through the market. Introduces the term measuring innovation and another understanding of individual innovation. Leitch et al. (2013) investigate how entrepreneurial leadership develops as a social process and what its role is. Their findings indicate that the ability of entrepreneurs as leaders to communicate successfully, influence behavior and lead individuals and groups, build relationships of cooperation and teamwork is very important. Leitch et al. (2013) analyze the need to create an atmosphere of support and security, and high participation of all employed members in planning and determining all things that affect them.

The findings of Leitch et al. (2013) indicate that the entrepreneurial leader should make an effort to realize individual efforts, interests, and goals successfully integrated into the joint venture, interests, and goals. De Jong and Den Hartog (2010) in the study state that innovation is a specific tool of entrepreneurship, by which entrepreneurs change the face of small business or a new different meaning of a product or service in our daily lives. According to De Jong and Den Hartog (2010), the constant search for new, better, and more perfect ones, which entrepreneurs are usually the first to embark on, has given rise to innovation. If we look at the situation that leads to the creation of innovations through the prism of running a business, the opportunity to start or improve a business is a chance to do something different and better. If we look at it from the economic aspect, then it is a combination of the use of materials, resources, physical and mental work, as well as capital or investment. Entrepreneurial leaders, as innovators, are people who create new combinations of these enumerated aspects. De Jong and Den Hartog (2010) in their



article deal with the developed measure of the IWB with four potential dimensions: research, generation, advocacy, and implementation of ideas.

Jaiswal and Dhar (2015) in their research address the role of transformational leadership and employee creativity. They state that creativity is the ability to look at situations, things, and phenomena from a new point of view, and creative people find new original solutions, that is, they have the ability to look at things in a new way. As creativity is the forerunner of innovation, and innovation is the implementation of creative solutions, many situations that require the creative behavior of employees can be described as problems. Jaiswal and Dhar (2015) found that transformational leaders encourage the creative behavior of employees and help them build the capacity for creative problem-solving. Jaiswal and Dhar (2015) state the conclusions, and the experimental nature of this paper, encourage contemporary research that aims to explain the effects of transformational leadership on follower creativity. The key skill or attribute of successful entrepreneurs is self-efficacy. This is an optimistic confidence in our ability to undertake the task, successfully complete it and achieve a favorable outcome. Self-efficacy comes from the social cognitive and provides the basis for human motivation, well-being, and achievement. Psychologist Bandura (1977) created the concept and coin of self-efficacy. Richter et al. (2012) state that people who have a strong sense of self-efficacy choose a path, and actions that make them feel competent and confident that they can produce the desired outcome. They think optimistically, are motivated to persevere when the challenge is chosen, and can correct their thoughts and actions. Richter et al. (2012) believe that these individuals see difficult tasks as challenges to master rather than avoid threats. In contrast, those who have poor self-efficacy are far more skeptical of their abilities, act in a self-exhaustive way, and tend not to use self-regulatory practices to adjust or improve thoughts and behaviors when challenges arise. Richter et al. (2012) state that self-efficacy is rated above talent in the formula for success. Many entrepreneurs show strong self-efficacy. Strong self-efficacy suggests they can produce their own future. A study by Currie et al. (2008) explores the possibility of introducing entrepreneurial leadership into the English public sector. In a study by Currie et al. (2008), they claim that entrepreneurship in the public sector is characterized by a combination of three different

agencies: "stakeholders", "entrepreneurial" and "political". According to a study by Currie et al. (2008), the entrepreneur in the public sector identifies market opportunities in the policy environment and optimizes the potential of innovation to improve the performance of the public sector organization. A study by Newman et al. (2018) explores the unique impact of entrepreneurial leadership on the relationship between creative employee self-efficacy (CSE) and innovative behavior. A study by Newman et al. (2018) found that the effect of dimensions of Self-efficacy is the largest and most important dimension of the model, and refers to trust in entrepreneurial characteristics, the persistence of the individual, and the tendency to take on the role of leader. The results of the Newman et al. (2018) suggest that leaders involved in modeling employee entrepreneurial behavior and directing employees toward identifying and exploiting entrepreneurial opportunities are more likely to encourage innovative behavior among employees with higher levels of creative self-efficacy than by allowing employees to participate in decision making. A study by Kim et al. (2017) investigated the application of entrepreneurial leadership and its impact on reliable, responsible behavior in the Chinese public sector. Results Kim et al. (2017) find that the level of trust and interaction in organizations is very important so that there is an increase in accountability and the creation of new ideas, which promotes broader ideas that can increase efficiency in the new Chinese civil service system. The main findings of Kim et al. (2017) provide clear lessons and inspiration on how to activate and nurture personal, organizational, and social innovation spirit and behaviors to maximize the effects of social innovation. Gupta, et al. (2004), state in their research and the obtained results that the newly formed companies appear in a competitive environment, which differ from the previous forms of behavior, concerning the classically formed companies. Gupta et al. (2004), they wrote an article that develops the construct of entrepreneurial leadership using existing works on entrepreneurship and leadership as a guide. The findings of Gupta et al. al. (2004), provide evidence that there is an absolute appeal of entrepreneurial leadership in all cultures and introduce preliminary factors that contribute to reducing social disparities in the perceived efficiency of new businesses. The article by Freeman and Siegfried (2015) examines three important challenges faced by people who start new businesses on modern principles and when

starting new businesses: caring about development, you must be infinitely persistent, and do market research in poor business conditions. In the article, Freeman and Siegfried (2015) come to the results that are important for their hypothesis, and these are the skills needed to start a new company and to run their business successfully. Freeman and Siegfried (2015) think here of their successful business during the founding of the company: think strategically, teach the staff in the company and do self-evaluation.

The study of Huang et al. (2014) tells us about the improvement of previous theoretical research. They examined the relationship between entrepreneurial leadership and the efficiency of new ventures with the introduction of research and exploitation innovations that will accelerate the modern business of a company set up in this way. The study by Huang et al. (2014) indicates that entrepreneurial leadership is positively associated with research and exploitation innovations, which in turn is closely related to new ideas that will be realized in the new firm. The results obtained by Huang et al. (2014) contribute to the need for this research so that the impact of entrepreneurial leadership can be good for achieving excellent results in a new endeavor. Huang et al. (2014) followed two types of innovative activities (i.e. research and exploitation innovations) and concluded that these relationships depend on the conditions achieved in the environment.

Surie and Ashe (2008) cite in their research the model they did and the results they came up with. They believe that entrepreneurial leadership is in an experimental phase, dominated by pragmatism, and far less important is the philosophical approach. Surie and Ashe (2008) point out in the obtained results that entrepreneurial leadership is related to ethics and that maintenance to create value requires ethical action for business results to be adequate. According to Leitch and Volery (2017) and their findings, leadership has been a major research topic in management for almost a century. Leitch and Volery (2017) state that many of his concepts have not yet been adopted in entrepreneurial leadership and are used in small business management. Leitch and Volery (2017) state that entrepreneurial leadership is still evolving and has not yet achieved adequate tools to assess its characteristics and behavior. Kang et al. (2015) state in their research that they discover the results they obtained by realizing that the founders of the researched companies have innovative behavior of entrepreneurs, who are very active in cooperation

with staff. Kang et al. (2015) come up with results that relate to company leaders with a positive attitude toward innovative employees and work on inspiring them. Kang et al. (2015) state in the research that they failed to find a special effect between the innovative climate and the behavior of leaders. Fontana and Musa (2017) state that they came up with results in their research where they measured entrepreneurial leadership (EL) intending to discover where innovation is and examining their relationship. Fontana and Musa (2017) in their research present the findings and prove that there is no connection between innovation performance and company performance. Therefore, Fontana and Musa (2017) encourage them with their obtained results and found that the obtained variables, and research shows the findings of the missing link of the influence of intellectual property on the performance of innovations. That is why Fontana and Musa (2017) contribute to science so their contribution is of great importance. Simsek et al. (2015) state in their research that they concluded that there is a connection between entrepreneurial leadership and innovation. Simsek et al. (2015) obtained results that are encouraging, but some of the more innovative issues remain insufficiently explored. In their work, Harrison et al. (2015) arrive at results that form the basis for gender relations and entrepreneurial leadership. Harrison et al. (2015) arrive at results that are adequate for gender and entrepreneurial leadership, as evidence of equality. Based on this, Harrison et al. (2015) propose a research plan for a gender analysis of the rapidly growing interface between leadership and entrepreneurship, which contains topics around which the future development of entrepreneurial leadership can be organized. Sawaeen and Ali (2020). state that Kuwaiti SMEs contribute to the country's economic growth by creating productive jobs for Kuwaiti youth and professionals by improving income diversification.

## METHODOLOGY

Starting from the defined problem area, the subject of research in this paper is the impact of entrepreneurial leadership on the innovative behavior of employees. The goal is to gain relevant scientific knowledge about methods for innovative behavior of employees in entrepreneurial leadership activities, primarily at the enterprise level, but also individual innovative projects, as well as to evaluate their contribution to organizational performance.

## Hypothesis

- H-1: Entrepreneurial leadership has a positive impact on employees' innovative work behavior.
- H-2: The innovative environment of the company influences the relationship between entrepreneurial leadership and the innovative work behavior of employees.
- H-3: Entrepreneurial self-efficacy has a good impact on entrepreneurial leadership on innovative work behavior of employees.

To achieve the research objectives, this study used data from a sample of 360 supervisor-subordinates working in small and medium enterprises (SMEs). A sample of 120 supervisor-intermediaries was taken in companies operating in the USA – California 120, in the Republic of Serbia – Vojvodina and Belgrade 120, and Bosnia and Herzegovina – Republic Srpska 120. Based on the determination of the basic set and sampling, a sampling strategy was developed and hypotheses were tested with the help of IBM SPSS Statistics. Data was collected with the help of a master's student at Fullerton University in Los Angeles – California, a master's student at the University of Novi Sad, and a master's student from the International University of District of BiH.

After rejecting poorly completed surveys, the final sample included 360 supervisor-subordinates out of 510 (response rate 70,58%), such a high rate was obtained by high engagement of interviewers. Demographic data of the respondents state that out of the total number of participants, 290 (80,55%) are men in all three groups, and 70 (19,45%) are women. The average age of the respondents was 37.5 years with SD of 6.65 years, while their average length of service in a particular organization was 7.25 years in all three groups, with SD of 4.25 years.

## Measurement Scales

**Entrepreneurial leadership:** To measure the subordinates' "perceptions of their immediate leaders" EL practices, we used an eight-item EntreLeadership questionnaire developed by Dave Ramsey (2011). Cronbach's alpha for this measurement scale was 0.87, which indicates a high degree of internal consistency.

**Innovative environment:** To measure the innovative environment, of the firm, we used a

three-item scale developed by Patterson et. al. (2005). Survey participants were asked to choose a number from 1 through 5 that best describes their firm's innovative environment. The answers are thus obtained according to the Likert scale of 5 degrees Likert (1932) (alpha 5 0.68).

Previous research has failed to reveal which personality traits distinguish a future entrepreneur and manager. Chen et al. (1998) came up with the results of individual characteristics that are highly entrepreneurial and proposed a construct of entrepreneurial self-efficacy (ESE) to predict what the probability is that someone will become an entrepreneur. According to the results obtained by Chen et al. (1998), these are five factors: marketing, innovation, management, risk-taking, and financial control. Study Chen et al. (1998) that the overall ESE scores distinguished entrepreneurship students from management and psychology students. They also found that entrepreneurship students have greater self-efficacy in marketing, management, and financial control than management and psychology students. De Jong and Den Hartog (2010) in their study address a developed measure of the IBW with four potential dimensions: research, generation, advocacy, and implementation of ideas. Leading entrepreneurs were asked to rate the frequency with which their subordinates exhibited different behaviors according to the Likert scale (Likert, 1932) ranging from 1 (never) to 5 (always).

The Jung et al. (2003) study builds on existing literature and proposed four hypotheses about how the leadership styles of top managers, directly and indirectly, affect their companies' innovations. Empirical research by Jung et al. (2003) on employee performance specified that the age, gender, education, and seniority of employees in an organization can affect their performance.

## Research and the Results

To assess the reliability of all data, we used IBM Amos 21 Software. Before going to analyze the hypothetical relationship between different variables of research, the study has provided the descriptive statistics of the selected sample and inter-variable correlations for all of the subject variables. The means, standard deviations, and inter-variable correlations are presented in Table 1.

The study provided descriptive statistics of the selected sample inter-variable correlations for all

subject variables. Mean values, standard deviations, and inter-variable correlations are shown in Table 1 for US Sample 1, Serbia Sample 1, and Bosnia and Herzegovina Sample 1.

Table 1: Means, Standard Deviation, and Inter-Variable Correlations  
US Sample 1

Scale	Mean	SD	1	2	3	4	5	6	7	8
1. Gender	0.83	0.17	1							
2. Age	35.65	6.54	.009	1						
3. Education	1,85	0.39	0.04	0.07	1					
4. Tenure	5.23	3.42	0.02	0.07	0.09	1				
5. Entrepreneurial Leadership	5.43	0.52	0.07	0.03	0.082	0.05	1			
6. Entrepreneurial Self-efficacy	5.32	0.39	0.05	0.33*	0.41	0.21	0.29*	1		
7. Firm's Environment	3.45	0.43	0.08	0.08	0.06*	0.28*	0.36*	0.32*	1	
8. Innovative Behavior	3.75	0.31	0.04	0.17	0.16*	0.19*	0.38*	0.29*	0.39*	1

Notes: N=120 dyads \*P<0.01, (two-tailed)

Serbia Sample 1

Scale	Mean	SD	1	2	3	4	5	6	7	8
1. Gender	0.81	0.16	1							
2. Age	34.75	6.65	0.02	1						
3. Education	1,85	0.46	0.05	0.06	1					
4. Tenure	5.25	3.54	0.04	0.05	0.07	1				
5. Entrepreneurial Leadership	5.65	0.55	0.05	0.07	0.09	0.08	1			
6. Entrepreneurial Self-efficacy	5.64	0.48	0.06	0.25*	0.35	0.13	0.38*	1		
7. Firm's Environment	3.55	0.35	0.06	0.08	0.22*	0.26*	0.45*	0.28*	1	
8. Innovative Behavior	3.45	0.32	0.05	0.18	0.26*	0.25*	0.43*	0.35*	0.46*	1

Notes: N=120 dyads \*P<0.01, (two-tailed)

Bosnia and Herzegovina Sample 1

Scale	Mean	SD	1	2	3	4	5	6	7	8
1. Gender	0.84	0.19	1							
2. Age	36.21	6.81	0.02	1						
3. Education	1,93	0.49	0.04	0.03	1					
4. Tenure	5.31	3.79	0.06	0.06	0.06	1				
5. Entrepreneurial Leadership	5.61	0.54	0.06	0.08	0.07	0.09	1			
6. Entrepreneurial Self-efficacy	5.62	0.49	0.07	0.23*	0.37	0.15	0.35*	1		
7. Firm's Environment	3.51	0.34	0.05	0.06	0.26*	0.28*	0.41*	0.29*	1	
8. Innovative Behavior	3.41	0.33	0.07	0.17	0.24*	0.23*	0.41*	0.31*	0.42*	1

Notes: N=120 dyads \*P<0.01, (two-tailed)

## RESULTS OF MEDIATION ANALYSES

The hypothesis (H-2) of this study is set up so that the company's innovative environment influences the relationship between entrepreneurial leadership (EL) and innovative employee behavior (IWBE). Baron and Kenny (1986) in their study seek to distinguish between the properties of moderator and mediator variables by explaining differences in human behavior. Baron and Kenny (1986) distinguish two functions of variables: a) the moderator function of the third variable and b) the

mediating function of the third variable. Baron and Kenny (1986) suggest three conditions that must be met: first, the independent variable should significantly relate to the dependent variable, second, the independent variable should significantly relate to intermediaries, and third, the control intermediate variable. In the paper, we used the experiences of Baron and Kenny (1986) to investigate the effect of meditation. As shown in Model 3 (Table 2), the innovative environment of the company has become a stronger predictor of innovative behavior of employees  $\Delta R^2 = 0,25$ , for



US Sample 2,  $\Delta R^2 = 0,24$ , for Serbia Sample 2,  $\Delta R^2 = 0,23$ , for Bosnia and Herzegovina Sample 2. The mean value for all three sets is  $\Delta R^2 = 0,24$ .

According to the study by Stuart et al. (1999), a statistical hypothesis was developed, which was tested based on the observation of a process model using a set of statistical variables, which stated the effect of mediation. The study sought the effect of Entrepreneurial Leadership (EL) when an innovative enterprise environment was introduced into the model (Table 2).

The company's innovative environment has become a predictor of Innovation Work Behavior  $R^2 = \text{model 1 } 0.07$ ; for US Sample;  $R^2 = \text{model 1 } 0.05$ , for Serbia Sample 2; For Bosnia and Herzegovina  $R^2 = \text{model 1 } 0.04$ .

The findings in all their samples suggest that the innovative environment of the analyzed firms confirms the link between Entrepreneurial Leadership (EL) and innovative employee behavior and supports the second hypothesis.

Table 2: Hierarchical Regression Model for Moderation  
US Sample 2

Variables		Innovation Work Behavior		
		Model 1	Model 2	Model 3
Step. 1	Age	0.14*	0.07	0.045
	Gender	0.15	0.06	0.044
	Education	0.15**	0.08	0.072
	Tenure	0,10	0.10	0.07
Step. 2	Entrepreneurial Leadership (EL)		0.41**	0.35*
	Firm's Environment (FE)		0,42	
Step.3	$R^2$	0.07	0.21	0.46
	$\Delta R^2$		0.17**	0.25**
	F	4.96	18.70**	35.49**

Notes: N=120 dyads: \*P<0.1, \*\*P<0.05 \*two-tailed teste; standardized coefficients are reported

Serbia Sample 2

Variables		Innovation Work Behavior		
		Model 1	Model 2	Model 3
Step. 1	Age	0.13*	0.06	0.044
	Gender	0.11	0.05	0.043
	Education	0.14**	0.07	0.071
	Tenure	0.10	0.06	0.065
Step. 2	Entrepreneurial Leadership (EL)		0.40**	0.37*
	Firm's Environment (FE)		0,46	
Step.3	$R^2$	0.05	0.20	0.44
	$\Delta R^2$		0.15**	0.24**
	F	4.95	18.72**	35.47**

Notes: N=120 dyads: \*P<0.1, \*\*P<0.05 \*two-tailed teste; standardized coefficients are reported

Bosnia and Herzegovina Sample 2

Variables		Innovation Work Behavior		
		Model 1	Model 2	Model 3
Step. 1	Age	0.12*	0.05	0.036
	Gender	0.10	0.04	0.043
	Education	0.13**	0.06	0.074
	Tenure	0,10	0.10	0.05
Step. 2	Entrepreneurial Leadership (EL)		0.43**	0.38*
	Firm's Environment (FE)		0,45	
Step.3	$R^2$	0.04	0.19	0.43
	$\Delta R^2$		0.14**	0.23**
	F	4.94	18.71**	35.43**

Notes: N=120 dyads: \*P<0.1, \*\*P<0.05 \*two tailed teste; standardized coefficient's are reported

Aiken et al. (1991) conducted a survey with 206 Japanese students and 243 Russian students. The results showed that Russians use repression more often as a regulation of emotions than the Japanese, and suppressing anger reduces depressive emotions among Russians, but not among the Japanese. Analogous to this research, the interpretation of the term (EL x ESE) was simplified, followed by the procedure of hierarchical regression. In the hierarchical regression, the control variables were entered in the first step, and the main effects were entered in the second step. That's how we got the interaction of the independent moderator. Moderation analyses (see tables US Sample 3, Serbia Sample 3, and Bosnia and Herzegovina Sample 3) confirmed that ESE strengthens the positive effect of EL on the innovative work behavior of employees in all three sets. The term interaction (EL x ESE) was shown to be statistically significant in the proposed direction as well  $\beta = 0,15$ ,  $P < 0.05$ ). It makes up 15% of the variance in the innovative work behavior of employees ( $\Delta R^2 = 0,15$ ,  $P < 0.01$ ). The results provide empirical support to the hypothesis (H-3).

In the last few decades, EL has gained growing consideration among entrepreneurship and leadership scholars and practitioners. Nguyen et al. (2021) examined the effect of entrepreneurial leadership, entrepreneurial orientation, and technological innovation capability on SMEs'. Miao et al. (2012) examined the mediating influence of identification with a leader on the relationship between follower perceptions of transformational leadership behavior and their work outcomes, using data obtained from migrant workers and their supervisors in a large manufacturing company located in south-eastern China. Kreiner et al. (2011) noted that



entrepreneurs demonstrate dominance over employee job satisfaction and organizational responsibilities when predicting group or organization performance and organizational civic behavior.

Table 3: Regression Analysis of Moderation for Innovation for Innovation Work Behavior  
US Sample 3

Variables		Innovation Work Behavior		
		Model 1	Model 2	Model 3
Step 1	Age	0.14	0.04	0.04
	Gardner	0.13	0.07	0.05
	Education	0.15	0.06	0.03
	Tenure	0.9	0.07	0.06
Step 2	Entrepreneurial Leadership (EL)		0.39	0.36
	Entrepreneurial Self-efficacy (ESE)		0.31	0.29
Step 3	(EL X ESE)			0.15
	R <sup>2</sup>	0.09	0.21	0.35
	ΔR <sup>2</sup>		0.13	0.14
	F		4.83	32.65

Notes: N=120 dyads; P<0.1, P<0.05 \*two-tailed teste; standardized coefficient's are reported

Serbia Sample 3

Variables		Innovation Work Behavior		
		Model 1	Model 2	Model 3
Step 1	Age	0.12	0.06	0.03
	Gardner	0.14	0.09	0.04
	Education	0.17	0.08	0.05
	Tenure	0.98	0.08	0.04
Step 2	Entrepreneurial Leadership (EL)		0.37	0.31
	Entrepreneurial Self-efficacy (ESE)		0.33	0.27
Step 3	(EL X ESE)			0.14
	R <sup>2</sup>	0.07	0.19	0.34
	ΔR <sup>2</sup>		0.11	0.15
	F		4.81	32.66

Notes: N=120 dyads; P<0.1, P<0.05 \*two-tailed teste; standardized coefficient's are reported

Bosnia and Herzegovina Sample 3

Variables		Innovation Work Behavior		
		Model 1	Model 2	Model 3
Step 1	Age	0.13	0.05	0.02
	Gardner	0.14	0.05	0.03
	Education	0.14	0.05	0.03
	Tenure	0.10	0.06	0.05
Step 2	Entrepreneurial Leadership (EL)		0.36	0.33
	Entrepreneurial Self-efficacy (ESE)		0.33	0.26
Step 3	(EL X ESE)			0.13
	R <sup>2</sup>	0.06	0.22	0.37
	ΔR <sup>2</sup>		0.14	0.17
	F		4.85	32.68

Notes: N=120 dyads; P<0.1, P<0.05 \*two-tailed teste; standardized coefficient's are reported

Ahlin et al. (2014) noted that there are several studies in entrepreneurship investigating determinants of innovation outcomes in SMEs. Although entrepreneurs' entrepreneurial creativity is often seen as a prerequisite, previous research indicates it is not an exclusive determinant of innovation. Ahlin, et. al. (2014) use the theoretical logic of social cognitive theory and innovation theory to develop a conceptual model of an entrepreneur's creativity, self-efficacy, and innovation outcomes. The model is then tested on a large sample of small and medium firms from two distinct economies: the United States and Slovenia. Ardichvili et. al. (2003) This paper identifies an entrepreneur's personality traits, and prior knowledge as antecedents of entrepreneurial alertness to business opportunities. The authors state in their paper that its entrepreneurial alertness, in turn, is a necessary condition for the success of the opportunity identification triad: recognition, development, and evaluation. Bear and Oldham (2006) conducted a study that examined the possibility of a curvilinear relation between the creative time pressure employees experience at work and their creativity. The authors also examined whether this curvilinear relationship was moderated by employees' assessments of the personality of openness to experience and support for creativity that employees received from supervisors and associates.

## DISCUSSION

The research in this paper gave results for gender, age, education, mandate, entrepreneurial leadership, entrepreneurial self-efficacy, company environment, and innovative behavior, i.e. all variables of subjects. Sample 1 from Bosna and Herzegovina. Kreiner et. al. (2021) the findings reveal that (1) the relationship between the job satisfaction of entrepreneurs and organizational responsibilities is negligible, indicating a constructive surplus; (2) Compare the relationship between entrepreneurs and employee job satisfaction and organizational responsibilities by adding significant increment validity another construct; (3) Entrepreneurship has a lower relative weight concerning entrepreneurs in a relationship and job satisfaction, as well as organizational, task performance, and efficiency of entrepreneurs; and (4) Entrepreneurs demonstrates dominance over employee job satisfaction and organizational responsibilities when predicting group or

organization performance and organizational civic behavior. Kreiner et. al. (2021), we recommend that future research examine relationships among entrepreneurs and their relationships with employees, as well as job satisfaction in the organization to potentially compare them.

The research in this paper yielded results as shown in Model 3 (Table 2), the company's innovative environment became a stronger predictor of innovative behavior of employees  $\Delta R^2 = 0.25$ , for Sample 2 USA,  $\Delta R^2 = 0.24$ , for Serbia Sample 2,  $\Delta R^2 = 0.23$ , for Bosnia and Herzegovina Sample 2. The mean value for all three sets is  $\Delta R^2 = 0.24$ .

Dorđević, and Čočkaló (2017) "provided the basic starting points for entrepreneurship, as well as business aspects of entrepreneurial behavior, as well as business aspects of entrepreneurial behavior, through theoretical and practical perspectives, global European and Western Balkans trends."

In researching this paper, the authors conducted a Moderation Analysis (see Tables Sample 3 USA, Sample 3 Serbia, and Sample 3 Bosnia and Herzegovina). Research has confirmed that ESE strengthens the positive effect of EL on the innovative work behavior of employees in all three sets. The research showed that the term interactions (EL x ESE) was statistically significant in the proposed direction  $\beta = 0.15$ ,  $P < 0.05$ ). In a survey that accounts for 15% of the variance in innovative work behavior of employees ( $\Delta R^2 = 0.15$ ,  $P < 0.01$ ). The results obtained in this study proved the hypothesis (H-3) and provide empirical support for the hypothesis (H-3).

Djordjevic et al. (2021) The paper presents the basic starting points and vision of entrepreneurship, as well as business aspects of entrepreneurial behavior, through theoretical and practical perspectives of global, European, and Western Balkan trends. Authors Djordjević et. al. (2021) devoted one part of the study to the analysis of possibilities for improving entrepreneurial behavior among young people in Serbia and the Central Banat Region, based on trends, statistical indicators, and results of research on youth attitudes towards entrepreneurship and starting your own business.

Many studies do not sufficiently consider the achieved performance in the context of diversity and compatibility of certain types of entrepreneurs

and appropriate types of organizations, which opens a new area of research. In order to better understand and quantify the contribution and performance of an individual entrepreneur or a team of entrepreneurs, new qualitative research is needed that will provide new evidence on the impact of entrepreneurial leadership on innovative employee behavior.

## CONCLUSION

This study aimed to investigate the mechanism of mediation and moderation to improve the innovative behavior of employees in the United States - California, the Republic of Serbia - Vojvodina, and Bosnia and Herzegovina - Republika Srpska in small and medium enterprises. The research was based on social-cognitive theory. The paper investigates the impact of entrepreneurial leadership on the innovative behavior of employees in the United States, the Republic of Serbia, and Bosnia and Herzegovina. The research confirmed the hypothesis of the mediating effect of the innovative behavior of companies and the innovative behavior of employees. Based on the results obtained in the research, suggest that entrepreneurial leadership has a significant positive impact on the innovative behavior of employees. The authors obtained the results they came to that the innovative environment of the company has an adequate relationship between the two variables. The study contributes to the existing scope of knowledge by exploring the impact of entrepreneurial leadership on innovative employee behavior through a multi-group analysis comparing the US, Serbia, and Bosnia and Herzegovina. This research is an attempt in the field of leadership and entrepreneurship that explores the mechanism for improving the innovative behavior of employees in a multi-group analysis comparing the US, Serbia, and Bosnia and Herzegovina.

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## UTICAJ PREDUZETNIČKOG LIDERSTVA NA INOVATIVNO PONAŠANJE ZAPOSLENIH: MULTIGRUPNA ANALIZA KOJA UPOREĐUJE SAD, SRBIJU I BOSNU I HERCEGOVINU

Ova studija imala je za cilj da istraži uticaj preduzetničkog liderstva na inovativno radno ponašanje zaposlenih kroz moderirajući put preduzetničke samoeфикаsnosti u inovacijama. Studija takođe objašnjava mehanizam kroz koji inovativno okruženje preduzeća posreduje u odnosu između preduzetničkog liderstva i inovativnog radnog ponašanja zaposlenih. Da bi se postigli ciljevi, ova studija je koristila podatke uzorka od 360 supervizor-podređenih koji rade u malim i srednjim preduzećima (MSP) koja posluju u SAD – Kaliforniji, Republici Srbiji – Vojvodini i Beogradu i Bosni i Hercegovini – Republici. Srpska. Na osnovu socijalne kognitivne teorije i specifičnog kontinuuma teorije samoeфикаsnosti, razvijen je konceptualni model i testirane hipoteze uz pomoć SPSS 20. Rezultati istraživanja u ovim subjektima potvrđuju značajan pozitivan efekat preduzetničkog liderstva na inovativno radno ponašanje zaposlenih. Studija je pokazala da inovativno okruženje posreduje u odnosu između preduzetničkog liderstva i inovativnog ponašanja zaposlenih. Rezultati su takođe potvrdili hipotezu da preduzetnička samoeфикаsnost ima pozitivan učinak na povezanost preduzetničkog liderstva i inovativnog ponašanja zaposlenih. Rezultati ovog istraživačkog rada imaju nekoliko implikacija na preduzetništvo i funkcionisanje malih i srednjih preduzeća koja se bave inovacijama i izazovnim poslovnim okruženjem. Prema nalazima brojnih autora koji se bave ovom problematikom, ovo istraživanje nije prvi pokušaj razvoja inovativnog ponašanja zaposlenih u poduzetničkim malim i srednjim preduzećima, ali svakako ima veliki uticaj na povećanje ефикаsnosti preduzetničkog liderstva na inovativno ponašanje zaposlenih.

**Ključne riječi:** preduzetnički liderstvo, inovativno okruženje, inovativno radno ponašanje, inovativno ponašanje zaposlenih.



## EFFECTIVENESS OF TECHNICAL AUDIT IN THE POWER SECTOR: A CASE FROM A DEVELOPING COUNTRY

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Original Scientific Paper

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**The paper examines the level and the factors that influence the effectiveness of technical audit in the power sector of Malawi from the perspective of auditors and auditees. Data was collected through a questionnaire that was analyzed using bivariate and multivariate statistics. Further to that, complementary data to measure the level of effectiveness was also collected and analyzed using the effectiveness calculator. Results show that the level of effectiveness of technical audit is low. Bivariate and multivariate analyses suggest that management support, organizational independence, and audit quality individually and collectively significantly influence the level of technical audit effectiveness.**

**Keywords:** Effectiveness; Internal audit; Malawi; Power sector; Technical audit.

### INTRODUCTION

Internal audit is defined as an “independent, objective assurance and consulting activity designed to add value and improve an organization's operations” ([Institute of Internal Auditors-Global, 2020a](#)). Unlike external audit which is annual and undertaken by auditors from outside of the organization and focuses on the fairness of the financial statements, internal audit is continuous, carried out by auditors who are the employees of the organization, and their work embraces all organizational operations ([Cohen & Sayag, 2010](#); [Saputra & Yusuf, 2019](#)). The primary purpose of an internal audit is to help “an organization accomplish its objectives by bringing a systematic, disciplined approach to evaluate and improve the effectiveness of risk management, control, and governance processes” ([Institute of Internal Auditors-Global, 2020b](#)). The output of internal audit work is a set of recommendations for the improvement of organizational operations. The recommendations are made based on a critical review of organizational policies and procedures, and how the internal controls effectively mitigate associated risks. Internal audit enhances

organizational efficiency and effectiveness through constructive criticism that is provided on a regular basis ([Cohen & Sayag, 2010](#)).

In the power sector, internal audit is divided into two: financial (or management) audit and technical audit. Financial audit appraises all organizational administrative operations such as human resources, finance, procurement, legal, and administration, while technical audit appraises engineering operations. Accordingly, internal audit functions in power organizations tend to have a financial audit and technical audit sections.

In the power sector, engineering operations are critically important to organizational effectiveness, hence, the effectiveness of the technical audit deserves considerable emphasis. Moreover, in developing countries like Malawi, whose power sectors are faced with significant technical and operational challenges, the role of technical audit and hence its effectiveness needed greater attention as one of the means for improvement. However, in developing countries, the technical component of internal audit is a new phenomenon that is still in its infancy. Furthermore, empirically, little is

known about its development and effectiveness. Basically, the existing literature focuses on examining the effectiveness of the entire internal audit function. It is against this background that this paper examines the effectiveness of technical audit as an integral part of the internal audit in the power sector in the developing country context of Malawi. It measures the level of effectiveness of technical audit and evaluates the factors that affect the same from the perspective of the auditors and auditees.

The remainder of the paper is arranged as follows: the second section discusses the composition of the power sector of Malawi. The third section reviews the extant literature regarding the effectiveness of internal audit function generally as there is hardly any literature on the effectiveness of the technical audit. The fourth section presents the methodology that was used while the fifth section presents the results and the ensuing discussion. Finally, the sixth section provides the concluding remarks.

## POWER SECTOR IN MALAWI

### Composition

Electricity is a crucial variable in the drive to reduce poverty, promote economic growth, and enhance living standards. Ritchie and Roser (2020) estimated that about 87% of the world's population (that is about 6.3 billion people) has access to electricity. However, in Malawi, which is an African country in the southern part of the continent, access to electricity is about 10%, making it the fourth lowest worldwide and the lowest in the Southern Africa Development Community region (JICA, 2019). The country has a total installed generation capacity of about 582.16MW. Presently, the main source of electricity is hydropower which contributes about 90% of the power (JICA, 2019). The power sector has two public companies: the Electricity Generation Company (EGENCO) and the Electricity Supply Corporation of Malawi (ESCOM). The former is only responsible for a generation while the latter is responsible for transmission and distribution.

As of December 2020, EGENCO was generating 73% of the total installed capacity and the

remainder was generated by private producers. EGENCO was established as a company in September 2016 after being carved out of ESCOM in the process of unbundling that was aimed at improving efficiency (EGENCO, 2021). Before its establishment, ESCOM used to be responsible for the generation as well as transmission and distribution of power. With the unbundling, ESCOM only transmits and distributes the power (ESCOM, 2018).

Other generators of power include Aggreko, a privately owned international company, which uses diesel generators. Aggreko has an installed capacity of 78MW. Numerous other private players generate power from bagasse (18.5MW), diesel (61.5MW), hydro (0.84MW), solar and wind hybrid (0.075MW), and Solar PV (0.87MW) (Taulo et al., 2015). Besides, ESCOM imports power from neighboring countries as follows: Mozambique (2MW) and Zambia (10MW) (ESCOM, 2020). All the other power companies are licensed only to generate power while ESCOM has the license to transmit and distribute power. The generated power is sold to ESCOM to transmit and distribute to the customers. Presently, the major players in the power sector of Malawi are ESCOM, EGENCO, and Aggreko.

### Technical audit functions in the power sector of Malawi

Technical audit is a new phenomenon in the power sector of Malawi. Presently, it is only ESCOM and EGENCO that have technical audit units. However, it is only in ESCOM that the unit is fully-fledged. EGENCO, being a new company, its unit is in the process of being set up. Thus, the paper focused on the technical audit unit of ESCOM. ESCOM is mandated to transmit and distribute electricity in Malawi (ESCOM, 2018). It has about 2500 employees with an electricity network in all 28 districts of the country. As is exhibited in Figure 1, ESCOM has three technical (engineering) directorates namely: transmission (also called system and market operations), distribution, and planning and development; and four administrative directorates namely: Human Resources and administration, finance, legal, and procurement. In addition, it has an internal audit section.

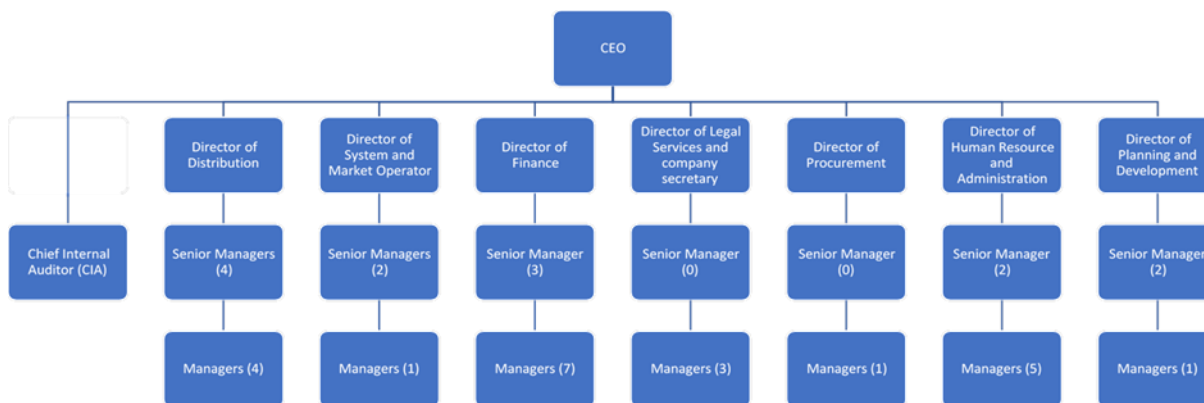


Figure 1: Organogram of ESCOM

The company has four management tiers. The first tier is the executive management tier which comprises the Chief Executive Officer (CEO) and seven directors. This is followed by the management tier, which is made up of senior managers and managers. Below is the professional tier consisting of senior officers/engineers, officers/engineers, and assistant officers/engineers. The fourth and final tier is the supervisory tier made up of artisans and ground workers. The company is overseen by the board of directors. As can also be observed in Figure 1, the highest position in the internal audit section is that of the Chief Internal Auditor at the senior management level.

Figure 2. (next page) provides the organogram for the internal audit section. The Chief Internal Auditor reports administratively to the CEO but functionally to the finance and audit committee of the board. At the management level, the internal audit section has the Chief Technical Audit Engineer responsible for managing the technical audit unit and the Finance Audit Manager responsible for managing the financial audit unit. The technical audit unit is staffed by engineers by profession. As can be noted in Figure 2, the Chief Technical Audit Engineer reports administratively to the Chief Internal Auditor but functionally directly to the Projects and Technical Committee of the board of directors.

In spite of the existence of technical audit in ESCOM, its engineering operations continue to experience significant technical challenges. The Malawi Energy Regulatory Authority (MERA), which is the regulator of the energy sector of Malawi, observed that the performance of ESCOM was below standard in terms of both transmission and distribution functions (MERA, 2018). As a

result, it is estimated that the total power losses were 23.5% when calculated using the power sold against power bought from generation companies. The losses comprise 13.5% as technical losses and 10% as non-technical losses. Basically, the non-technical losses occur due to theft, accounting errors, metering inaccuracies, and unmetered power. Power losses cause ESCOM to lose about USD 43.59 million annually (AZOROM, 2015).

## INTERNAL AUDITING EFFECTIVENESS

Scholars have conducted research on the effectiveness of internal audit focusing on internal audit function as a whole; however, this paper focuses only on its technical audit component. Further, the extant literature either evaluates the level of internal audit effectiveness or the factors that affect the effectiveness of internal audit, however, this paper combines the two strands.

### Measuring the level of internal audit effectiveness

Cristina and Cristina (2009) classified methods of measuring internal audit effectiveness into three: quantitative method, qualitative method, and qualitative and quantitative method. The quantitative method involves, among other things, numerical ascertainment of the extent to which audit plans are executed; determination of the time taken from ending audit work to the issuance of the final audit report; monitoring the number of findings cleared and time taken to clear them; verifying auditors' qualifications; and determination of how time available has been used in administering audit and other activities. The qualitative method measures effectiveness from the qualitative point of view that emphasizes carrying out surveys (through questionnaires or interviews)

soon after finishing internal audit assignments, where the respondents are the organizational managers (Weldu, 2017). The third method (qualitative and quantitative) is a combination of the two methods as such it is also called the mixed method. This method is considered robust and balanced as it combines the strengths of both methods. It is practically involving but rigorous hence it is popularly used in assessing effectiveness. Under this method, several approaches are used to measure internal auditing effectiveness, these include total quality

management; performance measurement matrix; balanced scorecard (BSC); SMART performance pyramid; performance prism; value-based management; and SWOT Analysis (Hijarunguru, 2017). Among these approaches, the studies of Boguslauskas and Rupšys (2007); B. A. Cristina and P. Cristina (2009); Baiden et al., (2016); and Hijarunguru (2017) established that the balanced scorecard is the one that is well known and frequently used.

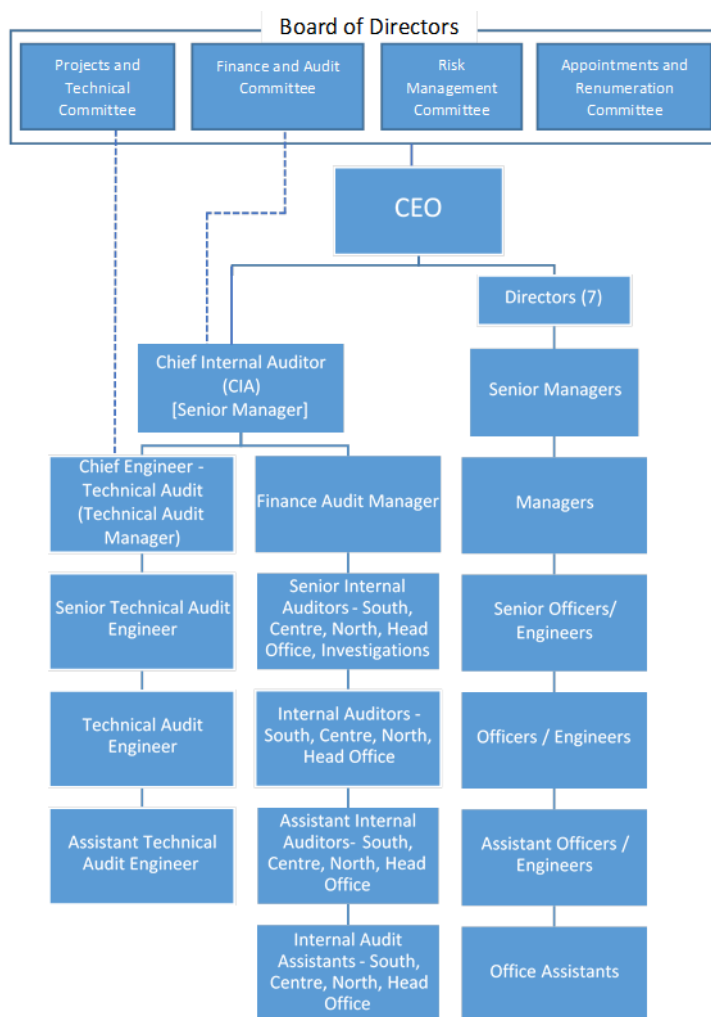


Figure 2: Organogram of the Internal Audit Section

The BSC is applauded for providing a flexible, multi-dimensional, and usable framework that allows critical evaluation of internal audit effectiveness from four key perspectives: financial or stewardship perspective; customer or stakeholder perspective; internal process and innovation perspective; and capabilities perspective to come up with a meaningful performance outcome (Graybeal et al., 2019). Further to that, it balances between short and long-

term measures, internal and external business processes, leading and lagging indicators, but also objective and subjective measures (Martin, 2004; Koutoupis et al., 2018). Besides, it is integrative in its orientation, in that, it links the organization's vision and strategy to its targets and initiatives. Accordingly, it is regarded as a management and measurement tool, an improvement and learning tool; a motivation and implementation tool, as well as a control and evaluation tool (Baiden et al.,

2016). In harmony with existing studies (Baiden et al., 2016; Filos et al., 2017; Boguslauskas & Rupšys, 2007), this paper utilized the BSC in determining the level of effectiveness of technical audit which is a key component of internal audit in the power sector. The level of effectiveness was determined quantitatively using the questionnaire. And further to that, the quantitative measurements were complemented by additional qualitative assessments using a tool developed by the Institute of Internal Auditors – Netherlands, which this paper is referred to as the “effectiveness calculator”.

The Institute of Internal Auditors – Netherlands developed a step-by-step tool that is used to calculate the level of effectiveness of the internal audit function. The tool is made up of effectiveness indicators in all four perspectives of the BSC (Institute of Internal Auditors - Netherlands, 2016). It provides twenty-four key performance indicators (KPIs) (Institute of Internal Auditors - Netherlands, 2016). It assigns to each KPI a norm as the expected level of performance and that

represents the standard pass mark. The actual score on each KPI is compared to the standard pass mark in ascertaining the level of effectiveness. Information for determining the actual score is sourced from the audit reports, audit work plans, and other relevant data for the function. The overall score on the effectiveness of the internal audit function is determined by a percentage of the total number of items that exceed the standard pass mark to the total number of items tested on the effectiveness calculator (Institute of Internal Auditors - Netherlands, 2016). 50% is considered the standard pass mark for an effective internal audit function.

All in all, based on the four BSC perspectives, the level of internal audit effectiveness can be measured by the composite score of financial, customer, internal business, and growth and innovative perspectives as presented in Figure 3. The composite score was used in this paper to measure the level of effectiveness of the technical audit.



Figure 3: BSC-based measure of the level of technical audit effectiveness

## Factors influencing internal audit effectiveness

### *Management Support*

The internal audit function works hand in hand with the executive arm of the organization in its day-to-day work. Accordingly, Marks (2013) argues that the function requires full management support for it to be effective. Fundamentally, management support is demonstrated through the provision of necessary resources, like finances or transport if required, providing training, introducing auditors to new technology and procedures, budgeting funds for certification, and other facilities that facilitate internal auditing works (Hailemariam, 2014). Besides, the rate at which management responds to audit recommendations is also a key indicator of management support and determines the impact of the audit function (Ahmad et al., 2009; Marks, 2013).

Marks (2013) found that where management support for audit function is inadequate, it renders the audit working environment to be hostile, which affects the effectiveness of the audit. On the other hand, the internal audit function gets motivated when it receives adequate management support (Ahmad et al., 2009). Impliedly, an excellent internal audit team, with the ability to come up with brilliant audit recommendations, would be rendered ineffective if there is no management support for the audit function. Based on the forgoing the paper hypothesized that:

H1: There is a significant effect of the level of management support on the effectiveness of the technical audit function.

### *Independence of Internal Audit*

Internal audit independence is “the freedom from conditions that threaten the ability of the internal audit function to carry out internal audit



responsibilities in an unbiased manner” (Institute of Internal Auditors - North America, 2019). Without independence, the internal audit function loses its ability to offer fresh perspectives and eventually becomes part of management (Yee et al., 2008). Hailemariam (2014) argues that independence is achieved when auditors are able to do their job with objectivity, integrity, impartiality, and without any conflict of interest. IIA-North America (2019) suggests that one way to achieve the degree of independence necessary to effectively carry out the responsibilities of the internal audit activity is to have a chief audit executive that has direct and unrestricted access to senior management and the board, which can be achieved through a dual reporting relationship.

George et al., (2015) found that the independence of internal audit is the most important factor that affects internal audit effectiveness. Similarly, Cohen and Sayag (2010) observed that organizational independence enhances the internal auditor’s effectiveness because it gives auditors a conducive working environment in which they can conduct their tasks objectively and without pressure. However, Hailemariam (2014) found that the independence of internal auditors was not significantly correlated to internal audit effectiveness. The negative results suggest inconclusiveness concerning the effect of the independence of the internal auditors on audit effectiveness. Hence indicating the need for further studies. This paper hypothesized that:

H2: There is a significant effect of the level of independence of the technical auditors on the effectiveness of the technical audit function.

### **Audit Quality**

The quality of an internal audit is determined by the internal audit department’s ability to provide useful findings and recommendations (Sawyer, 1995). Audit quality thus, hinges on the ability of the auditors to plan and carry out the audit work so that substantial findings are arrived at and workable recommendations for improvement are made (Mihre, & Yismaw, 2007). Mihret and Yismaw (2007) further argued that audit quality is contingent on the audit staff’s competence or expertise; reasonableness of the scope of service; effective planning, execution, and communication of internal audits. Auditors’ competence can be determined by academic level, experience, and the efforts of staff for continuous professional

development and compliance with audit standards (Hailemariam, 2014).

Mihret and Yismaw (2007) found that there was a positive correlation between audit quality and internal audit effectiveness. In harmony, George et al., (2015) also found that audit quality is significantly and positively associated with audit effectiveness. Generally, if internal audit quality is improved, it contributes to the appropriateness of procedures and operations of the auditee thereby contributing to the effectiveness of the auditee and the organization as a whole (Dittenhofer, 2001). Accordingly, the paper hypothesized that:

H3: There is a significant effect of the level of audit quality on the effectiveness of the technical audit function.

## **METHODOLOGY**

### **Data collection**

The study was conducted in the technical audit unit and all the audited technical units of ESCOM. As already discussed, in the power sector of Malawi, it is only ESCOM and EGENCO that have technical audit units. However, EGENCO is a relatively new company whose operational structures (including the technical audit unit) are in the process of being developed. As such, it is only ESCOM that has all its structures in place from which informative insights can be generated. Thus, the paper focused on audited engineering sections and the technical audit unit. The population for the study was ninety-two (92) making up of personnel acquainted with technical audit activities that included 79 supervisors, assistant engineers, engineers, senior engineers, 4 technical audit engineers, 5 managers, 3 senior managers, and 1 director (see Table 1). The chairperson of the Projects and Technical Committee of the Board was also included as is directly responsible for overseeing technical operations and technical audit activities at the board level. Considering the manageable size of the population, all the members of the population were sampled (Saunders et al., 2009).

Data were collected using a structured questionnaire that was adapted from Baiden et al., (2016) and Hailemariam (2014). Measurements regarding the level of effectiveness were adapted from the former and measurements of the factors affecting effectiveness were adapted from the latter. The questionnaire used a five-point Likert scale. Respondents were required to express their level of

agreement with the statements (questions) where the lowest score (1) represented strong disagreement and the highest score represented strong agreement (Brown, 2010). The questionnaire was organized into three parts: the first part comprised questions on the demography of respondents, while the second and the third parts contained items measuring the three influential factors and the BSC-based composite level of technical audit effectiveness respectively.

Table 1: Details of the study population

Category of respondents	Number
Engineers and supervisors	79
Technical audit engineers	4
Managers	5
Executive managers	3
Board member	1
<b>Total</b>	<b>92</b>

A pilot test was conducted on 10 respondents. According to Saunders et al., (2009), 10 is ideal for piloting a questionnaire for a sample with up to 200 respondents. Cronbach's Alpha was used as a measure of the reliability of the questionnaire. An Alpha score of greater than 0.7 is considered as an indication of high reliability (Ursachi et al., 2015). Table 2 shows the resultant values of Cronbach's Alpha for each variable. The lowest Alpha was 0.773 for the internal business perspective and the highest was 0.957 for audit quality. The scores indicated that the questionnaire was highly reliable.

Table 2: Reliability test results

Variable	Alpha
Management support	0.817
Organization independence	0.945
Audit quality	0.957
Financial perspective	0.821
Customer perspective	0.842
Internal business perspective	0.773
Growth and innovative perspective	0.790

Data collected using the questionnaire was complemented by the data that were collected from audit reports, audit work plans, and other relevant data for the technical audit function using the effectiveness calculator to measure the level of effectiveness.

### Data Analysis

Descriptive statistical analysis was used to summarise the results while inferential statistics was used to test the relationships between

dependent and independent variables. The level of technical audit effectiveness (TAE) was measured as a composite mean score of the four BSC perspectives. The TAE composite mean score from the questionnaire was complemented by TAE score based on the effectiveness calculator, which was determined by a percentage of the total number of items that exceed the standard pass mark to the total number of items tested on the effectiveness calculator (Institute of Internal Auditors - Netherlands, 2016).

In terms of inferential analysis, regression analysis was used. The multivariate regression model was used to examine the collective effect of three factors (management support, organizational independence, and audit quality) on the level of technical audit effectiveness. The model was specified as follows:

$$TAE_i = \beta_0 + \beta_1 MS_i + \beta_2 QA_i + \beta_3 OI_i + \varepsilon_i \quad (1)$$

Where: TAE is technical audit effectiveness; MS is management support; AQ is audit quality; OI is organizational independence;  $\beta_0$  is a constant representing the effectiveness of technical audit when every independent variable is zero;  $\beta_{1-3}$  are coefficients, in which every marginal change in variables on technical audit effectiveness correspondingly affects; and  $\varepsilon_i$  is the error term

Besides, bivariate analysis was conducted using chi-square and Cramer's V tests to examine the effect of an individual factor on the level of technical audit effectiveness. Each independent variable was tested against the dependent variable to check the extent of association with the dependent variable. Basically, the Chi-square test determines whether there is an association between categorical variables while Cramer's V test measures the strength of the association between the variables (Akoglu, 2018). Akoglu (2018) provides a guide to the interpretation of Cramer's V results as follows: 0 indicates no relationship; greater than 0 to 0.05 indicates a very weak relationship; greater than 0.05 to 0.10 indicates a weak relationship; greater than 0.10 to 0.15 indicates a moderate relationship; greater than 0.15 to 0.25 indicates a strong relationship, and greater than 0.25 indicates a very strong relationship.

## RESULTS AND DISCUSSION

### Profile of the respondents

The questionnaires were distributed to all ninety-two (92) respondents, out of which, sixty-five (65) responded representing a response rate of 73%. The respondents comprised 63 males and 2 females. The small number of female respondents was because of the small number of female engineers in ESCOM. 3 female engineers were given the questionnaire out of which 2 responded. Concerning work experience, the highest was in the range of 6-10 years (29.2%) followed by those with more than 20 years of experience (27.7%) and then those within the 15-20 years range (24.6%). Below these were those within the ranges of 11-15 years (13.8%) and 0 – 5 years (4.6%). This indicates that the majority of the respondents had considerable work experience to be able to provide a well-informed assessment of technical audit effectiveness. In terms of departments, 70.8% of the respondents were from distribution, which is the largest directorate in ESCOM, while 20% were from the transmission and 9.2% were from the head office. The majority of the respondents (64.6%) were bachelor's degrees holders, 23.1% were diploma holders, 7.7% were master's degree holders and 4.3% had other qualifications. Concerning positional categories, 84.6% of the respondents were from the professional category, 12.3% were supervisory category and 3.1% were managerial category.

### Preliminary reliability analysis

The Jarque Bera test was conducted for all the variables in the data combined. The p-value was found to be 0.4231, which was greater than the threshold value of 0.05. This means that data were normal hence normality was accepted at 0.05. Furthermore, the Shapiro-Wilk skewness and Kurtosis tests were conducted for individual variables, the results of which are shown in Table 3.

Table 3: Results for Shapiro-Wilk, Skewness, and Kurtosis

Variable	Shapiro-Wilk (sig)	Skewness Z-Value	Kurtosis Z-Value
MS	0.357	- 0.32997	- 0.38567
OI	0.125	- 0.00673	- 0.73208
AQ	0.063	+ 0.36364	- 1.2116
TAE	0.226	- 0.23569	- 1.3976

Shapiro-Wilk test results in Table 3 show that the p-values for all the variables were above 0.05, which attested for normality. Besides, the skewness and kurtosis' Z-value for all variables is within the allowable limits of between -1.96 and +1.96 (Pett, 2015) indicating that the collected data were normally distributed.

The heteroscedasticity test was conducted using the Breusch-Pagan test. The p-value for the regression was found to be 0.1017, which is greater than the critical value of 0.05. This indicated that the model was homoscedastic. Furthermore, a pairwise correlation was conducted and tolerance and variance inflation factor (VIF) was calculated to test for multi-collinearity in the model.

Table 4: Pairwise correlation of variables

	TAE	MS	OI	AQ
TAE	1.0000			
MS	0.6547 0.0000	1.0000		
OI	0.6332 0.0000	0.5625 0.0000	1.0000	
AQ	0.5779 0.0000	0.4255 0.0004	0.3506 0.0042	1.0000

As shown in Table 4, all the correlations between variables were less than 0.8. Further to that, tolerance for all the variables was well above the threshold of 0.10 threshold and VIF values were below 10 (see Table 5). The results indicated that there were no multi-collinearity problems in the regression model (Gujarati, 2004).

Table 5: Tolerance and Variance Inflation Factor (VIF)

Variables	Tolerance	VIF
MS	0.62418	1.60
OI	0.66852	1.50
AQ	0.80083	1.25

Autocorrelation assessment was conducted using the Durbin-Watson test. A t-statistic of 2.006787 was found, which indicated that there was no autocorrelation in the model (Field, 2009). Finally, a RESET test was also conducted to detect whether there were omitted variables and incorrect functional forms in the regression model (Sapra, 2018). Ramsey's test was used which gave a p-value for the F-statistic of 12.44%. Thus, at a 5% significance level, the results indicated that the functional form was correct, and the model did not suffer from omitted variables.

### Level of technical audit effectiveness

The four perspectives of the BSC were evaluated on a five-point Likert scale. The lowest score was 1 expressing strong disagreement and the highest score was 5 expressing strong agreement. A score of 3 indicated neutrality. Table 6 presents the individual mean scores for the four perspectives and the composite mean score representing the overall level of technical audit effectiveness. As can be observed in the Table, mean scores for all four perspectives and the composite mean score were below 3. The individual perspective scores were 2.6462 for the financial perspective, 2.7169 for the customer perspective, 1.9744 for the internal business perspective, and 2.6974 for the growth and innovation perspective, whereas, the composite mean score was 2.5087.

Table 6: Level of effectiveness: individual scores and composite mean Score

BSC elements	N	Mean	Std. deviation
Financial Perspective	65	2.6462	0.92163
Customer Perspective	65	2.7169	0.62239
Internal Business Perspective	65	1.9744	0.65962
Growth and Innovation Perspective	65	2.6974	0.65543
Technical Audit Effectiveness	65	2.5087	0.56107

Table 7: Results of qualitative assessment of effectiveness using effectiveness Calculator

Items	Actual Mark	Standard Pass Mark	Pass (1) or fail (0)
1. Number of management requests (# fulfilled/# request) (#) YTD (not in Year Plan)	100%	100%	1
2. Number/Percentage of audits realized within agreed assignment letter deadline per quarter	59%	70%	0
3. Hours of training per auditor YTD (hrs)	0	2 per year	0
4. Average audit client satisfaction p/Q, scale” Good=3, Satisfactory=2, Unsatisfactory=1 per quarter	1.25	2	0
5. Client score on ‘audit added value’, scale: Strongly Disagree=5, Strongly agree=1	4	1 or 2	0
6. At least <b>70%</b> of the original year plan is achieved in the relevant year.	50%	70%	0
7. All staff members have a tasking.	50%	100%	0
8. Auditors have at least a degree or are studying towards such a degree. <b>90%</b>	100%	90%	1
9. The average level of working experience among staff members is at least <b>10 years.</b>	37.5%	50%	0
10. Maximum of <b>5%</b> staff departures per year	0%	5% or less	1
11. Maximum average sickness absenteeism among audit staff members of <b>5%</b> .	0	5% or less	0
12. The financial budget is adequate for the continuing professional education and insourcing of external experts.	0	1	0
13. All audit staff members fulfill their annual CPE requirement. <b>100%</b>	0%	100%	0
14. All staff members have a personal development plan. <b>100%</b>	100%	100%	1
15. Meetings on technical audit matters are held at least twice per year. <b>100%</b>	100%	100%	1
16. All findings are included in Action Tracking. <b>100%</b>	100%	100%	1
17. 100% of the mandatory annual audits are performed in the relevant year. <b>100%</b>	64%	100%	0
18. The audit manager and the chair of the Technical Committee meet at least once every a quarter	1	1	1
19. A review is conducted for at least <b>25%</b> of audits (in writing or verbally)	23.35%	50%	0
20. Technical audit reports to Executive Board once per quarter. ( <b>once per quarter</b> )	1	1	1
21. The average number of recommendations per audit	7	7	1
22. Percentage of recommendations implemented by corrective action date	35.05%	70%	0
23. How many changes to the process	25%	70%	0
24. Actual(A) vs planned(P) costs (if A<P:100%; A>P: (1 - % of the excess))	100%	100%	1
<b>Overall Score</b>			<b>41.67%</b>

The score suggests that the respondents perceived the level of technical audit effectiveness as low on all four perspectives with the internal business

perspective scoring the lowest at 1.9744 and the customer perspective scoring the highest 2.7169. A consistent result was also found from the

effectiveness calculator. As exhibited in Table 7, the overall score was 41.67%. The technical audit unit passed ten KPIs while fourteen were below the standard level. Since 50% is the standard pass level (Institute of Internal Auditors - Netherlands, 2016); the overall score indicated that technical audit effectiveness was below the standard.

As can be observed in Table 7, the results on the effectiveness calculator indicated that technical audit was doing well, among other areas, in the handling of special management requests, qualification of technical auditors, staff departures, the inclusion of all findings in the action tacking, number of recommendations per audit, and cost of conducting the audit. On the other hand, the effectiveness calculator showed that technical audit performance was below the standard in areas such as the number of audit assignments achieved from the annual work plan, training of audit engineers, clients' satisfaction, the experience of audit engineers, an achievement on mandatory audits, implementation of recommendations by corrective action date, and a number of changes to the processes.

The results suggest that technical audit is not perceived as doing well in all four perspectives of the BSC. This is a matter of concern because an audit function that is not effective can hardly add value to the organization (Baiden et al., 2016). The results may to some extent explain the reasons that ESCOM continues to face operational challenges in spite of having a technical audit unit.

### Factors affecting technical audit effectiveness

Table 8. provides the descriptive statistics of the independent variables. As can be seen, all the mean scores were below 3. Management support scored 2.7323, organizational independence 2.2354, and audit quality 2.8454. The results indicate that the respondents were generally in agreement that management supports the function, and organizational independence of the unit and audit quality is unsatisfactory.

Table 8: Descriptive statistics of independent variables

Variables	N	Mean	Std. Deviation
Management Support	65	2.7323	0.70492
Organizational Independence	65	2.2354	0.64546
Audit Quality	65	2.8454	0.54727

### The collective effect of the factors on technical audit effectiveness

The regression results were obtained by regressing the dependent variable – technical audit effectiveness on the independent variables – management support, organizational independence, and audit quality. Table 9 provides the results of the regression analysis. The adjusted R<sup>2</sup> value was 0.5942, indicating that approximately 59.4% of the total variations in the effectiveness of the technical audit function could be explained by the predictor variables – management support, organizational independence, and audit quality. Further to that, the results indicated that the predictor variables have a significant effect on the effectiveness of the technical audit function ( $F = 32.24, p = 0.0000$ ).

Table 9: Results of multivariate regression analysis

Variable	Coef.	t-stat.	P > t	[95% Conf. Interval]
MS	0.2626	3.27	0.002	0.1022 - 0.4230
OI	0.2916	3.44	0.001	0.1223 - 0.4609
AQ	0.3280	3.60	0.001	0.1456 - 0.5104
Cons.	0.2062	0.81	0.420	- 0.3020 - 0.7143
<b>R<sup>2</sup></b>	<b>0.6133</b>	<b>F(2,61)</b>	<b>32.24</b>	
<b>Adj. R<sup>2</sup></b>	<b>0.5942</b>	<b>Prob &gt; F</b>	<b>0.0000</b>	

Besides, results in Table 9 show that management support ( $\hat{\beta} = 0.2626, p < 0.05$ ), organizational independence ( $\hat{\beta} = 0.2916, p < 0.05$ ), as well as audit quality ( $\hat{\beta} = 0.328, p < 0.05$ ), have positive significant values. The results indicated that all the predictor variables had a positive and significant

contribution to the effectiveness of the technical audit. Based on the model specification, the regression equation expressing the relationships between the dependent variable (technical audit effectiveness – TAE) and the predictor variables (management support – MS; organizational



independence – OI and audit quality – AQ) can be expressed as follows:

$$\text{TAE} = 0.2062 + 0.2626\text{MS} + 0.2916\text{OI} + 0.3280\text{AQ} + \varepsilon \quad (2)$$

Thus, holding all the other variables constant, the equation indicates that for every unit increase in management support, technical audit effectiveness increases on average by 0.2626 units; for every unit increase in organizational independence, technical audit effectiveness increases on average by 0.2916, and for every unit increase in audit quality, technical audit effectiveness increases on average by 0.3280.

### *The individual effect of the factors on technical audit effectiveness*

Table 10 provides the results of the tests of association between the dependent variable and independent variable's management support individually using chi-square and Cramer's V tests.

*Table 10: Test of association - Chi-square and Cramer's V*

Variables	Chi-square	Pr	Cramer's V
TAE and MS	28.4630	0.000	0.4679
TAE and OI	23.9538	0.000	0.4293
TAE and AQ	18.9893	0.001	0.3822

As seen in Table 10, Chi-square p-values for all variables were less than 0.05, thus indicating that there is a relationship between the independent variables (MS, OI, and AQ) and the dependent variables (TAE). Similarly, Cramer's V results indicate that there is a strong relationship between the dependent variable – technical audit effectiveness and all three independent variables. This is the case because Cramer's V values are all greater than 0.25 (Akoglu, 2018). Thus, the tests of association reveal significant relationships between individual predictor factors – management support, organization independence, and audit quality – and the dependent variable – technical audit effectiveness.

The results of both multivariate and bivariate analyses showed that the three factors have significant positive effects on the effectiveness of technical audit both collectively and individually. Thus, the results support the three study hypotheses, suggesting that technical audit effectiveness can be enhanced by improving management support, organizational independence, and audit quality among other factors.

## CONCLUSION

The results from the analysis of data collected by the questionnaire and the effectiveness calculator consistently showed that the level of technical audit effectiveness was low. In relation to the factors, the multivariate regression analysis indicated that approximately 59.4% of the total variations in the effectiveness of the technical audit can be explained by the three predictor variables – management support, organizational independence, and audit quality. Besides, a bivariate analysis indicates significant and strong relationships existing between technical audit effectiveness with management support, organizational independence, and audit quality.

Thus, in order to improve the effectiveness of technical audit, improvements need to be undertaken on all three factors. Management support can be improved by, among other means, providing adequate resources to the technical audit unit which will among others, enhance productivity, improve output quality, and reduced burnout in employees. Management support can further be improved by promptly responding to audit recommendations. Organizational independence of technical audit can be improved by not only creating dual reporting lines, where the head of technical audit reports directly to the board but more importantly by the management not interfering with the work of the technical auditors. This would enable auditors to provide audit opinions without any influence on the relationship with the clients. Audit quality can be improved by the enhancing academic qualifications of auditors, work experience, continuous professional development, and the auditor's ensuring compliance with audit standards.

The results of the study need to be applied cautiously because they are based on a single company. To ensure generalisability, further studies need to be conducted. Since presently there is only one company in Malawi with a fully-fledged technical audit in the power sector, the paper recommends cross-country studies. All in all, the study is unique and important because, to the best knowledge of the researchers, it is the first to evaluate the effectiveness of technical audit in the power sector. Thus, it extends the academic debate on internal audit practice generally and specifically in the power sector, moreover, in a developing country context.

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## EFIKASNOST TEHNIČKE REVIZIJE U ENERGETIKOM SEKTORU: SLUČAJ IZ ZEMLJE U RAZVOJU

U radu se ispituje nivo i faktori koji utiču na efikasnost tehničke revizije u elektroenergetskom sektoru Malavija iz ugla revizora i subjekata revizije. Podaci su prikupljeni putem upitnika koji su analizirani korišćenjem bivarijatnih i multivarijantnih statistika. Dalje, komplementarni podaci za merenje nivoa efektivnosti takođe su prikupljeni i analizirani korišćenjem proračuna efektivnosti. Rezultati pokazuju da je nivo efektivnosti tehničke revizije nizak. Bivarijantne i multivarijantne analize sugerišu da podrška menadžmenta, organizaciona nezavisnost i kvalitet revizije pojedinačno i zajedno značajno utiču na nivo efektivnosti tehničke revizije.

**Ključne reči:** Efektivnost; Interna revizija; Malavi; Energetski sektor; Tehnička revizija.

## EVALUATION OF FINANCIAL PERFORMANCE AND EFFICIENCY OF COMPANIES IN SERBIA

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Recently, various methods of multi-criteria decision-making, as well as DEA(Data Envelopment Analysis) models, have been used more and more worldwide to measure the financial performance and efficiency of companies. Based on that, this paper analyzes the efficiency of companies in Serbia using the ARAS method. According to the ARAS method, five most efficient companies in Serbia are JP POŠTA SRBIJE BELGRADE, JP EPS BELGRADE, JP SRBIJAGAS NOVI SAD, JP PUTEVI SRBIJE BELGRADE and COCA-COLA HBC - SERBIA DOO ZEMUN. First four are public companies, and the fifth is from the processing industry sector. Public enterprises are fundamentally efficient. Trading companies are well positioned. So, for example, the DELHAIZE SERBIA DOO BELGRADE retail chain is in the eleventh place. The efficiency factors of companies in Serbia are, in addition to macroeconomics, managerial skills in managing the company. They differ from company to company. Digitization of the company's entire operations plays a significant role in this.

**Keywords:** ARAS method; Financial performance; Efficiency; Factors; Companies; Serbia.

### INTRODUCTION

The issue of analyzing the financial performance and efficiency of companies is very complex, significant, and continuously relevant. It is therefore continuously researched theoretically, methodologically, and practically. It provides a detailed insight into the factors of financial performance and efficiency and what measures should be taken to achieve the target liquidity, solvency, and profitability of the company. The analysis of the financial performance and efficiency of the company is based on traditional and modern methods. In this work, summative methods based on multi-criteria analysis are used.

Recently, due to the reality of the obtained results, it is more challenging to measure the efficiency of companies using different methods of multi-criteria decision-making. Bearing that in mind, this paper analyzes the efficiency of companies in Serbia (i.e. their ranking) using the ARAS method as a subject of the research. The goal and purpose of this paper is to process the given problem as

complexly as possible in order to improve the efficiency of companies in Serbia in the future by taking appropriate measures.

As it is known, recently there has been an increasingly rich body of literature devoted to the evaluation of the efficiency of companies based on various methods of multi-criteria decision-making (Berman et al., 2018; Ersoy, 2017, 2022; Gaur et al., 2020; Levy et al., 2019; Lovreta & Petković, 2021; Tsai et al., 2021; Saaty 2008;). In this context, the role and importance of the ARAS method is increasing. In the relevant Serbian literature, for the first time, as far as we know, the performance and efficiency of Serbian companies are measured and analyzed using the ARAS method, which represents a certain scientific and professional contribution (Lukic, 2011; Lukic et al., 2019, 2021, 2022; Lukic et al., 2020a, 2020b, 2021; Lukic, 2011, 2020a 2020b, 2021a, 2021b, 2021c, 2021d, 2021e, 2021f; Lukic & Kozarevic, 2021).

The research of the treated problem in this work is based on the fundamental hypothesis of realistic analysis of the company's efficiency factors as a key assumption for improvement in the future by taking relevant measures. This can be easily achieved with the application (integrated or individually) of various multi-criteria decision-making methods, including the ARAS method, as well as DEA models (Bnaker et al., 1984; Lukic & Hadrovic-Zekic, 2019).

## MATERIALS AND METHODS

The necessary empirical data for the research of the treated problem in this paper were collected from the Agency for Economic Registers of the Republic of Serbia. Companies submit annual financial reports (balance sheet, income statement, cash flow report) to the Agency for Economic Registers of the Republic of Serbia, which further processes data for various business purposes of a macro and micro nature. Empirical data used in this paper are "manufactured" in compliance with relevant international standards. In terms of international comparability, there are no restrictions, whatsoever.

The analysis of the financial performance and efficiency of the company can be done on the basis of classic methodology - ratio analysis and modern methods based on multi-criteria analysis. They are used separately or in combination and complement each other. In this way, a more complete picture of the financial situation and efficiency of the company is obtained, and what measures should be taken in order to improve it in the future.

The Additive Ratio Assessment System (ARAS) is a multi-criteria analysis technique. It was developed by Zavadskas and Turskis (2010). Unlike other multi-criteria decision-making methods, the alternatives are ranked based on the utility function value (Chatterjee & Chakraborty, 2013; Dahooie et al., 2019; Jovčić et al., 2020; Koc & Uysal, 2017; Rostamzadeh et al., 2017; Sliogene et al. 2013). The ARAS method procedure includes several steps (Zavadskas & Turskis, 2010):

*Phase 1:* Create a decision-making matrix (DMM)

The decision-making matrix is created as follows:

$$X = \begin{bmatrix} x_{01} & \dots & x_{0j} & \dots & x_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} & \dots & x_{ij} & \dots & x_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{m1} & \dots & x_{mj} & \dots & x_{mn} \end{bmatrix}; i = \overline{0, m}; j = \overline{1, n} \quad (1)$$

where  $m$  – the number of alternatives,  $n$  – the number of criteria describing each alternative,  $x_{ij}$  – the value representing the performance value of the  $i$ -th alternative in terms of the  $j$ -th criterion,  $x_{0j}$  – the optimal value of the  $j$ -th criterion.

If the optimal value of the  $j$ -th criterion is unknown, then

$$\begin{aligned} x_{0j} &= \max_i x_{ij}, \text{ if } \max_i x_{ij} \text{ is preferable;} \\ x_{0j} &= \min_i x_{ij}^*, \text{ if } \min_i x_{ij}^* \text{ is preferable} \end{aligned} \quad (2)$$

*Phase 2:* Normalization of criteria values

In this stage, the initial values of the criteria are normalised - by defining the values  $\bar{x}_{ij}$  of the normalised decision-making matrix -  $\bar{X}$ .

$$\bar{X} = \begin{bmatrix} \bar{x}_{01} & \dots & \bar{x}_{0j} & \dots & \bar{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \bar{x}_{i1} & \dots & \bar{x}_{ij} & \dots & \bar{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \bar{x}_{m1} & \dots & \bar{x}_{mj} & \dots & \bar{x}_{mn} \end{bmatrix}; i = \overline{0, m}; j = \overline{1, n} \quad (3)$$

Normalization in the case of the desired maximum value is performed as follows:

$$\bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^m x_{ij}} \quad (4)$$

If a minimum value is preferable, the procedure consists of two phases:

$$x_{ij} = \frac{1}{x_{ij}^*}; \bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^m x_{ij}} \quad (5)$$

*Phase 3:* Define the normalised-weighted matrix -  $\hat{X}$

Weights are usually determined by the expert evaluation method. One should use only well-founded weights because they are always subjective and affect the solution. The sum of weights is limited (i.e. equal to 1):

$$\sum_{j=1}^n w_j = 1 \quad (6)$$



$$\hat{X} = \begin{bmatrix} \hat{x}_{01} & \dots & \hat{x}_{0j} & \dots & \hat{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}_{i1} & \dots & \hat{x}_{ij} & \dots & \hat{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}_{m1} & \dots & \hat{x}_{mj} & \dots & \hat{x}_{mn} \end{bmatrix}; i = \overline{0, m}; j = \overline{1, n} \quad (7)$$

The normalized-weighted values of the criteria are calculated as follows:

$$\hat{x}_{ij} = \bar{x}_{ij} w_j; i = \overline{0, m} \quad (8)$$

where  $w_j$  is the weight (importance) of the  $j$ -th criterion and  $\bar{x}_{ij}$  is the normalized rating of the  $j$ -th criterion.

Determining values of optimality function:

$$S_i = \sum_{j=1}^n \hat{x}_{ij}; i = \overline{0, m} \quad (9)$$

where  $S_i$  is the value of the optimality function of the  $i$ -th alternative. If  $S_i$  is the largest, the criterion is the best.

The utility degree ( $K_i$ ) of an alternative  $a_i$  is calculated (using the previous equation) as follows:

$$K_i = \frac{S_i}{S_0}, i = \overline{0, m} \quad (10)$$

where  $S_i$  and  $S_0$  are the optimality criterion values.

The value of  $K_i$  is in the interval  $[0, 1]$ . The relative efficiency (position, rank) of an alternative is determined according to the utility function values. The best alternative is the one with the greatest value.

In this paper, the weights of the criteria were determined using the AHP (Analytical Hierarchical Process) method. We will briefly point out its theoretical and methodological characteristics. The AHP method proceeds through several stages (Saaty, 2008):

*Phase 1:* Construct a pairwise comparison matrix

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{bmatrix} \quad (11)$$

*Phase 2:* Normalise the pairwise comparison matrix

$$a_{ij}^* = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}}, i, j = 1, \dots, n \quad (12)$$

*Phase 3:* Determination of relative importance, that is weight vector

$$w_i = \frac{\sum_{i=1}^n a_{ij}^*}{n}, i, j = 1, \dots, n \quad (13)$$

A consistent index – CI is of particular importance. He is a measure of the deviation of  $n$  from  $\lambda_{max}$ . It can be represented by the following equation:

$$CI = \frac{\lambda_{max} - n}{n} \quad (14)$$

The meaning is as follows: If  $CI < 0.1$ , the estimated values of the coefficients  $a_{ij}$  are consistent, and the deviation of  $\lambda_{max}$  from  $n$  is negligible. In other words, this means that the AHP method accepts an inconsistency of less than 10%. The consistency index is used to calculate the consistency ratio  $CR = CI/RI$ , where  $RI$  is a random index.

## RESULTS AND DISCUSSION

The selected criteria are financial indicators: C1 - Net profit, C2 - Business income, C3 - Business assets, C4 - Capital, and C5 - Number of employees. They are also key factors in the performance and efficiency of companies. With their adequate control, the company's target profit can be realized. Alternatives were observed (24) among largest companies in Serbia according to realized net profit in 2020. The initial data for measuring the efficiency of companies in Serbia are shown in Table 1. for 2020 using the AHP-ARAS method (Lukic, 2022). (The calculation was performed using the ARAS Software-Excel software.)

The weight coefficients of the selected criteria were determined using the AHP method (AHP With Arithmetic Mean Method). They are shown in Table 2. (The calculation was performed by using the AHP Software-Excel software.)

The empirical results of measuring the efficiency of companies in Serbia based on the ARAS method are shown in Tables 3-6 and Figure 1.

Table 1: Initial Data

	Companies	Net profit	Business income	Business assets	Capital	Number of employees
		C1	C2	C3	C4	C5
A1	TIGAR TIRES DOO PIROT	9,213	94,545	50,998	12.501	3,580
A2	COCA-COLA HBC - SERBIA DOO ZEMUN	5,668	26,649	49,349	41,272	962
A3	PHILIP MORRIS OPERATIONS AD NIŠ	4,861	23,786	27,506	16.201	595
A4	HEMOFARM AD VRŠAC	4,443	40,140	52,053	39,316	2,870
A5	FARMINA PET FOODS DOO INĐIJA	3,479	10,441	8,995	7,318	232
A6	DELHAIZE SERBIA DOO BELGRADE	3,931	111,485	72.196	42.305	12,889
A7	INVEJ AD BELGRADE-ZEMUN	3.402	125	6,867	120	54
A8	JT INTERNATIONAL AD SENTA	2,852	19,494	17.173	7,226	280
A9	KOEFIK DOO BELGRADE	2.174	157	3,423	2,991	16
A10	JP ROADS OF SERBIA BELGRADE	5.148	52.112	528.297	361.421	2,074
A11	IDC DOO BELGRADE	4.171	73,489	66,266	4.182	779
A12	DOO RZD INTERNATIONAL BRANCH BELGRADE	1.943	15,909	15.281	8,243	93
A13	DM INVEST DOO SMEDEREVSKA PALANKA	1,378	3,330	5,269	3.333	152
A14	INKOP DOO ĆUPRIJA	1.081	3.155	6,210	2,884	102
A15	TELENOR DOO BELGRADE	8.405	46,049	29,723	21,663	1.223
A16	TELEKOM SRBIJA AD BELGRADE	5,509	88.161	334.606	148.603	6,805
A17	VIP MOBILE DOO BELGRADE	3,606	33,599	49,532	0.000	1,350
A18	SBB DOO BELGRADE	3.282	27,857	65,021	24.134	1,655
A19	CETIN DOO BELGRADE	1.985	5,670	15,491	12,289	279
A20	JP EPS BELGRADE	12,883	282,731	913.683	609,792	24,478
A21	JKP BELGRADE ELEKTRANA BELGRADE	3.127	28,481	55,674	42.171	2010
A22	JP SRBIJAGAS NOVI SAD	2,990	87,228	204.195	121.019	934
A23	JUGOIMPORT-SDPR JP BELGRADE	1.286	14.162	56,310	21.129	363
A24	JP POST OF SERBIA BELGRADE	987	24,552	29,695	23,662	14,865
<b>Statistics</b>						
	Mean	45.1590	58.1260	110.9922	70.5690	204.7833
	Median	3.5425	31.0400	49.4405	21.3960	39.2390
	Std. Deviation	200.62977	63.69459	209.10842	138.90019	305.06081
	Skewness	4,898	2.178	3.063	3.163	1.632
	Std. Error of Skewness	.472	.472	.472	.472	.472
	Kurtosis	23,990	5,888	9,828	10,514	1.541
	Std. Error of Kurtosis	.918	.918	.918	.918	.918
	The minimum	1.08	3.16	3.42	.00	1.22
	Maximum	987.00	282.73	913.68	609.79	962.00

Note: Amounts in millions of dinars. Employees as an integer. Statistics were calculated by using SPSS software

Source: Agency for Economic Registers of the Republic of Serbia

Table 2: Weight of Criteria

Initial Comparisons Matrix	C1	C2	C3	C4	C5
C1	1	2.5	4	2	2
C2	0.4	1	6	1.25	1
C3	0.25	0.166667	1	0.5	1
C4	0.5	0.8	2	1	1
C5	0.5	1	1	1	1
SUM	2.65	5.46667	14	5.75	6

Normalized Matrix	C1	C2	C3	C4	C5	Weights of Criteria
C1	0.3774	0.4573	0.2857	0.3478	0.3333	0.3603
C2	0.1509	0.1829	0.4286	0.2174	0.1667	0.2293
C3	0.0943	0.0305	0.0714	0.0870	0.1667	0.0900
C4	0.1887	0.1463	0.1429	0.1739	0.1667	0.1637
C5	0.1887	0.1829	0.0714	0.1739	0.1667	0.1567
					SUM	1
Consistency Ratio	0.0676	COMPARE WITH 0.1; IT SHOULD BE LESS THAN 0.1.				

Table 3: Initial Matrix

Weights of criteria	0.3603	0.2293	0.09	0.1637	0.1567
Kind of criteria	1	1	1	1	1
	C1	C2	C3	C4	C5
A1	9,213	94,545	50,998	12,501	3,58
A2	5,668	26,649	49,349	41,272	962
A3	4,861	23,786	27,506	16,201	595
A4	4,443	40,14	52,053	39,316	2,87
A5	3,479	10,441	8,995	7,318	232
A6	3,931	111,485	72,196	42,305	12,889
A7	3,402	125	6,867	120	54
A8	2,852	19,494	17,173	7,226	280
A9	2,174	157	3,423	2,991	16
A10	5,148	52,112	528,297	361,421	2,074
A11	4,171	73,489	66,266	4,182	779
A12	1,943	15,909	15,281	8,243	93
A13	1,378	3,33	5,269	3,333	152
A14	1,081	3,155	6,21	2,884	102
A15	8,405	46,049	29,723	21,663	1,223
A16	5,509	88,161	334,606	148,603	6,805
A17	3,606	33,599	49,532	0	1,35
A18	3,282	27,857	65,021	24,134	1,655
A19	1,985	5,67	15,491	12,289	279
A20	12,883	282,731	913,683	609,792	24,478
A21	3,127	28,481	55,674	42,171	2,01
A22	2,99	87,228	204,195	121,019	934
A23	1,286	14,162	56,31	21,129	363
A24	987	24,552	29,695	23,662	14,865
MAX	987	282,731	913,683	609,792	962
MIN	1,081	3,155	3,423	0	1,223
0-Optimal Value	987	282,731	913,683	609,792	962

Table 4: Normalized Matrix

Weights of criteria	0.3603	0.2293	0.09	0.1637	0.1567
Kind of criteria	1	1	1	1	1
	C1	C2	C3	C4	C5
<b>0-Optimal Value</b>	0.4766	0.1685	0.2554	0.2647	0.1637
<b>A1</b>	0.0044	0.0564	0.0143	0.0054	0.0006
<b>A2</b>	0.0027	0.0159	0.0138	0.0179	0.1637
<b>A3</b>	0.0023	0.0142	0.0077	0.0070	0.1012
<b>A4</b>	0.0021	0.0239	0.0146	0.0171	0.0005
<b>A5</b>	0.0017	0.0062	0.0025	0.0032	0.0395
<b>A6</b>	0.0019	0.0664	0.0202	0.0184	0.0022
<b>A7</b>	0.0016	0.0745	0.0019	0.0521	0.0092
<b>A8</b>	0.0014	0.0116	0.0048	0.0031	0.0476
<b>A9</b>	0.0010	0.0936	0.0010	0.0013	0.0027
<b>A10</b>	0.0025	0.0311	0.1477	0.1569	0.0004
<b>A11</b>	0.0020	0.0438	0.0185	0.0018	0.1326
<b>A12</b>	0.0009	0.0095	0.0043	0.0036	0.0158
<b>A13</b>	0.0007	0.0020	0.0015	0.0014	0.0259
<b>A14</b>	0.0005	0.0019	0.0017	0.0013	0.0174
<b>A15</b>	0.0041	0.0274	0.0083	0.0094	0.0002
<b>A16</b>	0.0027	0.0525	0.0935	0.0645	0.0012
<b>A17</b>	0.0017	0.0200	0.0138	0.0000	0.0002
<b>A18</b>	0.0016	0.0166	0.0182	0.0105	0.0003
<b>A19</b>	0.0010	0.0034	0.0043	0.0053	0.0475
<b>A20</b>	0.0062	0.1685	0.2554	0.2647	0.0042
<b>A21</b>	0.0015	0.0170	0.0156	0.0183	0.0003
<b>A22</b>	0.0014	0.0520	0.0571	0.0525	0.1589
<b>A23</b>	0.0006	0.0084	0.0157	0.0092	0.0618
<b>A24</b>	0.4766	0.0146	0.0083	0.0103	0.0025

Table 5: Normalized Weighted Matrix

	C1	C2	C3	C4	C5
<b>0-Optimal Value</b>	0.1717	0.0386	0.0230	0.0433	0.0257
<b>A1</b>	0.0016	0.0129	0.0013	0.0009	0.0001
<b>A2</b>	0.0010	0.0036	0.0012	0.0029	0.0257
<b>A3</b>	0.0008	0.0033	0.0007	0.0012	0.0159
<b>A4</b>	0.0008	0.0055	0.0013	0.0028	0.0001
<b>A5</b>	0.0006	0.0014	0.0002	0.0005	0.0062
<b>A6</b>	0.0007	0.0152	0.0018	0.0030	0.0003
<b>A7</b>	0.0006	0.0171	0.0002	0.0085	0.0014
<b>A8</b>	0.0005	0.0027	0.0004	0.0005	0.0075
<b>A9</b>	0.0004	0.0215	0.0001	0.0002	0.0004
<b>A10</b>	0.0009	0.0071	0.0133	0.0257	0.0001
<b>A11</b>	0.0007	0.0100	0.0017	0.0003	0.0208
<b>A12</b>	0.0003	0.0022	0.0004	0.0006	0.0025
<b>A13</b>	0.0002	0.0005	0.0001	0.0002	0.0041
<b>A14</b>	0.0002	0.0004	0.0002	0.0002	0.0027
<b>A15</b>	0.0015	0.0063	0.0007	0.0015	0.0000
<b>A16</b>	0.0010	0.0120	0.0084	0.0106	0.0002
<b>A17</b>	0.0006	0.0046	0.0012	0.0000	0.0000
<b>A18</b>	0.0006	0.0038	0.0016	0.0017	0.0000
<b>A19</b>	0.0003	0.0008	0.0004	0.0009	0.0074
<b>A20</b>	0.0022	0.0386	0.0230	0.0433	0.0007
<b>A21</b>	0.0005	0.0039	0.0014	0.0030	0.0001
<b>A22</b>	0.0005	0.0119	0.0051	0.0086	0.0249
<b>A23</b>	0.0002	0.0019	0.0014	0.0015	0.0097
<b>A24</b>	0.1717	0.0034	0.0007	0.0017	0.0004

Table 6: Ranking

	0-Optimal Value	S	K	K	Ranking
		0.3023	1.0000	1.0000	
TIGAR TIRES DOO PIROT	A1	0.0168	0.0555	0.0555	12
COCA-COLA HBC - SERBIA DOO ZEMUN	A2	0.0345	0.1140	0.1140	5
PHILIP MORRIS OPERATIONS AD NIŠ	A3	0.0218	0.0721	0.0721	10
HEMOFARM AD VRŠAC	A4	0.0104	0.0345	0.0345	15
FARMINA PET FOODS DOO INĐIJA	A5	0.0090	0.0297	0.0297	18
DELHAIZE SERBIA DOO BELGRADE	A6	0.0211	0.0697	0.0697	11
INVEJ AD BELGRADE-ZEMUN	A7	0.0278	0.0920	0.0920	8
JT INTERNATIONAL AD SENTA	A8	0.0116	0.0383	0.0383	14
KOEFIK DOO BELGRADE	A9	0.0226	0.0746	0.0746	9
JP ROADS OF SERBIA BELGRADE	A10	0.0470	0.1556	0.1556	4
IDC DOO BELGRADE	A11	0.0335	0.1108	0.1108	6
DOO RZD INTERNATIONAL BRANCH BELGRADE	A12	0.0060	0.0197	0.0197	22
DM INVEST DOO SMEDEREVSKA PALANKA	A13	0.0051	0.0169	0.0169	23
INKOP DOO ČUPRIJA	A14	0.0037	0.0122	0.0122	24
TELENOR DOO BELGRADE	A15	0.0101	0.0333	0.0333	16
TELEKOM SRBIJA AD BELGRADE	A16	0.0322	0.1064	0.1064	7
VIP MOBILE DOO BELGRADE	A17	0.0065	0.0215	0.0215	21
SBB DOO BELGRADE	A18	0.0078	0.0257	0.0257	20
CETIN DOO BELGRADE	A19	0.0098	0.0325	0.0325	17
JP EPS BELGRADE	A20	0.1079	0.3567	0.3567	2
JKP BELGRADE ELEKTRANA BELGRADE	A21	0.0089	0.0294	0.0294	19
JP SRBIJAGAS NOVI SAD	A22	0.0511	0.1690	0.1690	3
JUGOIMPORT-SDPR JP BELGRADE	A23	0.0148	0.0488	0.0488	13
JP POST OF SERBIA BELGRADE	A24	0.1779	0.5884	0.5884	1

Note:  $S_i$  is the value of the optimality function of the  $i$ -th alternative. The utility degree ( $K_i$ ) of an alternative  $a_i$ .

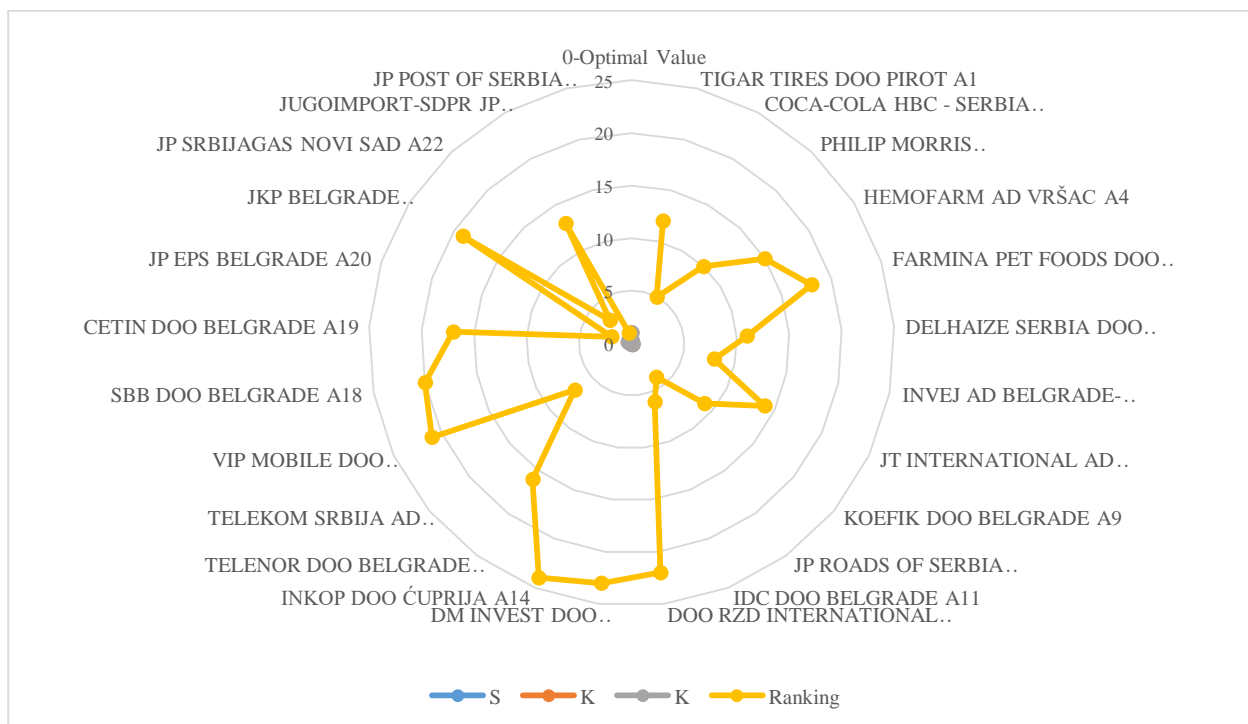


Figure 1: Ranking of companies in Serbia according to efficiency  
Source: Author's picture



According to the ARAS method, five most efficient companies in Serbia in 2020 are JP POST OF SERBIA BELGRADE, JP EPS BELGRADE, JP SERBIAGAS NOVI SAD, JP PUTEVI SERBIA BELGRADE and COCA-COLA HBC - SERBIA DOO ZEMUN. First four are public companies, and the fifth is from the processing industry sector. Public enterprises are fundamentally efficient. The retail chain DELHAIZE SERBIA DOO BELGRADE is in the eleventh place. The trading company JUGOIMPORT-SDPR JP BELGRADE is in thirteenth place. Trading companies are therefore well positioned.

In this paper, the impact of profit management, asset sales, capital, and human resources management on the financial performance and efficiency of companies in Serbia was analyzed using the given methodology. With their adequate control, the target profit can be achieved. The obtained results of the research on the treated problem in this paper show that the tested hypothesis has been confirmed.

In addition to these factors, primarily of an internal nature, the financial performance and efficiency of companies in Serbia are also influenced by others of an external nature. In the strictest sense of the word, factors of efficiency of enterprises in Serbia are the growth rate of gross domestic product, interest rate, inflation, employment rate, foreign direct investments, the efficiency of enterprise management, digitization of the entire enterprise operation, application of new business models, application of new concepts of cost, sales and profit management. Effective control of these factors can achieve the company's target profit.

Similar research does not exist in the literature, which makes international comparison difficult.

Research of the financial performance and efficiency of companies in Serbia was mainly carried out using ratio analysis. In order to obtain a more complete picture of the financial situation and efficiency of companies in Serbia, it is recommended to simultaneously use ratio analysis and multi-criteria decision-making methods. The ARAS method provides a more realistic representation of the efficiency of companies in Serbia compared to ratio analysis. For these reasons, it is recommended, especially in combination with other methods of multi-criteria

differentiation (TOPSIS, WASPAS, MARCOS, and others), as well as with DEA models.

## CONCLUSION

In Serbia, five the most efficient companies are JP POST OF SERBIA BELGRADE, JP EPS BELGRADE, JP SERBIAGAS NOVI SAD, JP PUTEVI SERBIA BELGRADE, and COCA-COLA HBC - SERBIA DOO ZEMUN. First four are public companies. The fifth company is from the processing industry. Basically, public benefits are effective. The efficiency of business management in Serbia was influenced by numerous macro and micro factors: growth rate of gross domestic product, interest rate, inflation, employment rate, foreign direct investments, the efficiency of enterprise management, application of new business models, application of new concepts of cost, sales and profit management, digitization of the entire enterprise operation, etc. The impact of the Covid-19 pandemic, which has been mitigated to some extent with electronic business, is also not significant. The target profit can be achieved by their adequate control.

In the future, in order to achieve the target efficiency of companies in Serbia, it is necessary to manage human resources, assets, capital, sales, and profit as efficiently as possible. For these purposes, among other things, new concepts of cost management should be increasingly applied (calculation of costs by basic activities, target costs, activity management, and others).

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## EVALUACIJA FINANSIJSKIH PERFORMANSI I EFIKASNOSTI SRPSKIH PREDUZEĆA

Sve se više u svetu u novije vreme koriste različite metode višekriterijumskog odlučivanja, kao i DEA (Data Envelopment Analysis) modeli, za merenje finansijskih performansi i efikasnosti preduzeća. Polazeći od toga, u ovom radu se analizira efikasnost preduzeća u Srbiji korišćenjem ARAS metode. Prema ARAS metodi pet najefikasnijih preduzeća u Srbiji su JP POŠTA SRBIJE BEOGRAD, JP EPS BEOGRAD, JP SRBIJAGAS NOVI SAD, JP PUTEVI SRBIJE BEOGRAD i COCA-COLA HBC - SRBIJA DOO ZEMUN. Prva četiri su javna preduzeća, a peto je iz sektora prerađivačke industrije. Javna preduzeća su u osnovi efikasna. Trgovinska preduzeća su dobro pozicionirana. Tako, na primer, maloprodajni lanac DELHAIZE SERBIA DOO BEOGRAD je na jedanaestom mestu. Na pozicioniranje preduzeća u Srbiji u pogledu efikasnosti uticali su, pored makroekonomskih faktora, i upravljačke veštine rukovodstva u pogledu što efikasnijeg upravljanja aktivom, kapitalom, prodajom, profitom i ljudskim resursama, koje su svakako različite od jednog do drugog preduzeća. Značajnu ulogu u tome imala je i digitalizacija celokupnog poslovanja. Takođe je zabeležen i uticaj pandemije korona virusa Covid-19.

**Ključne reči:** ARAS metoda; Efikasnost; Faktori; Preduzeća; Srbija.

## ATTRIBUTIVE QUALITY OF PRODUCTS IN DECIBELS

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**Traditional engineering can successfully define only the quality of measuring instruments and completed processes (*PCI* precision indices and *PPI* accuracy), while the quality of process results (semi-finished product, product, software, service) can only describe (good or bad quality, better or worse quality). In the modern consideration of quality, the quality of process results, today is defined by the number of decibels (dB), according to the discovery of the genius Japanese scientist Genichi Taguchi (1924 - 2012), pursuant to the Robust Technology Development Method. and standard ratio (*S/N*). Modern engineering considers the quality of process results, measuring instruments, and completing processes according to their quality characteristics (continuous, attributive). More often, continuous characteristics that can be more precisely defined are considered, while attribute characteristics can only be estimated. In this paper, four different types of process result quality with one attributive input variable are considered. After the calculations, the following results were achieved: in two classes with one type of error, poor quality results were obtained – 28.52, in two classes with two types of errors, the results obtained that the separation of  $A_2$  is better than  $A_1$  due to the difference of 7,532 dB, in the (*S/N*) ratio of the chemical reaction without side effects, the required results were obtained, in the methods of the ratio of the reaction rate of a chemical reaction with the side reactions, good quality results of 17.40 dB were obtained.**

**Keywords:** Quality engineering; Quality of process results; Attributive characteristic.

### INTRODUCTION

"Quality engineering" includes scientific principles and practices of quality assurance, as well as quality control of process results (semi-finished product, product, documentation, service). This term is newer and mainly refers to the chemical, construction, electrical and mechanical engineering. The history of quality has been created by many ingenious scientists discovering theoretical laws and well-known practitioners of innovative knowledge.

In the 17<sup>th</sup> century, the first scientists-inventors appeared (1711. De Moivre, 1713. Bernoulli J, 1724. Bernoulli D, 1724. Laplace) with discoveries of probability and distributions of probabilities. Theoretical statistical discoveries were made in the 18th century (1805. Legendre, 1807. Gauss, 1854. Boole, 1857. Poisson, 1869. and Galton, 1880.

Chebyshev). Most discoveries in the field of quality control were made in the 19<sup>th</sup> century (1900. Markov and Pearson, 1904. Spearman, 1905. Rayleigh, 1908. Gosset, 1912. Pareto, 1922. Fisher, 1924. Shewhart, 1928. Deming, 1929. Kolmogorov, 1938. Kendall, 1939 Weibull, 1941. Cochran, 1945. Wilcoxon, 1947. Bartlett, Mann, Whitney, and Dantzig, 1950. Mahalanobis, 1952. Anderson and Darling, 1953. Anscombe, 1962. Tukey and Johnson, 1964. Watson, 1964. Box, 1965. Shapiro, 1971. Cook, 1990. Yates). Finally, in the late 20<sup>th</sup> century, the latest theoretical and practical discoveries in the field of quality management were made (Smith, 1998; Taguchi, Subir, & Shin, 1999). These last two discoveries led to the emergence of Smith's new "Six Sigma System" and new "Taguchi Methods" of quality engineering. The inventor from New York Ing. William B. Smith, Jr. (1929 - 1993), "father of the Six Sigma system". He was educated at the

University of Minnesota (now known as the Carlson School of Management) and after nearly 35 years of work in engineering and quality assurance, he joined Motorola. There he was vice president and senior manager at Land Mobile and founded Motorola University and the Six-Sigma Institute. By implementing the Six Sigma system, Motorola had already saved more than \$ 15 million in 2005. The six sigma system is a new way of improving the business of organizations, in the processes of designing, implementing, and delivering process results, by applying new theoretical discoveries and practical experiences. This system is based on the practical idea of W. B. Smith (1929-1993) that processes with a scatter size ( $\sigma$ ), which have only a tolerance width of  $\pm 6\sigma$ , have at least 3.4 losses per million realizations. This has led to a significant increase in the quality of the process results in the world, as an extension of the manufacturing tolerances concerning the size of the scattering has been achieved.

In 1957, the Japanese scientist Dr. Genichi Taguchi (1929 - 1993) discovered new methods of designing experiments by designing the smallest number of experiments with orthogonal rows (Design of Experiments). Then, in 1972, he set the magnitude/deviation ratio, which enabled the first value definition of the quality of process results (S / N Ratio) in decibels (dB). Afterwards, in 1981, he established the border function of realization of quality inline production (On-line Quality), and in 1982 the function of realization of quality in serial production (Off-line Quality). In 1984, he proposed a special design of process result parameters (Parameter Design), and a little later in 1984 a special design of process result tolerances (Tolerance Design). In 1986, Taguchi proposed a new way of considering quality in the special science of quality engineering, in the design, production, and delivery of process results (Quality Engineering). Then, in 1992, he laid the foundations for a new outstanding approach to Robust Technology Development. Subsequently, in 1994, he defined Taguchi Methods with 3 criteria: Nominal is the best, Smaller is better, and Larger is better. Finally, in 2002, he developed a special quality review strategy (Mahalanobis-Taguchi Strategy).

The business of organizations, in order to fully satisfy customers, stakeholders, and employees, largely depend on the achieved quality of process results, which is discussed in detail in Quality Engineering. The quality of process results is the

level to which a set of quality characteristics effectively meets planned requirements and tasks. Quality engineering is a way of approaching anticipation or prevention of problems that may occur in the market, after the customer sells and uses the product in different circumstances and applied conditions, during the projected life of the product.

The quality of process results (semi-finished product, product, documentation, service) is characterized by its quality characteristics. Quality and reliability are the probability according to which the result of a process can perform its function, ie a set of characteristic quantities: Availability, Reliability, Security, Confidentiality, Integrity, and Maintenance.

The traditional understanding of quality takes into account the quality of process results, the quality of measuring systems, or the quality of completed processes. The quality of measuring systems and completed processes can be defined by a standardized (ISO 8258) Process Precision Index (*PCI*, *C<sub>p</sub>*) or Process Accuracy Index (*PPI*, *P<sub>p</sub>*). Unfortunately, the quality of process results can only be described in terms of attributes (there is or there is no quality, good or bad quality, better or worse quality, etc.).

Modern understanding of the quality of process results includes defining quality in decibels [dB], according to the findings of Japanese scientist Genichi Taguchi (1924-2012), whose methods cover the following main areas:

1. System design with Quality Loss Function (QLF) and Offline Quality Control (System design with Quality Loss Function (QLF) and Offline Quality Control (Logothetis, & Wynn, 1989; Nair, 1992; Taguchi, 1986, 1995),
2. Parametric design robust technology development and standard (S/N) ratio (Taguchi, 1984; Taguchi & Hiroshi, 1994; Taguchi, 1992; Taguchi & Rajesh, 2002; Taguchi et al., 2000, 2005; Taguchi et al., 2004; Wu & Hamada, 2002).
3. Tolerance design with criteria: Nominal is-best, Less-is-better, and More-better is better (Taguchi et al., 2005),
4. Design of experiments (DoE) with an orthogonal sequence of plans and multilevel experiments (Atkinson et al., 2007; Box, & Draper, 2007; Hardin & Sloane 1993; Moen et al., 1991).



The standard magnitude/variability ratio (signal-to-noise ratio,  $S/N$ ) establishes the appropriate input quantity ( $S$ ) and variability ( $N$ ) ratio, which Taguchi used for applications in the communications industry, is to check the sound quality. Starting from the fact that the radio receives a signal or voice wave emitted from broadcast stations and converts it into sound, voice is the input quantity (signal), the received voice wave is the output signal (response), where input is mixed in space with output variability signal (noise). Thus, sound quality is expressed by the ratio of the input signal and variability in decibels [dB], and of course the higher the  $(S/N)$  ratio, the better the quality.

Attributive characteristics are often used for data collection and analysis, but from a quality engineering point of view, they are not good quality characteristics. Such characteristics do not have much information, so the calculations are inefficient and there is an interaction between the input values (control factors). The classified data here contain 0 and 1 and e.g. The number of defaults can be expressed by 1, and without defaults by 0. The result calculated from a mixture of defects and without defects looks like a continuous variable but is actually calculated from data 0 and 1. Even in the case of chemical reactions, the result is part of the substance which reacted within the whole substance, in units of molecules or atoms.

Attributive characteristics are very widely used for data collection and analysis, but from the point of view of quality engineering, they are not quality characteristics. Not much information can be collected by using only such characteristics, so the study would be ineffective and there would be an interaction between control factors.

## METHODOLOGY

There is the following methodology to avoid such interactions:

- avoid data 0-1,
- when data with continuous variables cannot be measured due to lack of technology or other reasons, try to provide more than two classes, such as good, normal, and bad, or large, medium, and small, the more levels are classified, the more information is revealed, in this way, the trend of changing the control

factor can be noticed and somewhat inaccurate conclusions can be avoided,

- the best strategy is to use a function-based  $(S/N)$  ratio.

This assessment of product quality attributes features includes:

- two classes with one type of error,
- two classes with two types of errors,
- $(S/N)$  the ratio of Chemical Reactions without Side Reactions.
- Reaction Speed ratio methods of Chemical Reaction with Side Reactions.

## TWO CLASSES WITH ONE TYPE OF ERROR

The use of 0-1 data will reveal the interactions among control factors. Interaction is synonymous with inaudibility, and inconsistency. and inreability. In two production processes, the fraction is defective in the production of the component, indicated by  $p= 0,10$ .

For example, we measured separately Three Measuring Blocks (countermeasures) to obtain the component, denoted by  $p= 0.10$ . Three counteractions were taken separately to achieve the following outcomes:

- A: material,  $A_1$ : current material ( $B_1C_1$ );  $p= 0.10$ ,  $A_2$ : new material ( $B_1C_1$ );  $p= 0.02$ ,
- B: machine,  $B_1$ : current machine ( $A_1C_1$ );  $p= 0.10$ ,  $B_2$ : new machine ( $A_1C_1$ );  $p= 0.04$ ,
- C: method,  $C_1$ : current method ( $A_1B_1$ );  $p= 0.10$ ,  $C_2$ : new method ( $A_1B_1$ );  $p= 0.02$

Such a method is called the *one-factor-at-a-time approach*. If arithmetic activity is assumed, the fraction defective under  $A_2B_2C_2$  is calculated as:

$$p = 0.10 + (0.02 - 0.10) + (0.04 - 0.10) + (0.02 - 0.10) = -0.12 . \quad (1)$$

A negative fraction is unrealistic. To avoid such a problem it is recommended that one used the omega transformation, Following are the results of a test:  $y_i$ , values are either 0 or 1. Assume that 0 or 1 are good and defective products, respectively.

Letting the defective fraction be  $p$ , and the ratio  $(S/N)$  is calculated, so the data are decomposed and the total variation is (Taguchi, & Rajesh, 2002; Taguchi et al., 2004):

$$p = \frac{y_1 + y_2 + \dots + y_n}{n};$$

$$S_T = y_1^2 + y_2^2 + \dots + y_n^2 = np. \quad (2)$$

The result of the signal ( $S_p$ ) is calculated as a variation ( $p$ ), so since equation ( $p$ ) is a linear equation, ( $L$ ) its variation is denoted by ( $S_p$ ), where ( $D$ ) is the number of units of equation ( $p$ ):

$$S_p = \frac{L^2}{D};$$

$$D = \left(\frac{1}{n}\right)^2 + \left(\frac{1}{n}\right)^2 + \dots + \left(\frac{1}{n}\right)^2 =$$

$$= n \left(\frac{1}{n}\right)^2 = \frac{1}{n}. \quad (3)$$

By adding ( $p$ ) and ( $D$ ) to equation ( $S_p$ ), the error variation ( $S_e$ ) is calculated by subtracting ( $S_p$ ) from ( $S_T$ ), so the ratio of ( $S/N$ ) digital data is calculated as the ratio of signal variation to error variation in decibel units (dB), and ( $p = 0.0014$ ) used in omega transformations:

$$S_p = \frac{p^2}{\frac{1}{n}} = np^2 = S_m;$$

$$S_e = S_T - S_p = np - np^2 = np(1 - p), \quad (4)$$

$$S/N = 10 \log \frac{S_p}{S_e} = 10 \log \frac{np^2}{np(1-p)} =$$

$$= 10 \log \frac{p}{1-p} = -10 \log \left(\frac{1}{p} - p\right). \quad (5)$$

Using the omega transformation, the omega value of each state is calculated and for the current state ( $T$ ), condition  $A_2B_2C_2$  is estimated to:

$$A_1B_1C_1(p = 0.10); \eta = -10 \log \left(\frac{1}{p} - p\right) =$$

$$= -10 \log \left(\frac{1}{0.10} - 1\right) = -9.54,$$

$$A_2B_1C_1(p = 0.02); \eta = -10 \log \left(\frac{1}{p} - p\right) =$$

$$= -10 \log \left(\frac{1}{0.02} - 1\right) = -16.90,$$

$$A_2B_2C_1(p = 0.04); \eta = -10 \log \left(\frac{1}{p} - p\right) =$$

$$= -10 \log \left(\frac{1}{0.04} - 1\right) = -13.80,$$

$$A_1B_1C_2(p = 0.02); \eta = -10 \log \left(\frac{1}{p} - p\right) =$$

$$= -10 \log \left(\frac{1}{0.02} - 1\right) = -16.90.$$

Assume that the current condition is  $T$ , the state of  $A_2B_2C_2$  is estimated as follows:

$$S/N = -10 \log \left(\frac{1}{p} - p\right) = T + (A_2 - T) + (B_2 - T) +$$

$$+(C_2 - T) = A_2 + B_2 + C_2 - 2T =$$

$$= A_2 + B_2 + C_2 - 2T = -16.90 - 13.80 - 16.90 -$$

$$- 2(-9.54) = -28.52, p = 0.0014.$$

Obtained results showed that these processes are not of good quality ( $S/N = -28.52$ ), due to all negative values ( $S/N$ ) of the relationship, but it is still a slightly better process with existing material, machine, and method, which is the least negative  $S/N = -9.54$  (Taguchi, 1962; Wu, & Hamada, 2002; Wadsworth, 1997).

## TWO CLASSES WITH TWO TYPES OF ERROR

To explain this case, a copper smelting process is used as an example. From copper ore (copper sulfide), metal copper is extracted to produce crude copper. It is desirable that all copper in the ore is included in the crude copper and to include all non-copper materials in the slag (waste). Actually, some impurities are included in the crude copper, and some copper is included in the slag. For example, Table 1. shows the input/output in the copper smelting process. In the table there are two types of faults:  $p$ , part of the copper included in the slag, and  $q = 1 - p$ , is the fraction of the impurities included in the product. From Table 2., two types of mistakes:  $p$ , a fraction of copper included in the slag, and  $q$ , the fraction of impurities included in crude copper ingot,  $p$  is the fraction of copper mistakenly included in the slag, and  $(1 - p)$  is called yield, is the fraction of noncopper materials included in the product. Both fractions are calculated by the fraction in weight, are calculated as follows:

$$p = \frac{Bp^*}{A(1-q^*) + Bp^*}; q = \frac{Aq^*}{Aq^* + B(1-p^*)}. \quad (6)$$

Table 1: Input and output values of the smelting

Input	Output		Total
	Product	Slag	
Cooper	$A(1 - q^*)$	$Bp^*$	$A(1 - q^*)Bp^*$
Noncooper	$Aq^*$	$B(1 - p^*)$	$Aq^*B(1 - p^*)$
Total	$A$	$B$	$A+B$

Table 2: Input and output values with  $p$  and  $q$ 

Input values	Output values		Total
	Product	Slag	
Cooper	$1 - p$	$p$	1
Noncooper	$q$	$1 - q$	1
Total	$1 - p + q$	$p + 1 - q$	2

To compare  $p$  and  $q$ , when the furnace temperature is high, more copper melts into the product, therefore  $p$  decreases. However, at the same time, no more copper materials melt into the product, which increases ( $q$ ). The factor, which decreases  $p$  but increases  $q$  is called the *tuning factor*. The tuning factor does not improve the process separation function of the process. A good separation function is to reduce both  $p$  and  $q$  simultaneously.

To find control factors that can reduce  $p$  and  $q$  together, it is important to evaluate the function after adjusting  $p$  and  $q$  on the same basis. For example, if you want to know which level of control factor,  $A_1$  and  $A_2$ , there is a better separation of functions. Assume that  $p$  and  $q$  values for  $A_1$  and  $A_2$  are  $p_1, q_1$  and  $p_2, q_2$  respectively. According to the earlier,  $(p_1+q_1)$  with  $(p_2+q_2)$ . cannot be compared. Consequently, the data must be transformed in such a way that the comparison can be carried out on the same basis.

For this purpose, the standard ratio ( $S/N$ ) is used, which is calculated after tuning, to get to the point where  $(p = q)$ . This fraction is denoted by ( $p_0$ ) and the standard ratio ( $S/N$ ) is calculated as:

$$p_0 = \frac{1}{1 + \sqrt{\left(\frac{1}{p} - 1\right)\left(\frac{1}{q} - 1\right)}}; \quad (7)$$

$$S/N = 10 \log \frac{(1-2p_0)^2}{4p_0(1-p_0)}$$

For example, the aim was to separate A from the mixture of A and B. The separating functions of the two conditions were compared. Table 3. shows hypothetical results after separation. To calculate the standard ( $S/N$ ) ratio, the results in the table are converted into fractions to obtain Table 4.

Table 3: Results of the experiment after separations

Separations	Input	Product	Slag	Total
$A_1$	A	1.025	3.975	5.000
	B	38.975	156.025	195.000
	Total	40.000	160.000	200.000
$A_2$	A	1.018	3.782	4.800
	B	38.982	256.218	195.200
	Total	40.000	160.000	200.000

Table 4: Results in a fraction

Separations	Input	Product	Slag	Total
$A_1$	A	0.20500	0.79500	1.00000
	B	0.19987	0.80013	1.00000
	Total	0.40487	1.59513	2.00000
$A_2$	A	0.21208	0.78792	1.00000
	B	0.19970	0.80030	1.00000
	Total	0.41178	1.58822	2.00000

Condition  $A_i$  and conditions  $A_1$  and  $A_2$  are:

$$p = \frac{3975}{5000} = 0.79500; q = \frac{3875}{195.000} = 0.19987,$$

$$p_0 = \frac{1}{1 + \sqrt{\left(\frac{1}{p} - 1\right)\left(\frac{1}{q} - 1\right)}} = \frac{1}{1 + \sqrt{\left(\frac{1}{0.795} - 1\right)\left(\frac{1}{0.19987} - 1\right)}} = 0.496602,$$

$$S/N(A_1) = 10 \log \frac{(1-2p_0)^2}{4p_0(1-p_0)} =$$

$$= 10 \log \frac{[1-2 \cdot 0.496602]^2}{4 \cdot 0.496602(1-0.496602)} = -41.981 \text{ dB}.$$

$$S/N(A_2) = -34.449 \text{ dB}.$$

The obtained results showed that the separation of  $A_2$  is better than the separation of  $A_1$  due to the difference:

$$A_2 - A_1 = -34.449 - (-41.981) = 7.532 \text{ dB}.$$

## (S/N) OF CHEMICAL REACTION WITHOUT SIDE REACTIONS

The nature of the function of a chemical reaction is to change the combining condition of molecules or atoms. In most cases, it is impossible to measure the behavior of individual molecules or atoms. Instead, only the unit, such as yield, can measure the behavior of an entire group. The yield used in chemical reactions sounds like a continuous variable, but it is a fraction of the number of molecules or atoms.

The basic function of a chemical reaction is to change the combining state of molecules or atoms. When substances A and B react to form material C, A and B collide and the molecules of A gradually decrease. In this case, it is ideal that reaction speed is proportional to the concentration of A": ( $A + B \Rightarrow C$ ). This is an example of classifying attribute data, for process characteristics without side reactions.

If the initial amount of the main raw material  $A = Y_0$ , and the amount at time  $T = Y$ , the proportion of the number of changes in time  $T = Y/Y_0$  then the reaction rate is obtained with a reduced amount, which is differentiated by time:

$$\frac{dY}{dT} = \beta \left( \frac{1-Y}{Y_0} \right). \quad (8)$$

and from this equation arises:

$$\frac{Y}{Y_0} = 1 - e^{-\beta T}, \quad (9)$$

Previously shown amount in parentheses on the right gives the concentration (A), so as:

$$p_0 = 1 - \frac{Y}{Y_0}; p_0 = e^{-\beta T}, \quad (10)$$

The ideal zero-point proportional function is obtained by substituting  $(-\ln p_0 = y)$  in the last function, so the ideal zero-proportional function is obtained:

$$p_0 = e^{-\beta T}, -\ln p_0 = \beta T, -\ln p_0 = y. \quad (11)$$

For example let ( $T$ ) be the signal factor and the remaining fractions at different times ( $p_1, p_2, \dots, p_k$ ) according to the table in Table 5. and also the ideal proportional relationship between other fractions and time.

Table 5: The remaining fractions at different times

Time	$T_1$	$T_2$		$T_k$
Fraction of remaining main raw material	$p_1$	$p_2$	...	$p$
$\ln \frac{1}{p_0}$	$y_1$	$y_2$	...	$y_k$

From the results in a table the variation of  $y_1, y_2, \dots, y_k$  is decomposed as follows - Total variations are broken down into variations due to generic function and variations caused by deviation from a generic function:

$$S_T = y_1^2, y_2^2, \dots, y_k^2, (f = k). \quad (12)$$

The proportional term of the variation, the linear equation, the effective divisor, and the variations of the error are shown in Table 6:

$$\begin{aligned} S_\beta &= \frac{L^2}{\gamma}, (f = 1); \\ L &= y_1 T_1 + y_1 T_1 + \dots + y_1 T_1; \\ \gamma &= T_1^2 + T_2^2 + \dots + T_k^2; \\ S_e &= S_T - S_\beta, (f = k - 1). \end{aligned} \quad (13)$$

Table 6: ANOVA table for chemical reaction

Source	$f$	$S$	$V$	$E(V)$
$\beta$	1	$S_\beta$	...	$\sigma^2 + \gamma\beta^2$
$e$	$k-1$	$V_e$	...	$\sigma^2$
Total	$k$			

Relationship ( $S/N$ ), and sensitivity assessment ( $S$ ) are:

$$\begin{aligned} S/N &= 10 \log \frac{\frac{1}{\gamma}(S_e - V_e)}{V_e}; \\ \eta &\Rightarrow 10 \log \frac{\beta^2}{\sigma^2}; \\ S &= 10 \log (S_\beta - V_e); S \Rightarrow 10 \log \beta^2. \end{aligned} \quad (14)$$

## REACTION SPEED RATIO METHODS OF CHEMICAL REACTION WITH SIDE REACTIONS

In chemical reactions, noise factors are not included in the experiment because of the cost increase. When there are side reactions, the reaction speed of side-reacted products ( $\beta_2$ ), may be considered as noise, therefore, its ( $S/N$ ) ratio is written as:

$$S/N = \frac{\beta_1^2}{\beta_2^2}. \quad (15)$$

In order to maximize the total reaction speed ( $\beta_1$ ), denoted by ( $h_1$ ), it is calculated using a larger-the-better characteristic. We also want to minimize the side-reacting speed ( $\beta_2$ ), denoted by ( $h_2$ ). The ( $S/N$ ) ratio of ( $\beta_2$ ) is calculated using a smaller-the-better characteristic. The two ( $S/N$ ) ratios are added together to obtain the overall ( $S/N$ ) ratio, denoted by ( $h$ ), and also in the decibel scale:

$$S/N = S/N_1 + S/N_2; S/N = 10 \log \frac{\beta_1^2}{\beta_2^2}. \quad (16)$$

This is called the speed ratio method, and a sample of the data collection is also shown in Table 7:

$$\begin{aligned} \beta_{11} &= \frac{y_{11}}{T_1}, \beta_{12} = \frac{y_{12}}{T_2}, \dots, \beta_{1k} = \frac{y_{1k}}{T_k}; \\ \beta_{21} &= \frac{y_{21}}{T_1}, \beta_{22} = \frac{y_{22}}{T_2}, \dots, \beta_{2k} = \frac{2k}{T_k}. \end{aligned} \quad (17)$$

Table 7: Data collection for the speed ratio method

Time	$T_1$	$T_2$	...	$T_k$
$M_1$	$y_{11}$	$y_{12}$	...	$y_{1k}$
$M_2$	$y_{21}$	$y_{22}$	...	$y_{2k}$
$M_1$	$\beta_{11}$	$\beta_{12}$	...	$\beta_{1k}$
$M_2$	$\beta_{21}$	$\beta_{22}$	...	$\beta_{2k}$

( $S/N$ ) ratio of ( $M_1$ ), ( $S/N$ ) ratio of ( $M_1$ ), and ( $S/N$ ) ratio of the speed ratio method is:

$$\frac{S}{N_1} = -10 \log_k \left( \frac{1}{\beta_{11}^2} + \frac{1}{\beta_{12}^2} + \dots + \frac{1}{\beta_{1k}^2} \right);$$

$$S/N_2 = -10 \log_k \left( \beta_{11}^2 + \beta_{22}^2 + \dots + \beta_{2k}^2 \right), \quad (18)$$

$$S/N = S/N_1 + S/N_2. \quad (19)$$

Since the generic function of reactions is defined,  $B$  is estimated from the of  $M_1$  and  $M_2$  in Table 9:

$$\frac{S}{N_1} = -10 \log \frac{1}{10} \left( \frac{1}{\beta_{11}^2} + \frac{1}{\beta_{12}^2} + \dots + \frac{1}{\beta_{110}^2} \right) - 10 \log \frac{1}{10} \left( \frac{1}{0.275^2} + \frac{1}{0.0318^2} + \dots + \frac{1}{0.2477^2} \right) =$$

$$= -25.17 \text{ dB},$$

$$\frac{S}{N_2} = -10 \log \frac{1}{10} (\beta_{21}^2 + \beta_{22}^2 + \dots + \beta_{210}^2) = -10 \log \frac{1}{10} (0^2 + 0.0018^2 + \dots + 0.0086^2) =$$

$$= 42.57 \text{ dB},$$

$$S/N = S/N_1 + S/N_2 = -25.17 + 42.57 = 17.40 \text{ dB}.$$

The results obtained using the speed ratio method showed that this process has a good quality, due to all the positive values of the ratio ( $S/N$ ) = 17.40 dB.

Table 8: Estimates of proportional constant

	Time [h]									
	$T_1$	$T_2$	$T_3$	$T_4$	$T_5$	$T_6$	$T_7$	$T_8$	$T_9$	$T_{10}$
$M_1: \beta_1$	0.0275	0.0318	0.0803	0.1204	0.1731	0.2085	0.2237	0.2289	0.2342	2.4770
$M_1: \beta_2$	0.0000	0.0018	0.0033	0.0051	0.0086	0.0106	0.0107	0.0101	0.0093	0.0086

## CONCLUSIONS

In traditional engineering, only the quality of measuring instruments and the quality of completed processes (*PCI* precision and accuracy indices, *PPI*) can be successfully defined, while the quality of process results (semi-finished product, product, software, service) can only be described as good or poor quality/ better or worse quality). In modern consideration of quality, the quality of process

$$y = \beta T; y = \ln \frac{1}{p}; \beta = \frac{y}{T}; \quad (20)$$

The values of  $\beta$  estimated under  $M_1$  are larger-the-better, and the ones under  $M_2$  are smaller-the-better. Therefore, the larger-than-better ( $S/N_1$ ) ratio is calculated from the former  $\beta_1$  values, and the smaller-the-better ( $S/N$ ) ratio, ( $S/N_2$ ) ratio, is calculated from the latter  $\beta_2$  values. The ( $S/N$ ) ratio of the operating window using the speed ratio method is calculated by:

$$S/N = S/N_1 + S/N_2. \quad (21)$$

Table 8. shows the estimates of  $\beta_1$  (under  $M_1$ ) and  $\beta_1$  (under  $M_2$ ). From table ( $S/N_1$ ) and ( $S/N_2$ ) are calculated:

results is now defined by the number of decibels (dB), according to the discovery of Japanese scientist Genichi Taguchi, using the Robust Technology Development Method and Standard Ratio ( $S/N$ ).

The standard ( $S/N$ ) ratio (signal-to-noise ratio,  $S/N$ ) establishes the appropriate ratio of the values of input quantity ( $S$ ) and variability ( $N$ ), which Taguchi used for application in the communications industry, to check the quality of



sound waves. Starting from the fact that the radio receives a signal or a wave of voice that is broadcast from broadcast stations and converts it into sound, the voice is the input quantity (signal), and the received voice is the output signal (response). The input is mixed in space with the variability of the output signal (noise), so the sound quality is expressed by the ratio of the value of the input signal and the variability in decibels [dB]. This paper considers the application of four different types of evaluation of the quality of process results, with one input value and continuous characteristics.

After the performed calculations, the following results were achieved:

- in two classes with one type of error, the obtained results showed that these processes are not of good quality ( $S/N = -28.52$ ), due to all negative values ( $S/N$ ) of the relationship, but it is still a slightly better process with existing material, machine, and method, which is the least negative  $S/N = -9.54$ .
- in two classes with two types of errors, the obtained results showed that the separation of  $A_2$  is better than the separation of  $A_1$  due to the difference:  $A_2 - A_1 = -34.449 - (-41.981) = 7.532 \text{ dB}$ .
- in ( $S/N$ ) ratio of Chemical Reaction without Side Reactions, relationship ( $S/N$ ), and sensitivity assessment ( $S$ ) are:

$$S/N = 10 \log \frac{\frac{1}{2}(S_e - V_e)}{V_e};$$

$$\eta \Rightarrow 10 \log \frac{\beta^2}{\sigma^2};$$

$$S = 10 \log (S_\beta - V_e);$$

$$S \Rightarrow 10 \log \beta^2.$$

- in Reaction Speed ratio methods of Chemical Reaction with Side Reactions, the results obtained using the speed ratio method showed that this process has good quality, due to all the positive values of the ratio ( $S/N$ ) = 17.40 dB.

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## ATRIBUTIVAN KVALITET PROIZVODA U DECIBELIMA

Nažalost, tradicionalno inženjerstvo može uspešno definisati samo kvalitet mernih instrumenata i kvalitet završenih procesa, indeksima preciznosti i tačnosti *PCI* i *PPI*, a kvalitet rezultata procesa (poluproizvod, proizvod, dokumentacija, usluga) može samo opisati (dobar ili loš kvalitet, bolji ili lošiji kvalitet, itd.). U savremenom razmatranju kvalitet rezultata procesa se definiše brojem decibela (dB), prema otkriću genijalnog japanskog naučnika Genichi Taguchi (1924 - 2012), uz Robust Technology Development Method i sa standardnim odnosom S/N. Savremeno inženjerstvo razmatra kvalitete mernih instrumenata, završenih procesa i rezultata procesa prema njihovim kontinualnim i atributivnim karakteristikama kvaliteta. Naravno češće se razmatraju kontinualne karakteristike koje se mogu preciznije definisati jer se atributivne karakteristike mogu samo proceniti. U ovom radu se razmatraju četiri različita tipa kivaliteta rezultata procesa, s jednom atributivnom ulaznom promenljivom. Proračunom su postignuti su sledeći rezultati: kod dveju klasa sa jednom vrstom greške dobijen je loš kvalitet (– 28.52 dB), kod dveju klasa sa dve vrste grešaka dobijeno je da je odvajanje  $A_2$  bolje od  $A_1$  zbog razlika od 7.532 dB, kod hemijske reakcije bez nuspojave dobijeni su traženi rezultati i u metodama odnosa brzine hemijske reakcije sa sporednim reakcijama, dobijen je dobar kvalitet od 17.40 dB.

**Ključne reči:** Inženjering kvaliteta; Kvalitet rezultata procesa; Atributna karakteristika.

## THE IMPACT OF TECHNOLOGY AUDIT ON TECHNOLOGY CAPABILITIES IN PAKISTANI TRAINING INSTITUTES

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In recent times, there has been an increasing trend by organizations to focus on audits which help to find out their shortcomings and identify hidden opportunities. Technology audit is one significant example of audits being conducted in Pakistan. In this research, the benefits of the technology audit in the training institutes of Pakistan and its relationship with various technology capabilities are examined. The literature review developed a framework and revealed the positive and significant relationship of technology audit with specific technology capabilities. The top government sector organizations, such as WAPDA Engineering Academy, Faisalabad, and Regional Training Centre (Lahore & Faisalabad) were approached for responses to the questionnaire. For this study, a survey research methodology was adopted in the form of a questionnaire. 205 valid responses were used to analyse the data using Reliability analysis, Normality Tests, Correlation Matrix and Regression Analysis. The results revealed the potential benefits of technology audit, such as a better technology environment; improved knowledge about competitors; improved innovation; better quality and research; and improved technology creation, acquisition, exploitation, and protection. The tested and verified model filled to void in the literature of demonstrating the benefits of technology audit, and how this would allow the training institutes to identify the technical shortcomings in their organization leading to better technology capabilities. Moreover, as a practical contribution, macro and micro-level recommendations are made, supporting training institutes to improve overall organisation technology capabilities.

**Keywords:** Technology Audit; Quantitative Methods; Technology Capability.

### INTRODUCTION

Presently, it is an era where the competition in organizations is at its peak (Rashid et al., 2020). Organizations try to perform better than their competitors to get a competitive advantage. So, organizations use various strategies to be able to present themselves as unique. One of the key areas for growth is to identify and eradicate shortcomings. In this regard, auditing is an important practice that is helpful (Huang, 2019).

Audits identify the current status of an organization in any particular area (Naik & Saunshi, 2017). For example, The use of financial audits, to identify financial lackings, is common in organizations. However, to judge the technological

capacity of the organizations, a technology audit shall be used. Technology audit aids in identifying the strengths and weaknesses of an organization (Kovács & Stion, 2016). Moreover, it also helps to determine the position of an organization with respect to other organisations (mainly competitors). After conducting technology audits, proposals are developed that help to improve the technological capabilities of an organisation. These are mostly developed by consultants, from outside of the organisation, focusing on specific objectives. The most common goals are:

- To identify the position of the company's products and market to achieve growth with greater sustainability.
- To identify the areas in technology that need to be focused on.

- To solve general problems that require innovative solutions.
- To find out the means of transferring technologies.

In Pakistan, although, different types of audits such as quality audits, and financial audits are conducted, however, anecdotal evidence suggests that it is not common to perform technology audits, especially, in training institutes. The possible reason for this is the unawareness of the organizations about the technology audit and its potential advantages. Furthermore, the literature lacks any information on the potential benefits of technology audits in training institutes, and why is it worth investing in adopting them. Therefore, a need to explore the impact of technology audit in a firm, with regard to technological advancements is needed to be identified. This leads to our overarching research problem:

*“What is the role of technology audit performed in improving the technological capabilities of the organization”*

This research conducted a literature review to identify the previous studies, both theoretical and empirical, on the use of technology audit. This led to the development of a framework and associated hypotheses. Later, a quantitative analysis was conducted, leading to the discussion, and exploring the benefits of using a technology audit to improve an organization’s technological capabilities.

## LITERATURE REVIEW

In the past, technology has been defined in different ways and from different perspectives. For example, before 1930, technology was considered the study of industrial arts (Schatzberg, 2006). As technology advanced, it was defined as ‘the way we do things’ to help organizations achieve their objectives (Khalil, 2000). Arthur (2009) defined technology in a broader context as “a means to fulfill a human purpose” (Arthur, 2009). With regard to its impact on society, technology was viewed as an activity that impacts the overall organizational culture (Borgmann, 2006). Technology can significantly reduce the risk of failures (Bakator, Đorđević, Čoćkalo, Nikolić, & Vorkapić, 2018). Similarly, White and Bruton (2010) defined technology as:

*“It is the practical implementation of learning and knowledge by individuals and organizations to aid human endeavour”.*

### The Need for Technology Audit

Organizations have used different strategies, such as 5s tools, to improve the organizational business processes (Vorkapić, Čoćkalo, Đorđević, & Bešić, 2017). Technology strategy includes the policies, plans, and procedures for acquiring knowledge and managing technology by exploiting them for maximum organizational profit. For developing the technology strategy of the organization, the role of technology audit cannot be undermined (Hannafin, 2008).

Several researchers agree that technology assessment methodologies need to be improved (James et al., 2000, Tushman, 1995; Zou, 2002). However, the measurement of technology integration along with technology adoption is regarded as a difficult business (Balbinot, 2007; Hannafin, 2008).

As a subset of technology strategy, a technology audit is used to identify the strengths and weaknesses of the technological assets of the organization (Khalil, 2000). The technological capacity, procedures, and needs of an SME are investigated using a technology audit (Kelessidis, 2000). This allows the organisations to recognize their technology needs, explore technology trends and establish a detailed course of action by depicting the current status of the organization and its potential role in technology solutions to achieve its business goals (Report on relevant methods and examples of Technology Audit, 2013). The iterative process keeps the organization coherent with the latest technology trends (Khalil, 2000). It is important to mention that there is no universal standard to carry out a technology audit, however, there are some general guidelines that are usually followed. For example, Ford (1988) stated that the technology audit helps to identify

- The technologies on which the business depends.
- The position of the company compared to its competitors.
- The Life cycle position on which the company depends.
- The strength of the company (Either product or process).

- The company’s policy on protecting its technology.
- The emerging and developing technologies.
- The value of the company’s technology to its customers.
- The company’s systematic procedures for the optimal exploitation of technologies.
- The chances of sharing the technological assets of the organisations be shared with other organisations.
- The various factors that can positively or negatively affect the technological progress of the organisation.
- The new emerging technologies inside and outside the organisation.

### **Role of Technology Audit in Technology improvement**

The technology audit models are not generally applicable to all organisations but are designed to assess specific organisations that are in the interest of the authors (Štrukelj & Dolinšek, 2011).

Technology audit has been a topic of interest in the Higher education institutions of the United Kingdom for the last few decades. Questions, such as what is a technology audit? Are there any standard procedures for these techniques? What are the outcomes of the audit? etc. have been majorly addressed. The major opportunities identified by the technology audit were patents, software product development, research opportunities, media exposure, consultancy services, etc. Technology audits, especially, information technology audits have been found to reduce risks (Stoel & Havelka, 2021).

To find the outcomes of the technology audit in the education sector, Dr Margret Sheen conducted a survey at the University of Strathclyde with the aim to identify the linkages of the faculty of science and engineering with the outside industry (Sheen, 1998). The key areas of technology interests of the university, such as the importance of the need for digital communication between the departments of the University and the Industry, were identified. Similarly, Kirkland (1994) displayed that the technology assessment in a university can enhance university research. For example, in 1992, the department of state decided to carry out audits in about 40 of the top higher education institutions which provided a snapshot of the current standings of these institutions. The

results of the audit stated technology was not considered as the core area of interest by many institutes due to the possible distraction from teaching and research. Therefore, technology audit was considered a useful tool in terms of the exploitation of technology, however, should be practiced in conjunction with research and innovation.

In the health sector, Gerrard identified the positive impact of technology audit in identifying the current standings of veterinary practices in UK health (Gerrard & Little, 1994). For example, thermometers and stethoscopes were used as the basic diagnostic instruments, along with some more technologically advanced instruments, such as ophthalmoscopes and microscopes. Moreover, other than diagnostics, the technology also contributed to the areas of accounting, stock control, telecommunications, etc. As the veterinary is becoming increasingly specialized, the chances of more accurate diagnosis are increasing. Therefore, it was concluded that there is a potential relationship between the exploitation of new technologies and the organization's probability of reaching its maximum efficiency.

These researches indicated that the use of a technology audit helps to improve the organization ‘technologically. Furthermore, previous research has focused more on the need for auditing in terms of finances, rather than technology, in the training institutes (Mugo, 2013). This warrants a need to explore further benefits of the technology audit, especially on the training institutes, which has not been researched enough.

### **MODEL SPECIFICATION**

Although numerous work has been done to improve innovation still a large number of organizations fail to maintain and continue innovation (Cormican & O’Sullivan, 2004; Ahmed, 1998). Jakubavicius explained the relationship between the technology audit and innovation management (Jakubavičius & Vilys, 2008). Some of the innovation performance indicators were identified, as shown in Table 1, using which a questionnaire was developed and a survey was conducted to find a relationship between technology audit and innovation. The correlation analysis is shown in Table 1.



Table 1: Correlations of technology audit and innovation performance of the SME (Jakubavičius & Vilys, 2008)

Variable	Means	SD	Rate of product innovation	Rate of process innovation	Technology indicators	Overall benefit
Technology audit used	4.22	1.17	0.47	0.444	0.473	0.419

Strong positive relationships were found between technology audit and innovation. So, it was established that the technology audit plays a vital role in improving the innovation capabilities of the organization.

Similarly, in the development of the conceptual framework for this research, various other models and previous literature were used. A significant model, in this study, was the Garcia-Arreola TAM (Technology Audit Model), shown in Figure 1. Dolinšek et al. (2007) in their research paper on the

development of the ‘technology audit’, focused on the companies who were striving for the improvement in efficiencies and the effectiveness of their technical capabilities. The major focus of the research was the implementation of TAM (Technology Audit Model) which could be beneficial for organizations to improve their technology capabilities. Technology capabilities are known to be the major driver of the firm's performance (Wilden & Gudergan, 2015). This TAM was used as a principal model in developing our conceptual framework.

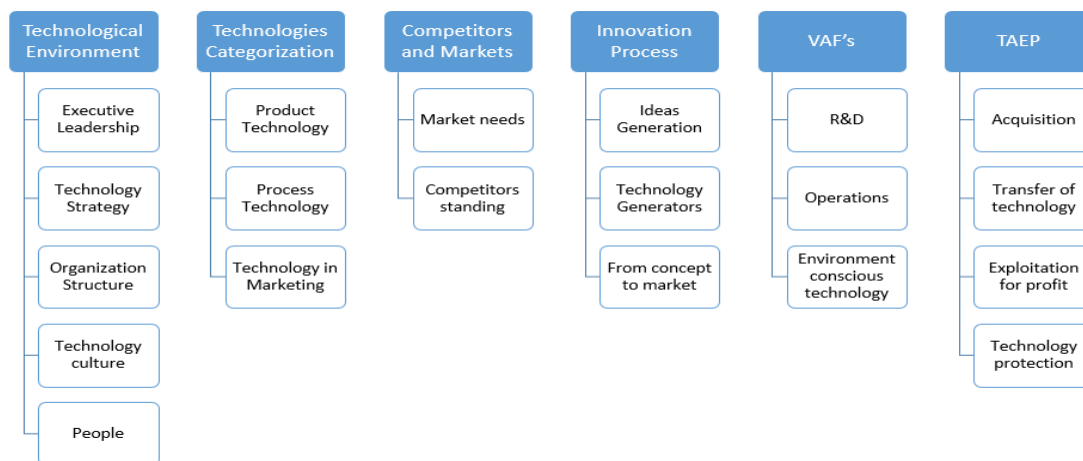


Figure 1: Technology Audit Model (TAM) Structure (Khalil, 2000)

This model identifies the major domains that Technology audit targets. These include Technological Environment, Technology Categorization, Competitors and Market, Innovation Process, Value-added functions (VAFs), Technology Acquisition, and Exploitation.

Similarly, a study on the technology audit with the case example in the School of Biological and Molecular Sciences BMS Oxford Polytechnic (Bell et al., 1992) was found relevant in the development of our conceptual framework. The technology audit was carried out to find opportunities in the institution. Mainly the opportunities were found in the areas of Research and Development, Technology Innovation, Collaboration with other institutes, Awareness about the changing trends and patents, and protecting technologies.

Furthermore, Dr Geoff Potter conducted a Technology audit at the Department of Chemistry at the University of Warwick (Bell et al., 1992). The potential benefits of technology audit found in his research consisted of Patents, Human Resource practices, and Organizational culture supporting technology.

Hannafin (2008) researched in the US regarding the technology audit in schools. The results of the audits found some of the findings of the technology audit. They found some improvements in the field regarding the implementation of new technology strategies, awareness about changing trends, technology innovation, acquisition, and exploitation.

The literature review in various educational/ training institutes showed some diversity in outcomes leading to the idea of a survey to see what might be of importance in a Pakistani training institute context. Further, the exact benefits of the technology audits need to be consolidated. From the TAM model and the work of authors, Figure 2 shows the significant areas that the technology audit can potentially impact, which are:

**Technological Environment:**

- Human Resource Practices,
- Implementing new technology strategies,
- Organizational culture supporting technology,
- Learning Organization.

**Knowledge about Competitors:**

- Competitors Assessment,

- Awareness about changing trends,
- Benchmarking.

**Innovation:**

- Technology Innovation,
- Ideas generation.

**Quality & Research:**

- Quality and standards,
- Research & Development,
- Analysing Progress.

**Technology Acquisition and Exploitation:**

- Creating acquiring and transferring technologies,
- Collaboration with other institutes,
- Exploiting current technologies,
- Patents and protecting technology.

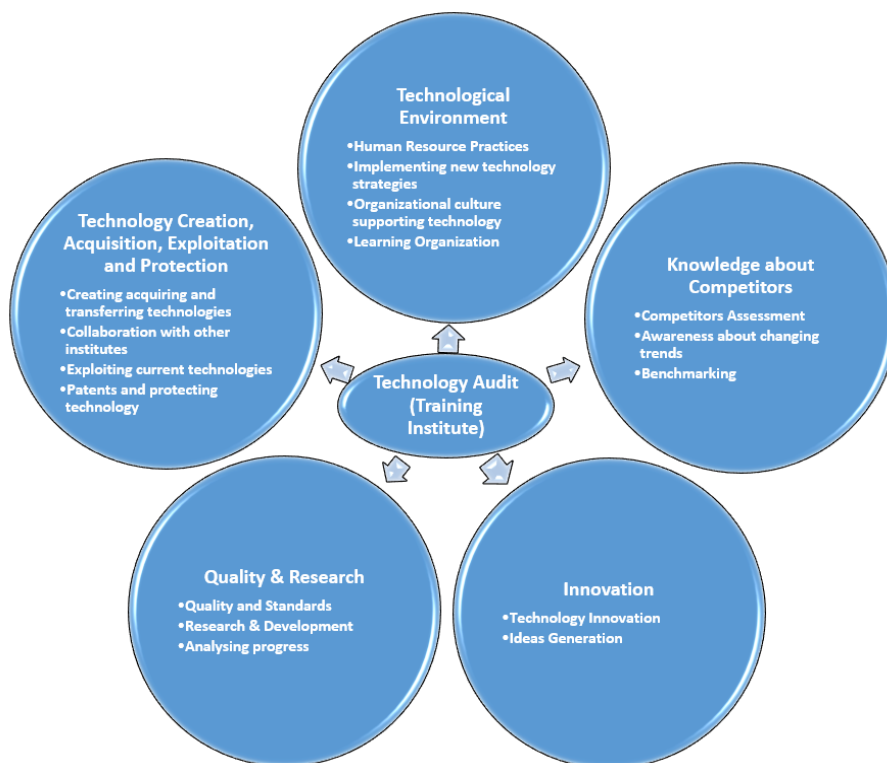


Figure Error! No text of specified style in document.: Relationship of Technology Audit with Variables

The Hypotheses developed from the model are:

- H1: Technology Audit has a positive and significant impact on the Technological Environment.
- H2: Technology audit has a positive and significant impact on knowledge about competitors.
- H3: Technology audit has a positive and significant impact on Innovation.
- H4: Technology audit has a positive and significant impact on Quality and Research.

H5: Technology audit has a positive and significant impact on Technology Creation, Acquisition, Exploitation, and Protection.

**METHODOLOGY AND DATA COLLECTION**

The research methodology was adopted from the book ‘The advanced research methods’ by Saunders et al. (2009). The positivism research philosophy was chosen for this research which means there is considered to have a single and

objective reality. In pursuance of this reality, a quantitative survey was used. Deductive research, which is used when already much of the work is done on the topic and further research is done to test the hypotheses, was chosen for this research.

Similarly, the purpose of research can be of three types; exploratory, explanatory, or descriptive (Saunders et al., 2009). Exploratory studies are conducted to find something new. Robson stated, “these studies are of great use to find out what is happening; to seek new insights; to ask questions and to assess phenomena in a new light” (Robson, 2002). Qualitative analysis and Inductive approach are examples of exploratory studies. Descriptive studies are referred to as “the studies which portray an accurate profile of a person, event or a phenomenon” (Robson, 2002). This is usually an extension of both explanatory and exploratory types of studies. In an explanatory study, we usually create a relationship between different types of variables. These studies usually create a relationship between different types of dependent and independent variables. For this research, an explanatory type of research was followed.

### Questionnaire

According to Saunders et al. (2006), there are three types of sources that can be used for the collection of data; primary, secondary, and tertiary. The primary data in this research was gathered from the questionnaires and secondary data from organizational reports etc.

The main use of questionnaire-based research is to test the hypotheses. The questionnaire, adapted from Garcia-Arreola TAM (Technology audit model), consisted of questions relating to technology audit and technology capabilities. Firstly, a pilot questionnaire was circulated to understand the ‘respondent fatigue and awareness’. 30 results were obtained. For this pilot study, Cronbach’s Alpha was 0.82 which is acceptable (Hair, 2018). A total of 17 five-point Likert scale questions, based on five categories, were used for this research survey and the options ranged from strongly agree to strongly disagree.

Questions were formulated in such a way as to gather adequate information. Full efforts were made to remove the participant and the observer errors and minimise the bias error.

### Sampling Technique

Purposive sampling was used for the data collection. In this technique, the respondents are selected based on certain qualities they possess (Etikan et al., 2016). In this case, the required quality of the respondent was adequate knowledge and understanding of the recently adopted technologies by their organization. A total of 281 questionnaires were distributed in three institutions. Some questionnaires were filled on the spot and most of them were handed over to the administration. A total of 208 questionnaires were gathered from the institutions. Their details have been mentioned in Table 2. Out of these, 3 were unfilled and incomplete, leaving 205 valid responses. So the overall response rate was 72.9%.

Table 2: Information of respondents

Age				
	Frequency	Percent	Valid Percent	Cumulative Percent
18-25	22	10.7	10.7	10.7
26-35	83	40.5	40.5	51.2
36-60	100	48.8	48.8	100.0
Total	205	100.0	100.0	
Qualification				
	Frequency	Percent	Valid Percent	Cumulative Percent
Under Graduate	50	24.4	24.4	24.4
Graduate	117	57.1	57.1	81.5
Postgraduate	35	17.1	17.1	98.5
PhD	3	1.5	1.5	100.0
Total	205	100.0	100.0	

### DATA ANALYSIS AND RESULTS

#### Reliability, Validity, and Normality

Firstly, it is important to conduct the reliability test of the questionnaire, after which further analysis can be done. A reliability of 0.7 and above is considered very good (Hair, 2018). The reliability that has been calculated for each variable separately has been above 0.6 which is an acceptable range. So based on these results, the questionnaire has been proven to be fit to carry out further analysis, as shown in Table 3.

The questionnaire has been adapted from a validated model published in a book by Khalil (2000). Further, it has been validated by industrial experts and academic professors. They have done the content validity and face validity of the

questionnaire and declared the questionnaire valid for this research.

Table 3: Reliability Tests

Technology Audit	
Cronbach's Alpha	N of Items
.760	3
Technological Environment	
Cronbach's Alpha	N of Items
.770	4
Knowledge about competitors	
Cronbach's Alpha	N of Items
.744	3
Innovation	
Cronbach's Alpha	N of Items
.660	2
Quality and Research	
Cronbach's Alpha	N of Items
.635	3
Technology Creation, Acquisition, Exploitation and Protection	
Cronbach's Alpha	N of Items
.759	4

For the best results of the statistical analysis, one must be sure about the distribution of data. If the

data distribution is close to normal, the results will be accurate. Once the normality of the data is tested, one can now select the statistical tools for this type of data. Therefore checking the normality of the data is considered a vital part of the research to obtain accurate results. The skewness and kurtosis method is usually used to check the normality of the data. The accepted range of skewness is taken from -1 to +1 and kurtosis is taken from -2 to +2 (George & Mallery, 2010). The normality test of our data for individual variables was carried out and all the data was found within the prescribed limits of normality.

The correlation analysis of the variables, as shown in Table 4, was conducted, as shown in Table 3. It is observed that the technology audit has the strongest correlation with 'Technology creation, acquisition, and exploitation' while the weakest relationship is with 'knowledge about competitors'. This will be further discussed in regression analysis for testing individual hypotheses.

A regression test for each of the hypotheses was conducted and the results were displayed.

Table 4: Correlations Analysis

	TA	TE	KAC	I	QR	TCAEP
Technology Audit (TA)	--					
Technological Environment (TE)	0.513**	--				
Knowledge about Competitors (KAC)	0.381**	.970**	--			
Innovation (I)	0.501**	.855**	.799**	--		
Quality and Research (QR)	0.446**	.958**	.923**	.849**	--	
Technology Creation Acquisition, Exploitation and protection (TCAEP)	0.586**	.991**	.959**	.858**	.952**	--

**H1: Technology Audit has a positive and significant impact on Technological Environment**

For testing the hypothesis, a regression is measured between the dependent and independent variables. Technology audit is the independent variable while the Technological Environment is the dependent variable.

In regression analysis (Table 5), the value of R (0.513) shows a strong relationship between technology audit and the technological environment. R square value (0.263) shows that

26.3% variance in the dependent variable is due to the technology audit.

As shown in Table 6, for every unit increase in technology audit, there is a 0.482 increase in the Technological environment. The sig value is less than 0.05 which shows that the independent variable rightly predicts the dependent variable.

Hence, Technology audit has a positive and significant impact on the technological environment.

**H2: Technology audit has a positive and significant impact on knowledge about competitors**

For testing the hypothesis, a regression is measured between the dependent and independent variables. Technology audit is regarded as the independent variable while Knowledge about competitors is regarded as the dependent variable.

In the case of regression analysis (Table 7), the value of R (0.381) shows a strong relationship between technology audit and ‘knowledge about

competitors’. R square value (0.145) shows that a 14.5% variance in the dependent variable is due to the technology audit.

As shown in Table 8, for every unit increase in technology audit, there is a 0.392 increase in ‘Knowledge about competitors’. The sig value is less than 0.05 which shows that the independent variable rightly predicts the dependent variable.

Hence, Technology audit has a positive and significant impact on ‘Knowledge about competitors’.

Table 5: Regression model summary - Technological Environment

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.513a	.263	.259	.60055

a. Predictors: (Constant), Technology Audit

Table 6: Coefficients Summary- Technology Audit Vs Technological Environment

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.366	.145		9.454	.000
	Technology Audit	.482	.057	.513	8.514	.000

a. Dependent Variable: Technological environment

Table 7: Regression model summary- Knowledge about competitors

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.381a	.145	.141	.70984

a. Predictors: (Constant), Technology Audit

Table 8: Coefficients Summary- Technology Audit Vs Knowledge about competitors

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.636	.171		9.579	.000
	Technology Audit	.392	.067	.381	5.865	.000

a. Dependent Variable: Knowledge about competitors

**H3: Technology audit has a positive and significant impact on innovation**

For testing the hypothesis, a regression is measured between the dependent and independent variables. Technology audit is regarded as the independent variable while Innovation is regarded as the dependent variable.

In the case of regression analysis (Table 9), the value of R (0.501) shows a strong relationship between technology audit and ‘Innovation’. R square value (0.251) shows that 25.1% variance in the dependent variable is due to the technology audit.

As shown in Table 10, for every unit increase in technology audit, there is a 0.464 increase in Innovation. The sig value is less than 0.05 which



shows that the independent variable rightly predicts the dependent variable.

Hence, Technology audit has a positive and significant impact on innovation

**H4: Technology audit has a positive and significant impact on Quality and Research**

For testing the hypothesis, a regression is measured between the dependent and independent variables. Technology audit is regarded as the independent variable while ‘Quality and Research’ is regarded as the dependent variable.

In the case of regression analysis (Table 11), the value of R (0.446) shows a strong relationship between technology audit and ‘knowledge about competitors’. R square value (0.199) shows that 19.9% variance in the dependent variable is due to the technology audit.

As shown in Table 12, for every unit increase in technology audit, there is a 0.405 increase in ‘Quality and Research’. The sig value is less than 0.05 which shows that the independent variable rightly predicts the dependent variable.

Hence, Technology audit has a positive and significant impact on ‘Quality and Research’.

Table 9: Regression model summary- Innovation

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.501a	.251	.248	.59622

a. Predictors: (Constant), Technology Audit

Table 10: Coefficients Summary- Technology Audit Vs Innovation

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.342	.143		9.355	.000
	Technology Audit	.464	.056	.501	8.254	.000

a. Dependent Variable: Innovation

Table 11: Regression model summary: Quality and Research

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.446a	.199	.195	.60545

a. Predictors: (Constant), Technology Audit

Table 12: Coefficients Summary- Technology Audit and Quality and Research

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.539	.146		10.564	.000
	Technology Audit	.405	.057	.446	7.094	.000

a. Dependent Variable: Quality and research

**H5: Technology audit has a positive and significant impact on Technology Creation, Acquisition, Exploitation, and Protection**

For testing the hypothesis, a regression is measured between the dependent and independent variables. Technology audit is regarded as the independent variable while ‘Creation, Acquisition, Exploitation

and Protection’ is regarded as the dependent variable.

In the case of regression analysis (Table 13), the value of R (0.586) shows a strong relationship between technology audit and ‘knowledge about competitors’. R square value (0.344) shows that

34.4% variance in the dependent variable is due to the technology audit.

As shown in Table 14 every unit increase in technology audit, there is a 0.554 increase in Technology creation, acquisition, exploitation, and protection. The sig value is less than 0.05 which

shows that the independent variable rightly predicts the dependent variable.

Hence, the Technology audit has a positive and significant impact on ‘Technology Creation, Acquisition, Exploitation, and Protection’.

The final framework, showing the relationship of variables, is shown in Figure 3.

Table 13: Regression model summary- Technology Creation, Acquisition, Exploitation, and Protection

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.586a	.344	.341	.56982
a. Predictors: (Constant), Technology Audit				

Table 14: Coefficients Summary-Technology Audit and Technology Creation, Acquisition, Exploitation, and Protection

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.211	.137		8.831	.000
	Technology Audit	.554	.054	.586		
a. Dependent Variable: Technology Creation, Acquisition, Exploitation, and Protection						

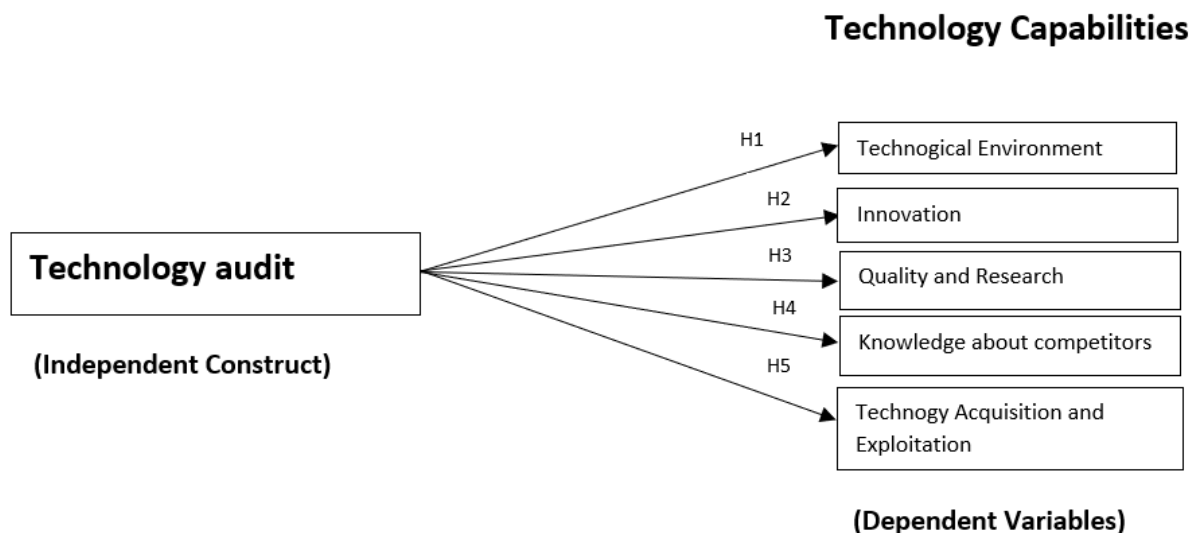


Figure 3: Relationship between technology audit and technology capabilities

**DISCUSSION AND FINDINGS**

The results revealed a strong association between the technology environment and the parameters of the technology capabilities of an organization. For example, the first hypothesis revealed that technology audit has a close association with the technology environment. In support of this, (Bross, 1999) asserted that the technology audit helps in

developing new technology strategies, which in return helps to create the overall technology environment in the organization. Further, the second hypothesis was partially supported showing a low variance caused in the dependent variable of ‘knowledge about competitors’. Bross (1999) stated that technology audit has the potential to improve the competitiveness of an organization in the industry, without any empirical reference.

Similarly, the third hypothesis demonstrated that the introduction to technology audit can enhance innovation practices in the organization. This was supported by, Gordon and Tarafdar (2010), who claimed that an audit, specifically an Information technology audit, can boost innovation in different industries and on different levels. This would result in an overall improvement in organizational performance, as implied by Adegbesan and Ricart (2007). Similarly, the fourth hypothesis was supported by different audits in other sectors, such as clinical audits in the medical sector that can improve the overall quality of clinical care in the hospitals (Siddiqi et al., 2008). The testing of the final hypothesis revealed that the technology audit can lead to better creation, acquisition, and exploitation of technology. Akbar and Suraida (2017) stated that technology audits will not work if the workers rely on their competence. Therefore, employees need to follow and acquire new technologies rather than just relying on their skills. This can lead to better technology exploitation. However, some literature states that technology adoption does not necessarily lead to technology creation (Liu et al., 2017). This warrants a need to be explored further.

Overall, it can be seen that the technology audit has the strongest association with technology acquisition, creation, and exploitation, while the weakest (although significant) association is the knowledge about competitors. This shows that technology audit leads to new ideas and innovation, which further leads to the better acquisition and creation of technology, while, it does not necessarily enhance the knowledge about the competitors, as it is also dependent on gathering audit results of competitors.

## RECOMMENDATIONS AND CONTRIBUTION

The training institutes in Pakistan are making an effort to improve their standards and be transformed into better institutions in terms of technology, however, still, a lot of factors are acting as constraints. For example, lack of knowledge about the latest techniques, poor organizational culture, and lack of commitment are some of the general factors which hamper the growth of these institutions. Based on our research, there are a few recommendations at both the macro

as well as micro-level, to improve the technological capabilities of the organizations.

### Recommendations at National Level (Macro Level)

A few recommendations at the Macro level are:

- A national-level technology policy should be made to make Pakistan in line with the top technology-oriented countries. The policy-making panel should include highly expert professionals from various fields to formulate efficient and effective policies for technology growth. Further, the new areas in technology, such as digital technologies, should also be addressed and explored.
- The funding for the technology sector must increase substantially by some top technology-rich countries.
- Efficient steps regarding secrecy and protection of technology must be taken by the government to encourage the development of technology.
- Extra incentives must be awarded to the people involved in the government institutions which work for the development of technology.

### Recommendations at Institutional Level (Micro Level)

- The institutions must be educated about the advantages of efficient technology audit and their role in technology growth. If the institutions are already practising technology audit, then it must be assessed as per standard technology audit models.
- The institutions must create a technology environment that would transform the overall organizational culture into a technology culture.
- The institutions must benchmark themselves with other top training institutes of the country as well as of other developed countries. This will help the training institutes to adopt good policies to cover up the shortcomings.
- The institutions must be aware of the changing trends in technology locally as well as globally. This will make these institutions assess where they are currently standing and what target they should achieve.
- Innovation in terms of technology must be promoted and the employees must be encouraged to float the ideas regardless of their position in the organization. This will encourage the growth of technology in these organizations.

- Research and Development play a vital role in the progress of any organization. Proper attention and funds must be allocated to these areas and special incentives must be given to the employees which are associated with this sector.
- The current technologies which are present in the organizations must be fully exploited and utilized. The creation of technology must be encouraged and in case of failure, proper technology acquisition measures must be taken.
- Protection of technology through patents must be done in the training institutes. Such practices will reward innovation and the creation of technology and will be a symbol of motivation.

Although the practice of technology audit is relatively common in the developed world, however, in Pakistan, it is not given much importance. This research would create awareness among organizations about the use of technology audit and their use as effective tools for enhancing the technological capabilities of the organizations (both in terms of teaching to trainees as well as using technology tools). Although this research was conducted in training institutes, the impact should not be restricted to this context and should be followed for any type of technology organization. The researchers who are researching in the field of technology could also from this research. They would understand that technology audits can play a significant role in the identification of hurdles in technology advancement. Moreover, the tested model may be applied to different types of organizations.

## CONCLUSIONS

In the current global environment, organizations are adopting technology and becoming digitized at an exponential rate. In this era of technological growth, the standard of an organization can be judged by the type of technology it incorporates. Similarly, all the standard training institutions of Pakistan are striving hard to match up with the pace of rapidly changing technology and take a lead in comparison to others. In an attempt to answer the overarching research question, this research highlighted the importance of using technology audits in the organization. The positive relationship of technology audit with the technology environment, knowledge about competitors, innovations, quality, and research, and technology creation, acquisition, exploitation,

and protection was conceptualized, tested, and verified. This research established that the technology audit has immense benefits starting from the acquisition of technology to become more innovative and developing better strategies. As for recommendations to the training institutes, indulging in the practice of regular technology audits can ultimately lead to better performance outcomes for the organizations.

This research is limited and restricted to the context of one country, i.e. Pakistan. Further, only the training institutes are considered for this research. As a future recommendation, similar research can be conducted in other countries and use this research according to their environment. Moreover, the comparison of the public sector and private sector institutes in various technological environments, using specific technologies, such as digital technologies are proposed for future researchers. Finally, the research canvass can be expanded to other sectors, such as construction and information technology.

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## UTICAJ TEHNOLOŠKE REVIZIJE NA TEHNOLOŠKE SPOSOBNOSTI U PAKISTANSKIM INSTITUTIMA ZA OBUKU

U poslednje vreme, sve je veći trend organizacija da se fokusiraju na revizije koje pomažu da se otkriju njihovi nedostaci i identifikuju skrivene šanse. Tehnološka revizija predstavlja značajan primer revizija koje se sprovode u Pakistanu. U ovom istraživanju se ispituju prednosti tehnološke revizije u institutima za obuku u Pakistanu i odnosi sa različitim tehnološkim mogućnostima. Kroz pregled literature razvio se okvir i otkrio se pozitivan i značajan odnos revizije tehnologije sa specifičnim tehnološkim mogućnostima. Za popunjavanje upitnika obraćeno najvećim organizacijama iz vladinog sektora, kao što su WAPDA Inženjerska akademija, Faisalabad i Regionalni centar za obuku (Lahore & Faisalabad). Za ovu studiju usvojena je metodologija anketnog istraživanja. Ukupno 205 validnih odgovora je korišćeno za analizu podataka korišćenjem analize pouzdanosti, testova normalnosti, korelacione matrice i regresione analize. Rezultati su otkrili potencijalne prednosti tehnološke revizije, kao što je bolje tehnološko okruženje; poboljšano znanje o konkurentima; poboljšane inovacije; bolji kvalitet i istraživanje; i poboljšano stvaranje, nabavka, eksploatacija i zaštita tehnologije. Testirani i verifikovani model doprinosi literaturi koja pokazuje prednosti tehnološke revizije i kako bi to omogućilo institutima za obuku da identifikuju tehničke nedostatke u svojoj organizaciji koji vode ka boljim tehnološkim mogućnostima. Štaviše, kao praktičan doprinos, date su preporuke na makro i mikro nivou, koje podržavaju institute za obuku da poboljšaju sveukupne tehnološke sposobnosti organizacije.

**Ključne reči:** Tehnološka revizija; Kvantitativne metode; Tehnološka sposobnost.



## EFFECTS OF GENDER, AGE, AND EDUCATION ON ENTREPRENEURIAL ORIENTATION AND INTENTIONS AMONG FREELANCERS

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Original Scientific Paper

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**The topic of this paper are the values of the individual entrepreneurial orientation and the Theory of planned behavior dimensions, among freelancers in the Western Balkan countries (Bosnia and Herzegovina, Croatia, Montenegro, and Serbia). The effects of four control variables: gender, age, education level, and previous entrepreneurial experience were also examined. Freelancers best perceive support for an entrepreneurial venture as well as their proactivity. Entrepreneurial intentions were assessed as the worst. The greatest impact on the observed dimensions occurs in the division of the sample into freelancers who have/do not have previous experience in entrepreneurship. As for the other control variables, statistically significant differences occur in only three other cases: dimensions RT - Risk-taking and PBC - Perceived behavioral control on the side of male freelancers, and dimension IN - Innovativeness on the side of younger freelancers. A comparison was made with a similar study, where the respondents were conventional employees. In general, freelancers have greater entrepreneurial intentions than conventional employees. Freelancers are more consistent in terms of entrepreneurial intentions: there are no differences in these intentions if the sample is divided according to the gender and age of freelancers. These results are discussed in the paper.**

**Keywords:** Individual entrepreneurial orientation; Theory of planned behavior; Entrepreneurial intention; Freelancers; West Balkan.

### INTRODUCTION

Industry 5.0 is characterized as an era of entrepreneurship where everyone's talent has room for success. The time of smart robots, autonomous cars, supercomputers, and the development of nanotechnology has enabled great opportunities for everyone to learn and progress. The amount of information and their intensive exchange enables the rapid development of the economy and innovation, both in the sphere of production and

services. It is this dynamism that has led to the emergence of freelancers, as a hybrid employee model. Freelancers are seen as employed because they are hired on a part-time basis to do work as conventional employee, however, they do work at their own risk and without organizational support (Born & Witteloostuijn, 2013). Freelancers are often very successful in their work, highly skilled, and earn more than their conventionally employed colleagues (Burke, 2015). As these workers are most often physically distanced from their

employers, the only way to get a job is to show their knowledge, and experience and build a good reputation based on their work. According to Boohenhold and Klinglmair (2016), freelancers, as self-employed people, are generally just waiting for a favorable market opportunity to become entrepreneurs. This could be of great importance for the Western Balkans, where, according to StartIt (2019), Serbia, Northern Macedonia, and Bosnia and Herzegovina are at the very top in the number of freelancers worldwide. This shows the existence of a large number of educated and digitally literate people in this region, as well as the fact that these people are ready to learn, adapt to the market, and compete for jobs with people from all over the world. Of course, the high unemployment rate should not be neglected here, so the population is turning to the Internet as an opportunity to earn money, but that does not diminish the importance of these workers and their capacity to improve the economy of the region.

Entrepreneurship is very important for stimulating economic growth, and without new jobs, it is impossible to imagine innovation, because new companies modernize the market and with their competitiveness encourage competition to progress. According to Liang et al. (2018), entrepreneurial skills are in a kind of paradoxical relationship, because with age, creativity, and willingness to take risks and adapt to change decline, and in youth lack the experience, resources, and networking to successfully start a business. Of course, this relationship depends a lot on the type of entrepreneurship that an individual starts. When it comes to freelancers, they are mostly young people with a lot of creativity and knowledge, however, they lack experience and connection with colleagues. It is digital entrepreneurship that transforms traditional forms of business by creating new businesses and innovations (Sahut et al., 2019) and enables the progress and economic growth of a country. The same authors state that the gender gap in digital entrepreneurship is significantly smaller compared to traditional types of entrepreneurship, and such findings can be very important for developing economies, as they enable equal inclusion of women in the labor force. When the positive impact of higher education on entrepreneurship is taken into account (Paray & Kumar, 2020), there is a favorable climate for the creation of successful entrepreneurs.

Entrepreneurship among freelancers has been attracting the attention of authors only in the last few years since as a form of business it enables a desirable work-life balance (Anninke et al., 2016). Freelancers are often highly educated and highly skilled individuals looking for suitable opportunities to become entrepreneurs (Bogenhold & Klinglmair, 2016). The new economy is characterized by fin-tech ecosystems of start-ups such as capital markets, insurance, wealth management, innovative payment, and similar (Lee & Shin, 2018). These are very innovative businesses in which a large number of employees are young freelancers (Damian & Manea, 2019). Young, self-motivated, and result-driven freelancers can be a powerful driver of a developing economy precisely because of their exposure to a global dynamic market, and they can be of great importance for a country's economic growth.

This paper examines the level of entrepreneurial intentions of digital freelancers in the Western Balkans (Bosnia and Herzegovina, Croatia, Montenegro, and Serbia), through control variables of gender, age, education, and previous entrepreneurial experience. There is a lack of such research in the Western Balkans region, which is a theoretical contribution of this paper. The practical contribution of this paper is reflected in the guidelines that can be of great importance in formulating the legal framework in which freelancers operate in these countries due to the difficulties that prevent the smooth development of this hybrid mode of operation. Freelancers can be of great importance to the economy, and it is important to make their work easier as they can contribute to the great development of entrepreneurship and innovation.

## **THEORY AND HYPOTHESES**

### **Gender and entrepreneurial orientation and intentions**

Having entrepreneurial thinking and intentions, as well as the potential to create value in an environment and conditions, may depend on that environment and the conditions in which the individual finds himself. Certain characteristics of a person can have an impact on the decisions he makes, so people who are risk-taking, bold, and ambitious may have more pronounced entrepreneurial intentions (Ahl, 2006). These traits are most commonly considered masculine traits.

This narrative has also become a stereotype in some cultures, and the syntax "successful entrepreneur" is almost exclusively related to men (Quang Hung & The Tuan, 2020). Also, according to (Hanson, 2009), men and women do not have the same approach or results in entrepreneurial projects. According to Wagner and Sternberg (2004), women have a more pronounced fear of failure than men, and this may lead to women being less likely to choose to be entrepreneurs because they take fewer risks. Jena (2020) states that business management students do not show any difference in entrepreneurial attitudes and intentions depending on gender, which is very important. This may also depend on the culture to which the population belongs, so women can be expected to take on certain roles, which are not necessarily in line with entrepreneurship, as may be the case in the Western Balkans where women are still expected to play traditional roles, like the one who take care of the children and the home.

Entrepreneurship ecosystems include a large number of interconnected elements that often strengthen each other but also make a condition of growth and progress (Kantis and Federico, 2012). In the case of women, Brush and Green (2016) show that environments in which there is economic and infrastructural support for childcare have a positive impact on the development of entrepreneurship among women. A positive impact has also been observed in environments where women are equal to men in the labor force, pay equality, and where there is equality in managerial positions and family support (Thebaud, 2015). Women often have fewer opportunities for self-employment (Verheul et al., 2012) in the conventional sense. However, this gender gap in entrepreneurship has already been established (Guzman & Kacperczyk, 2019), with most research relating to entrepreneurship in the conventional sense. Few studies show this relationship in the digital industry. As entrepreneurship is a set of steps within the process, it is necessary to determine whether the unequal sex is so pronounced and when the environment has changed, ie completely digital.

### **Age and entrepreneurial orientation and intentions**

Testing age-productivity patterns is not a novelty in science and such research exists, and in recent years it has been particularly pronounced due to plenty of research in the field of economics. Thus,

Liang et al. (2018) point out that certain characteristics of a successful entrepreneur clearly decline with the aging of the individual, primarily because of logical thinking and reasoning. Also, creativity, the ability to remember and process information, as well as adapt to new situations and solve problems are on the side of young people (Acemoglu et al. 2014). Of course, these features, or their lack, are not the solution to the success or failure of entrepreneurship. A successful business venture requires skills and knowledge gained through work experience and interaction with other professionals. Also, a developed network of associates is something that is very important in business, because it provides access to various resources, and it is something that is developed and acquired over the years. This leads to a paradox, where young people have neither adequate work experience nor a social network, and older people have reduced creativity, logical thinking, and the power to adapt. This speaks about the diversity of entrepreneurship because different generations, due to a different view of the world, create entrepreneurial ventures in different ways. Willpower and entrepreneurial intent diminish as an individual ages, and the opportunity to start a business grows with business experience and the accumulation of other resources (Lee & Vouchilas, 2016).

Pierre et al. (2020), find that age is one of the key factors in the success of an entrepreneurial venture and show that business success is on the side of the elderly. Although young people have various advantages, especially in terms of energy and originality, this is simply not enough because the resources are on the side of the elderly. In addition to the desire for independence and self-employment, ie entrepreneurship, it is necessary to create certain opportunities and conditions for that. It is the absence of such opportunities that prevents young people from starting their own businesses, that is, the existence of opportunities enables older people to successfully realize their entrepreneurial endeavors (Quang Hung & The Tuan, 2020). The same authors confirm the trend that the number of successful entrepreneurs is in the middle-aged and elderly population. There is a need to examine whether these rules also apply to digital workers, given that these workers are mostly young people, that this branch of industry is very dynamic and prone to change, and, at the same time, from a successful entrepreneur expects to be able to send changes and adapt to them, which is a characteristic of young people.

## Education and entrepreneurial orientation and intentions

Entrepreneurship education differs from the usual training of employees because, in addition to knowledge, the entrepreneur must be able to manage all business processes and their final results. The European Commission has developed the Entrepreneurship Action Plan 2020, which is based on the following strategies: development of entrepreneurship education, creating a favorable business environment, modeling, and involving specific groups (European Commission, 2013). This shows how influential education is in the development of entrepreneurship. According to Bae et al. (2014), students who are exposed to proactive models in education through business planning and interaction with successful entrepreneurs, show greater motivation and interest in entrepreneurial projects which can lead to greater chances for success and efficiency. Boldureanu et al. (2020) show that it is the interaction between students and successful entrepreneurs that can positively influence their desire to start a business and increase their entrepreneurial intentions. This is also confirmed by Hatten and Ruhland (1995), who find that students are much more likely to become entrepreneurs if they attend an entrepreneurship-related program.

According to Nowiński et al. (2017), the link between education and entrepreneurial intentions has not been sufficiently explored, especially in Central and Eastern European countries. Their research conducted in the Czech Republic, Hungary, Poland, and Slovakia finds that education greatly contributes to increasing entrepreneurial intentions, especially helping to reduce the gender gap, and women who are highly educated do not lag behind entrepreneurial intentions compared to their male peers. Quality education enables both development of learning skills, and the exchange of information and experiences, and at the same time inspires students to be successful people. According to Hanayati et al. (2020), vocational students show strong links between their education and entrepreneurial intentions, and the authors particularly emphasize the importance of teacher involvement and activities such as entrepreneurial seminars, internal training, and courses. This complex education enables the development of a different view of the world, the development of social skills, and the exchange of knowledge, and

all of the above is very important for the development of successful businesspeople and entrepreneurs. These impacts have not yet been sufficiently explored in the Western Balkans, especially among digital workers and freelancers, and this population is particularly focused on constant learning and improvement.

## Freelancers and entrepreneurial orientation and intentions

Dynamic and agile economies are characterized by a successful business sector that is entrepreneurial and free of bureaucratic processes and very flexible (Burke & Cowling, 2020). Freelancers, as self-employed individuals, are just contributing to this business spirit. Freelancers are often described as an underperforming version of entrepreneurs (Damian, Empoli, 2021), but the same authors state that they are the ones who quickly accept changes and are ready to improve and adapt to changes in the market. As the work of freelancers is already turned towards a high level of independence, both in the financial and in the sphere of managing their own time, their entrepreneurial intentions are motivated mainly by money (Wach et al., 2016). The strong influence of personality traits among freelancers in building startups has also been noticed (Shi, 2019).

Digital freelance workers are often very successful in entrepreneurial ventures because they are exposed to innovation (Damian & Manea, 2019) and have the ability to react quickly to entrepreneurial opportunities and fill the market gap. The influence of self-motivation and discipline, which are expressed by freelancers, is certainly important here because they are not exposed to the conventional hierarchy and control of management but perform their work duties without external influences. Freelancers have transformed developed economies as highly educated self-employed individuals, who successfully create added value and play a key role in creating innovation and new jobs as well as expanding entrepreneurship (Burke & Cowling, 2020). Among IT freelancers, more pronounced entrepreneurial intentions were noticed (Sultana et al., 2018). However, these relations are unexplored in the Western Balkans.

Based on the previous considerations, the paper sets out four hypotheses:

H1: There is a statistically significant difference in the average scores of individual entrepre-



neurial orientations, Theory of planned behavior, and entrepreneurial intention dimensions, for male and female freelancers.

- H2: There is a statistically significant difference in the average scores of individual entrepreneurial orientation, Theory of planned behavior, and entrepreneurial intention dimensions, for young and old freelancers.
- H3: There is a statistically significant difference in the average scores of individual entrepreneurial orientation, Theory of planned behavior, and entrepreneurial intention dimensions, for high school and faculty freelancers.
- H4: There is a statistically significant difference in the average scores of individual entrepreneurial orientation, Theory of planned behavior, and entrepreneurial intention dimensions, for freelancers who have and have no previous experience in entrepreneurship.

## METHOD

### Survey instruments (measures)

The Individual Entrepreneurial Orientation (IEO) questionnaire was used to measure individual entrepreneurial orientation (Bolton & Lane, 2012). This questionnaire has 3 dimensions and 10 items. The dimensions are 1. Risk-taking, 2. Innovativeness, and 3. Proactiveness.

The Theory of Planned Behavior dimensions and entrepreneurial intentions were measured using the Entrepreneurial Intention Questionnaire (EIQ) (Liñán & Chen, 2009). This questionnaire has 4 dimensions and 20 items. The dimensions are 1. Personal attitude, 2. Subjective norm, 3. Perceived behavioral control, and 4. Entrepreneurial intention.

In both questionnaires, respondents used a seven-point Likert scale for evaluation.

## Participants and data collection

The survey was conducted in the Western Balkans (Bosnia and Herzegovina, Croatia, Montenegro, and Serbia) among freelancers living and working in these countries. The questionnaires were filled out through the Google Forms platform where a total of 318 valid questionnaires were collected. The sample consisted of 204 female (64.2%) and 114 male freelancers (35.8%) of which 211 were young (up to 35 years of age, 66.4%) and 107 old freelancers (over 35 years of age, 33.6%). The total sample consists of 78 high school educated (24.5%) and 240 university-educated freelancers (75.5%), of which 136 have previous experience in entrepreneurship (42.8%), while 182 freelancers do not have this experience (57.2%).

## RESULTS

### Descriptive statistics

Descriptive statistics for the dimensions of individual entrepreneurial orientation, Theory of planned behavior, and entrepreneurial intention, are shown in Table 1. Cronbach's alpha values range from  $\alpha = 0.774$  to  $\alpha = 0.955$ .

### T-test

A t-test was used to compare average scores of individual entrepreneurial orientation, Theory of planned behavior, and entrepreneurial intention dimensions. The analysis was performed according to three variables: gender, age, and education of freelancers, so the results of these analyzes are presented in three tables (Table 2, Table 3, and Table 4). The results with a statistically significant difference in the mean scores of the observed dimensions are shown in bold font and shaded fields.

Table 1 Descriptive statistics

Names of dimensions	Abbr.	N	Min	Max	Mean	Std. Deviation	$\alpha$
Risk-taking	RT	318	1.000	7.000	4.60901	1.523675	0.839
Innovativeness	IN	318	1.000	7.000	5.04874	1.349576	0.877
Proactiveness	PR	318	1.000	7.000	5.66457	1.097425	0.774
Personal attitude	PA	318	1.000	7.000	4.81447	1.608233	0.934
Subjective norm	SN	318	1.000	7.000	5.79979	1.227144	0.836
Perceived behavioral control	PBC	318	1.000	7.000	4.37212	1.489912	0.916
Entrepreneurial intention	EI	318	1.000	7.000	3.82442	1.831590	0.955

Table 2 T-test of average values on individual entrepreneurial orientation,  
Theory of planned behavior and entrepreneurial intention dimensions,  
depending on the freelancers' gender (1 - Male; 2 - Female)

Dimens.	Freelancers gender	N	Mean	Std. Deviation	Std. Error Mean	Levene's Test for Equality of Variances		t-test for Equality of Means		
						F	Sig.	t	df	Sig. (2-tailed)
RT	1 Male	114	<b>4.84795</b>	1.513064	.141711	.004	.949	2.102	316	.036
	2 Female	204	<b>4.47549</b>	1.516899	.106204			2.103	234.418	.037
IN	1 Male	114	5.12939	1.333384	.124883	.855	.356	.796	316	.427
	2 Female	204	5.00368	1.359712	.095199			.801	237.791	.424
PR	1 Male	114	5.73099	.999387	.093601	4.038	.045	.806	316	.421
	2 Female	204	5.62745	1.149278	.080466			.839	262.063	.402
PA	1 Male	114	4.89298	1.605561	.150375	.119	.731	.650	316	.516
	2 Female	204	4.77059	1.611999	.112862			.651	234.708	.516
SN	1 Male	114	5.64912	1.328784	.124452	.186	.666	-1.641	316	.102
	2 Female	204	5.88399	1.161386	.081313			-1.580	208.881	.116
PBC	1 Male	114	<b>4.66520</b>	1.502455	.140718	.027	.871	2.647	316	.009
	2 Female	204	<b>4.20833</b>	1.461055	.102294			2.626	228.470	.009
EI	1 Male	114	4.04094	1.816774	.170157	.017	.897	1.580	316	.115
	2 Female	204	3.70343	1.833112	.128344			1.584	235.687	.115

Table 3 T-test of average values on individual entrepreneurial orientation,  
Theory of planned behavior and entrepreneurial intention dimensions,  
depending on the freelancers' age (1 - Young; 2 - Old)

Dimens.	Freelancers age	N	Mean	Std. Deviation	Std. Error Mean	Levene's Test for Equality of Variances		t-test for Equality of Means		
						F	Sig.	t	df	Sig. (2-tailed)
RT	1 Young	211	4.72196	1.510316	.103974	.140	.709	1.863	316	.063
	2 Old	107	4.38629	1.532424	.148145			1.855	210.381	.065
IN	1 Young	211	<b>5.15995</b>	1.315727	.090578	.106	.745	2.074	316	.039
	2 Old	107	<b>4.82944</b>	1.394310	.134793			2.035	202.502	.043
PR	1 Young	211	5.73934	1.056091	.072704	1.416	.235	1.711	316	.088
	2 Old	107	5.51713	1.165753	.112698			1.657	195.500	.099
PA	1 Young	211	4.90237	1.653551	.113835	2.723	.100	1.371	316	.171
	2 Old	107	4.64112	1.507400	.145726			1.413	231.352	.159
SN	1 Young	211	5.86572	1.235018	.085022	.206	.650	1.347	316	.179
	2 Old	107	5.66978	1.206634	.116650			1.357	217.549	.176
PBC	1 Young	211	4.40126	1.477205	.101695	.115	.735	.489	316	.625
	2 Old	107	4.31464	1.520014	.146945			.485	207.792	.628
EI	1 Young	211	3.94076	1.887033	.129909	4.124	.043	1.594	316	.112
	2 Old	107	3.59502	1.702309	.164568			1.649	233.499	.100



Table 4 T-test of average values on individual entrepreneurial orientation.  
Theory of planned behavior and entrepreneurial intention dimensions.  
depending on the freelancers' education (1 - High school; 2 - University)

Dimens.	Freelancers' education	N	Mean	Std. Deviation	Std. Error Mean	Levene's Test for Equality of Variances		t-test for Equality of Means		
						F	Sig.	t	df	Sig. (2-tailed)
RT	1 High Sch	78	4.71368	1.424101	.161248	2.189	.140	.698	316	.486
	2 Faculty	240	4.57500	1.555998	.100439			.730	141.480	.467
IN	1 High Sch	78	5.14744	1.260949	.142774	.501	.480	.743	316	.458
	2 Faculty	240	5.01667	1.378152	.088959			.777	141.520	.438
PR	1 High Sch	78	5.70513	.913236	.103404	3.096	.079	.375	316	.708
	2 Faculty	240	5.65139	1.152382	.074386			.422	163.232	.674
PA	1 High Sch	78	4.71026	1.479083	.167473	1.610	.205	-.658	316	.511
	2 Faculty	240	4.84833	1.649546	.106478			-.696	144.240	.488
SN	1 High Sch	78	5.69658	1.274895	.144353	1.165	.281	-.855	316	.393
	2 Faculty	240	5.83333	1.212058	.078238			-.833	125.396	.406
PBC	1 High Sch	78	4.47436	1.412702	.159957	.590	.443	.697	316	.486
	2 Faculty	240	4.33889	1.515522	.097827			.723	139.103	.471
EI	1 High Sch	78	3.82906	1.820790	.206164	.104	.747	.026	316	.980
	2 Faculty	240	3.82292	1.838874	.118699			.026	131.843	.979

Table 5 T-test of average values on individual entrepreneurial orientation.  
Theory of planned behavior and entrepreneurial intention dimensions.  
depending on the freelancers' previous entrepreneurial experience (1 - Yes; 2 - No)

Dimens.	Freelancers previous entrepren. experience	N	Mean	Std. Deviation	Std. Error Mean	Levene's Test for Equality of Variances		t-test for Equality of Means		
						F	Sig.	t	df	Sig. (2-tailed)
RT	1 Yes	136	<b>4.85539</b>	1.510295	.129507	.356	.551	2.513	316	.012
	2 No	182	<b>4.42491</b>	1.511621	.112049			2.514	291.098	.012
IN	1 Yes	136	5.19118	1.385853	.118836	.224	.636	1.631	316	.104
	2 No	182	4.94231	1.315587	.097518			1.619	282.491	.107
PR	1 Yes	136	5.70343	1.133604	.097206	.128	.721	.545	316	.586
	2 No	182	5.63553	1.071826	.079449			.541	281.812	.589
PA	1 Yes	136	<b>5.26912</b>	1.414921	.121328	3.882	.050	4.488	316	.000
	2 No	182	<b>4.47473</b>	1.662893	.123262			4.593	310.656	.000
SN	1 Yes	136	5.84559	1.265502	.108516	.009	.922	.575	316	.566
	2 No	182	5.76557	1.200056	.088954			.570	282.311	.569
PBC	1 Yes	136	<b>4.99632</b>	1.207907	.103577	7.437	.007	6.919	316	.000
	2 No	182	<b>3.90568</b>	1.512619	.112123			7.145	314.581	.000
EI	1 Yes	136	<b>4.49755</b>	1.646418	.141179	1.733	.189	5.966	316	.000
	2 No	182	<b>3.32143</b>	1.805203	.133811			6.046	303.698	.000

## DISCUSSION

### Discussion of the results of descriptive statistics

According to Table 1. from the individual entrepreneurial orientation dimensions. the dimension PR - Proactiveness has the highest average score, followed by IN - Innovativeness and finally RT -

Risk-taking. This order could be assumed given the nature of the observed dimensions: many people, especially highly educated such as freelancers in this sample. behave proactively. innovation is less common. and even fewer people are willing to take risks.

From the Theory of planned behavior dimensions, the highest average grade has the dimension SN - Subjective norm, which certainly has to do with the pronounced collectivist national culture in Serbia (Rajković et al., 2020) and the pronounced collectivist organizational culture in companies in Serbia (Mali et al., 2020; Vlahović et al., 2020). The research was conducted in Western Balkan countries, but most of the sample is from Serbia. In addition, other countries covered by the survey have a similar national culture. As expected, the EI - Entrepreneurial intention dimension has the lowest average rating. There is also a difference between attitudes toward entrepreneurship and real intentions to start an entrepreneurial venture: it is one thing to have a favorable opinion about entrepreneurship, and quite another to have strong intentions to start your own business. Dimension PBC - Perceived behavioral control has an average score slightly higher than the mid-range, so it can be said that freelancers evaluate their ability as average when it is about engagement in entrepreneurship.

### Discussion of the results of the t-test

#### *Freelancers gender*

According to Table 2, males have a statistically significantly higher average score for RT - Risk-taking and PBC - Perceived behavioral control. Men are simply more prone to risk and have a higher perception of their entrepreneurial abilities. However, this does not result in higher entrepreneurial intentions: men have a higher average score for EI - Entrepreneurial intention compared to women but this difference is not statistically significant.

Compared with other studies, these results show similarities in terms of greater risk readiness for males (Wagner & Sternberg, 2004). Also, in the dimension of PBC - Perceived behavioral control, male students have higher values for this dimension (Rajković et al., 2021), as well as among employees (Mali et al., 2021). The biggest difference exists in the dimension EI - Entrepreneurial intention: male students have higher values for this dimension (Rajković et al., 2021), as well as among employees (Mali et al., 2021). Thus, female freelancers show relatively more entrepreneurial intentions than female students and married women. This is probably a consequence of the nature of the work of freelancers which according to some

parameters, is close to the way entrepreneurs work so in this case women do not lag behind men so much.

#### *Freelancers age*

According to Table 3, younger freelancers have higher average scores for all dimensions, but the difference is statistically significant only at IN - Innovativeness. In the research (Mali et al., 2021), differences between the same dimensions for younger and older employees were observed, and many more statistically significant differences were discovered in almost all dimensions. Therefore, it can be concluded that younger people have more energy and self-confidence for entrepreneurship, which is in line with some previous research (Acemoglu et al. 2014; Liang et al., 2018). For freelancers, this is somewhat less pronounced compared to conventionally employed persons. The reason may be that all freelancers, regardless of age, have a dynamic and uncertain job, so older freelancers are more open, better accept changes, risks and must be proactive and believe in their abilities.

It should be borne in mind here that freelancers are mostly younger people so the age category limit in this study is set quite low, at the age of 35, so that the sample can be divided evenly. Thus, even conditionally speaking, the older group of freelancers has a lot of them who according to their age (for example, from 35 to 45), could not be said to belong to older people.

#### *Freelancers' education*

According to Table 4, there are no statistically significant differences in the average scores of the observed dimensions for high school and university-educated freelancers. The same result, for the same dimensions, was obtained in the research (Mali et al., 2021), for high school and university-educated persons. According to these findings, the degree of education does not seem to have an impact on the strength of the individual entrepreneurial orientation and the Theory of planned behavior dimensions.

#### *Freelancers' previous entrepreneurial experience*

According to Table 5, the most differences in the average scores of the observed dimensions occur between freelancers who have previous experience in entrepreneurship and freelancers who do not

have previous experience in entrepreneurship. These are the following dimensions: RT - Risk-taking, PA - Personal attitude, PBC - Perceived behavioral control and EI - Entrepreneurial intention. It is obvious that the existence of previous entrepreneurial experience, largely gives courage for risk, provides the necessary security in their abilities and, finally, shapes new entrepreneurial ambitions, attitudes and intentions. A similar result exists in the reference (Mali et al., 2021), for employed persons, who have or do not have previous entrepreneurial experience.

## CONCLUSION

Observed at the level of the entire sample, from all of the individual entrepreneurial orientation and the Theory of planned behavior dimensions, freelancers best evaluate the support they can receive for an entrepreneurial venture, as well as their proactivity. Entrepreneurial intentions were assessed as the worst. However, these intentions are significantly higher concerning the research in which the respondents were conventionally employed persons (Mali et al., 2021).

The most statistically significant differences in the average scores of the observed dimensions occur in the division of the sample into freelancers who have or have no previous experience in entrepreneurship, on the side of those who have such experience. This is a result consistent with a similar study in which the respondents were conventionally employed. At the same time, it should be noted that of all the control variables observed in this paper, only in the case of previous experience in entrepreneurship, there is a statistically significant difference for an important dimension: EI - Entrepreneurial intention.

For other control variables, statistically significant differences occur in only three other cases: for dimensions, RT - Risk-taking and PBC - Perceived behavioral control on the side of male freelancers, and dimension IN - Innovativeness on the side of younger freelancers. In the research, in which the respondents were conventionally employed persons, there are significantly more differences, especially on the side of younger respondents and men. From this, it can be concluded that female freelancers do not lag so much behind their male colleagues, as well as that older freelancers do not lag so much behind their younger colleagues, in terms of entrepreneurial attitudes and intentions.

So, overall freelancers have greater entrepreneurial intentions than conventionally employed people. In addition, freelancers are more consistent in terms of entrepreneurial intentions: there are no differences in these intentions if the sample is divided according to the gender and age of freelancers. It can be stated that hypothesis H4 has been confirmed, hypotheses H1 and H2 have been partially confirmed, while hypothesis H3 must be rejected.

The theoretical significance of the paper is that it examines the individual entrepreneurial orientation and the Theory of planned behavior dimensions for freelancers, as a group of respondents who are not sufficiently represented in similar research. This is especially important considering that freelancers are becoming more and more numerous. In practical terms, the importance of the paper is that it indicates potential directions in the development of entrepreneurial intentions for different groups of employees.

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## EFEKTI POLA, STAROSTI I OBRAZOVANJA NA PREDUZETNIČKU ORIJENTACIJU I NAMERE MEĐU FRILENSERIMA

Tema rada su vrednosti individualne preduzetničke orijentacije i teorija dimenzija planiranog ponašanja, kod frilensera u zemljama Zapadnog Balkana (Bosna i Hercegovina, Hrvatska, Crna Gora i Srbija). Ispitivani su i efekti četiri kontrolne varijable: pol, starost, nivo obrazovanja i prethodno preduzetničko iskustvo. Frilenseri najbolje vide podršku za preduzetnički poduhvat, kao i njihovu proaktivnost. Najgore su ocenjene preduzetničke namere. Najveći uticaj na posmatrane dimenzije javlja se kod frilensera koji imaju/ nemaju prethodno iskustvo u preduzetništvu. Za ostale kontrolne varijable, statistički značajne razlike se javljaju u samo tri druga slučaja: za dimenzije RT – preuzimanje rizika i PBC – percipirana kontrola ponašanja na strani muških frilensera i dimenzija IN – inovativnost na strani mladih frilensera. Napravljeno je poređenje sa sličnom studijom, gde su ispitanici bili konvencionalno zaposlene osobe. Generalno, frilenseri imaju veće preduzetničke namere od konvencionalno zaposlenih ljudi. Frilenseri su konzistentniji u pogledu preduzetničkih namera: nema razlika u ovim namerama ako se uzorak podeli prema polu i starosti frilensera. Ovi rezultati su razmatrani u radu.

**Ključne reči:** Individualna preduzetnička orijentacija; Teorija planiranog ponašanja; Preduzetnička namera; Frilenseri; Zapadni Balkan.

## MINIMUM COVARIANCE DETERMINANT-BASED BOOTSTRAPPING FOR APPRAISING AIR PASSENGER ARRIVAL DATA

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**Air travel management is a case-special process since it includes different types of uncertainties such as ungovernable passenger mobility, variable costs as well as extraordinary restrictions like the Covid-19 pandemic. Therefore, the use of robust and reproducible statistical evaluations under uncertainty is required. The cornerstone of this study is the adaptation of bootstrapping and the robust Minimum Covariance Determinant (MCD)-based parameter estimation under a heterogeneous process. In addition, the study includes a novel bootstrapping regression implementation. The methodological developments have been tested by Serbia's air transport data. The results showed that combining robust estimator and bootstrapping provides some advantages for determining outliers and also making advanced diagnostics. Thus, a state-of-the-art approach based on accuracy, reproducibility, and transparency has been introduced and its usability in the air travel mobility process has been exhibited.**

**Keywords:** Air travel; Robust estimator; Bootstrapping; Correlation.

### INTRODUCTION

As a rapid and safe transportation system, the airline includes many complex dynamics affected by different internal (personal management, equipment, organization) and external (climate, cost, distance) sources (Bogetic et al. 2014; Tomic et al. 2012). Air transportation deals with socio-economics, competitiveness, welfare, and also associated base sectors such as tourism and international trade. One of the key management terms is knowledge management for passenger satisfaction (Kavalić et al. 2022). The growth of air transportation positively affects the progress of various industries especially tourism (Oktal & Garcia, 2017). The United Nations World Trade Organization (UNWTO) describes tourism as a social, cultural, and economic phenomenon entailing the movement of people to countries or places outside their usual environment for personal or business/professional objectives (UNWTO, 2022).

Recently, an increasing dependency on air transport by the accommodation sector has created a relationship between air transport and tourism more

complex trade (Dileep & Kurien 2022). In addition, both international and domestic tourist destinations now increasingly rely on air transport for tourism flows. The parallel lines between air transport and tourism-based passenger mobility were identified by Lohmann and Duval (2014) as common motivation, objective function, and shared emphasis on sustainability.

The investigations for analysing the relationships between air passenger dynamics and different sectors like tourism from a statistical point of view have gained popularity over the last two decades due to the requirements for economical optimization, system modelling, and investment planning. In one of the pioneer studies, Medeiros et al. (2008) discussed the air passenger arrival contribution to international tourism in Mallorca (Spain), and a neural network model was developed. In this way, the level of international demand was appraised computationally. In another study, some econometric models were suggested for evaluating air passenger traffic flows and related tourism demand (Fildes et al. 2011). To establish decision rules for long-term forecasting of air passengers, Sharma et al. (2018) suggested a



hybrid rough set model. In a similar novel work, for the purpose of projecting air passenger demand, the top 20 busiest airports' passenger counts were employed in a global vector autoregressive technique (Gunter & Zekan, 2021). In a recent study, it was discussed the effect of the Covid-19 pandemic on air passenger dynamics in the EU countries by using a time series analysis (Barczak et al. 2022).

Although many investigations in literature focused on the dynamics of the air transportation system and passenger demand topics, there are novel studies performed on simulation and robust estimation in the topic "airline and tourism" such as Assaf (2011) and Van De Vijver et al. (2011). However, the statistical analyses were performed only via conventional estimators and these modelling tools also do not consider critical issues such as the existence of outliers, the heterogeneous property of air passenger dynamics, and also the nonlinear structure of trend (location and scatter). Therefore, a highly robust estimator of location and scatter as well as a fast algorithm is required (Hubert et al. 2018).

To fill this gap in the literature, this study suggests a new algorithm by considering an appraisal based on complexity reduction and robustness. The theoretical cornerstone of the suggested model is to adapt bootstrapping and the robust Minimum Covariance Determinant (MCD)-based parameter estimation. In this way, a simulation-based robust correlation can be calculated. In addition, the study also conducts a novel bootstrapping regression application. Finally, revealing a state-of-the-art approach based on accuracy, reproducibility, and transparency is the main result of this study. The methodology has been tested using Serbia air passenger records and the merits of the hybrid statistical approach have been underlined.

The remainder of the article is organized as follows. Section 2 introduces the methodological ground used in this study. Section 3 presents the numerical experiments and the results along with a brief discussion. Section 4 summarizes the findings of the investigation.

## METHODOLOGY

### Robust Distance Measure by Minimum Covariance Determinant (MCD)

If a multivariate data set is available, by using a  $n \times p$  data matrix  $X = (x_1, x_2, \dots, x_n)^t$  with  $x_i =$

$(x_{i1}, x_{i2}, \dots, x_{ip})^t$ , a  $p$ -dimensional tolerance ellipse can be structured based on Mahalanobis distance measure:

$$MD(x) = \sqrt{(x - \bar{x})^t S^{-1} (x - \bar{x})} \quad (1)$$

In Eq. (1),  $MD$  and  $S$  correspond to the  $\alpha$ -quantile of the chi-squared distribution  $\sqrt{\chi_{p,0.975}^2}$ , and the sample covariance matrix, respectively. Because the tolerance ellipse designed via MD aims to contain all measurements and also a sensitive outlier, the MCD estimator was suggested as a strong robust estimator of multivariate location and scatter based on robust distance (MCDRD) (Rousseeuw & Van Driessen 1999):

$$MCDRD(x) = \sqrt{(x - \bar{\mu}_{MCD})^t \bar{\Sigma}_{MCD}^{-1} (x - \bar{\mu}_{MCD})} \quad (2)$$

In Eq(2),  $\bar{\mu}_{MCD}$  and  $\bar{\Sigma}_{MCD}$  represent the estimate of location and covariance estimate, respectively. The robust distance expressed produces a much smaller ellipse compared with the MD and it includes the regular measurements. Thus, the MCD is projected for elliptically symmetric unimodal distributions. As recorded in Cator and Lopuhaa (2010), the distributional properties of the MCD estimators provide some tools to perform an effective robust statistical evaluation. These estimators have the same high breakdown point as the minimum volume ellipsoid estimators. To reach a high level of robustness the shape parameters  $\bar{\mu}_{MCD}$  and  $\bar{\Sigma}_{MCD}$  can be calculated by reweighting as follows (Hubert & Debruyne 2010).

$$\hat{\mu}_{MCD} = \frac{\sum_{i=1}^n W(d_i^2) x_i}{\sum_{i=1}^n W(d_i^2)} \quad (3)$$

$$\hat{\Sigma}_{MCD} = c_1 \frac{1}{n} \sum_{i=1}^n W(d_i^2) (x_i - \hat{\mu}_{MCD})(x_i - \hat{\mu}_{MCD})^t \quad (4)$$

where  $d_i = \sqrt{(x - \hat{\mu}_0)^t \Sigma_0^{-1} (x - \hat{\mu}_0)}$ .  $W$  and  $c_1$  denote suitable weight function and a consistency factor, respectively. By using the robust covariance matrix, a robust correlation matrix between the variables  $X_i$  and  $X_j$  can be provided by

$$r_{ij} = \frac{s_{ij}}{\sqrt{s_{ii}s_{jj}}} \quad (5)$$

Where  $s_{ij}$  denotes the MCD covariance estimate.

**Bootstrapping for parameter estimation and regression**

As a nonparametric statistical technique, bootstrapping is applied for statistical inference based on the statistical distributions of the sample data. The main superiority of the bootstrap is its applicability with limited data and no requirement for distributional assumptions. In addition, this approach is relatively simple and general to handle complex relationships. The bootstrapping simulation can be considered for two purposes: estimating standard errors and optimizing regression coefficients.

To estimate the standard error of the sample mean, the following procedure can be employed (James et al., 2021):

- Decide on the number of bootstrap samples  $M$ .
- Randomly draw  $n$  measurements  $Y_{b1}^*, Y_{b2}^*, \dots, Y_{bn}^*$  for each sample  $b = 1, \dots, M$  with replacement and compute the bootstrap mean:

$$\bar{Y}_b^* = \frac{\sum_{i=1}^n Y_{bi}^*}{n} \tag{6}$$

- Estimate the standard deviation of the bootstrap means based on  $M$  bootstrap samples,

$$SE^*(\hat{Y}^*) = \sqrt{\frac{\sum_{b=1}^M (\bar{Y}_b^* - \bar{Y}^*)^2}{M-1}} \tag{7}$$

$$\bar{Y}^* = \frac{\sum_{b=1}^M \bar{Y}_b^*}{M} \tag{8}$$

In general, it is difficult to determine standard errors in an analytical way and in most cases, the requirement for robust standard errors has also emerged (Fox & Weisberg, 2019). In addition, the SE expression given in Eq. (7) needs a generalization due to deriving the empirical sampling distribution for an estimator  $\hat{\theta}$  of the parameter  $\theta$ . To fulfill these two conditions and adapt the calculations to MCD-based estimation the following generalized equation can be structured:

$$SE_{(\hat{\theta}^*)}^*(MCD) \equiv \sqrt{\frac{\sum_{b=1}^M (\hat{\theta}_b^*(MCD) - \bar{\theta}^*(MCD))^2}{M-1}} \tag{9}$$

To provide the SE for the parameter  $\theta$ , the robust estimator (MCD) considers the estimates for normally distributed data based on RD given in Eq

(2). Before reaching the final solution in Eq. (9), the MCD-based bootstrapping algorithm considers the correlation matrix and some adaptive parameters. The bootstrap parameter estimation can be used for measuring the gauge of the robustness and also estimating regression coefficients of the bootstrap regression solution.

The conventional bootstrap-based regression parameter estimation procedure given in (Fox, 2016) can be modified. In the adapted procedure, the general regression expression  $z_i' = [Y_i, X_{i1}, \dots, X_{ik}]$  is considered and the measurements are resampled. By using the bootstrapping,  $M$  sets of regression coefficients  $\beta_b^* = [A_b^*, B_{b1}^*, \dots, B_{bk}^*]'$  are provided. The parameter estimation procedure can be summarized as follows:

- Estimating regression coefficients ( $\beta_b$ ), response ( $\hat{Y}_i$ ) and residual ( $E_i$ ).
- Selecting bootstrap of the errors  $e_b^* = [E_{b1}^*, E_{b2}^*, \dots, E_{bn}^*]'$  and obtaining bootstrapped targets  $y_b^* = [Y_{b1}^*, Y_{b2}^*, \dots, Y_{bn}^*]'$ .
- Using bootstrapped targets and fixed X-values, get re-sampled regression coefficients  $\beta_b^* = [A_b^*, B_{b1}^*, \dots, B_{bk}^*]'$ .

It should be underlined that the regression model procedure is bootstrapped by handling the indicator variables as (Fox, 2016):

- random and selecting bootstrap samples directly from the measurements  $z_i'$ .
- fixed and resampling from the residuals  $E_i$  of the modelled regression.

The number of replications is one of the critical parameters in bootstrapping applications. James et al. (2021) suggest 1000 replications as general to provide accurate results.

**IMPLEMENTATION**

Travelers can be classified into two major groups in general: visitors (travel for leisure, business, etc.) and non-visitors. Tourists can be recruited for the first group with the excursionists (same-day visitor). UNWTO expresses a visitor that is a person who travels with a non-remunerative purpose to a foreign country for a period not exceeding one year. Similarly, a domestic tourist is described as a visitor whose maximum duration may be up to six months and the place being visited has to be inside the country of origin (Dileep, 2019). Due to the close connection among

transportation, tourism, and travel management, the case study aims attention at the air passenger (visitor) dynamics and mobility which includes a considerable amount of heterogeneity and uncertainty resources from personal and external management characteristics.

**Data and structure identification**

The case study focused on understanding Serbia's air passenger mobility as one of the critical topics in air travel management. The air travel system in Serbia is structured by many parameters such as economic progress, international trade, new tourist destinations along with international relationships, growth of population with changes in demography, aviation technology, lifestyle, and income. Therefore, dynamic and ever-changing records encountered in similar countries can be mentioned.

The data includes the passenger (tourist) arrivals in Serbia from the records kept by The Tourism Organisation of Serbia (TOS) and the Statistical Office of the Republic of Serbia (PBC) such as (PBC 2020; TOS 2013). The data set consists of both domestic and foreign tourist records between 2003 and 2019. Due to the global pandemic coronavirus disease (COVID-19) and its travel restrictions (Aleksic et al 2022), the observations for the years 2020 and 2021 were omitted. The focal point of this implementation is to show the relationship between foreign and domestic mobility in Serbia. Table 1 summarizes the descriptive statistical properties of the data set. Figure 1 indicates the basic correlations and densities.

Table 2: Descriptive statistics for passenger arrival data.

Data Set	Minimum	Maximum	Mean ( $\mu$ )	Standard Deviation ( $\sigma$ )	Coefficient of Variation $CV = (\sigma / \mu) * 100$
Domestic	1165536	1843432	1535790	456146	29.7
Foreign	339283	1846551	900922	189067	21.0

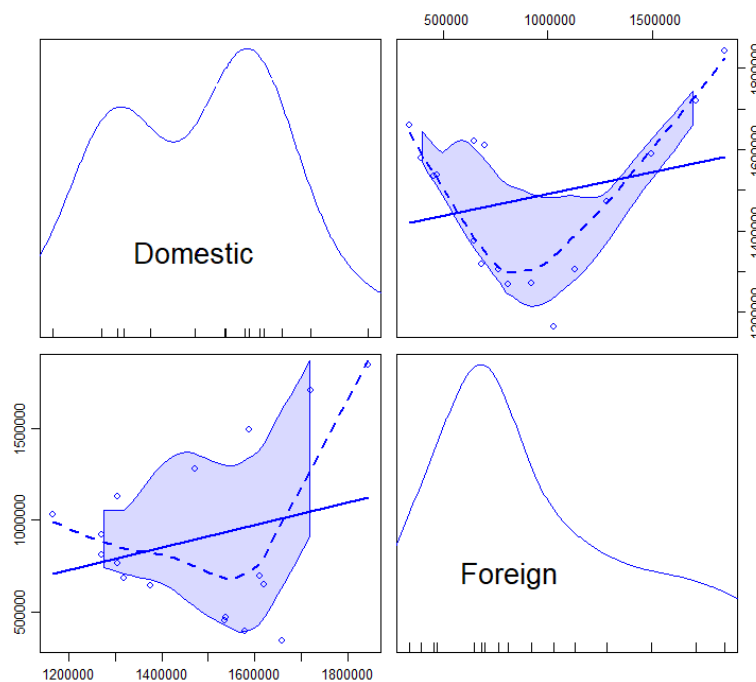


Figure 1: Correlations and densities for arrivals.

**Application and results**

Before the MCD-based bootstrapping implementation, first, the relationship between conventional distance measure and MCD (robust distance) was shown. The data set contains the

numbers of arriving passengers for 17 years. The scatter plot illustrated with the classical (Mahalanobis) and robust 97.5% tolerance ellipses in Figure 2 explores the domains. The MD identifies how far away the observation is from the centre of the cloud, relative to the size of the cloud.

Therefore, as seen in Figure 3, the MD-based tolerance ellipse encompassed all measurements. In addition, the MD produces a large area and none of the observations seems outlier. However, both

Figures 2 and 3 illustrate that the RD-based tolerance ellipse has a much smaller structure and it encloses the regular data points. The MCD-based measure clearly specifies seven outliers.

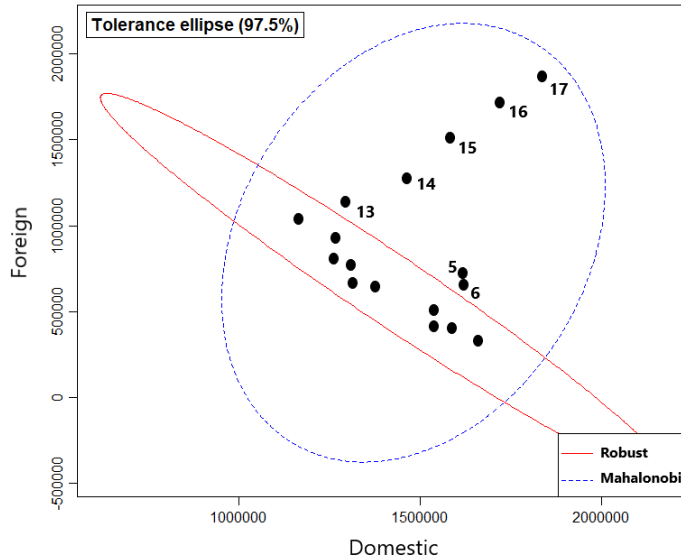


Figure 2: Bivariate air passenger data with conventional and robust tolerance ellipses.

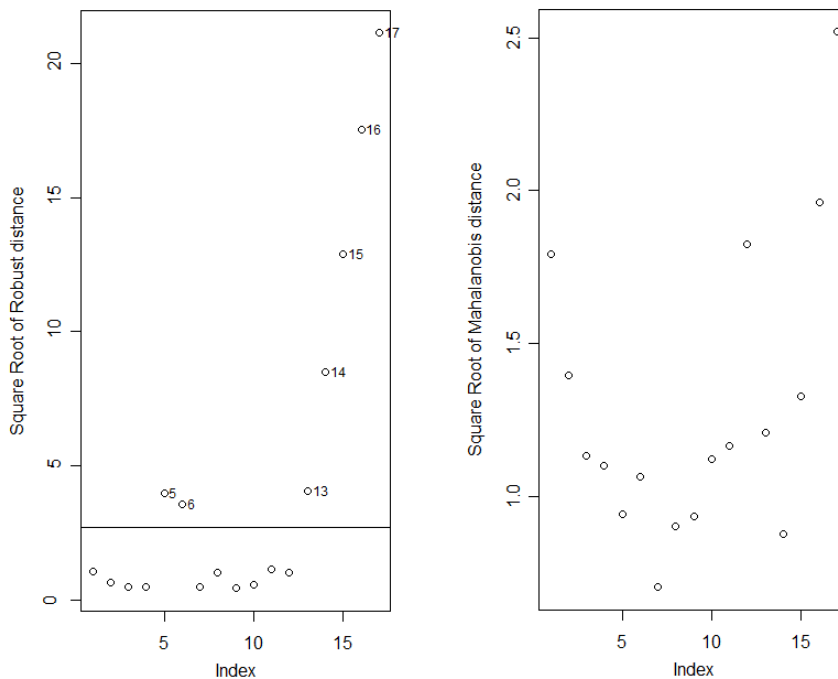


Figure 3: MCD and Mahalanobis distance measures for air passenger data.

Based on the detection and diagnosis capacity of MCD, a series of bootstrapping implementations were performed and the standard error for the correlation coefficient measured between the variables was estimated using case-resampling simulation instead of a formula. The following simulation procedure was followed by using the “robustbase” library in R (Hubert et al., 2012).

- determine the correlation via simulated data, provided by sampling  $M$  cases with replacement from the  $M$  cases of the measured data set used for input.
- repeat Stage 1 for a large number of bootstrap replications.

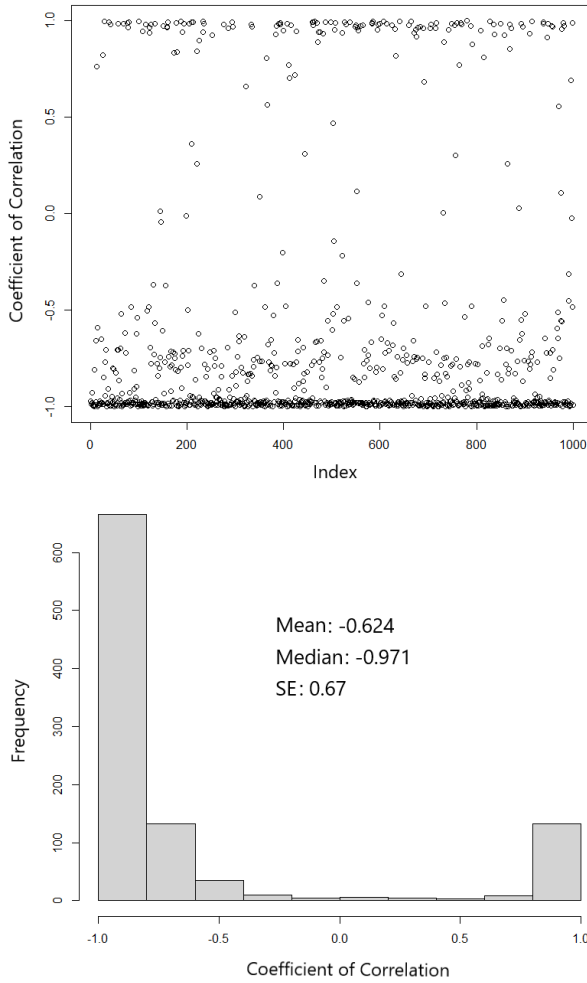


Figure 4: Variation of correlations provided by MCD-based bootstrapping.

Following these two steps, the standard deviation of the bootstrapped values of the correlation coefficient estimated its standard error. Figure 4 illustrates the variation of the correlations provided as a result of bootstrapping with 1000 repetitions.

To explore the relationship between foreign and domestic passenger arrivals, first, the function structure was selected and then a bootstrapping regression algorithm was implemented. Figure 5 shows both linear and polynomial base regression models for simulations. As can be seen in Figure 5, the quadratic model has better performance for model fitting. In the bootstrap model, the following least-squares solution for the coefficients can be considered:

$$\beta_b^* = (X'X)^{-1}X'y_b \text{ for } b = 1, \dots, M. \quad (10)$$

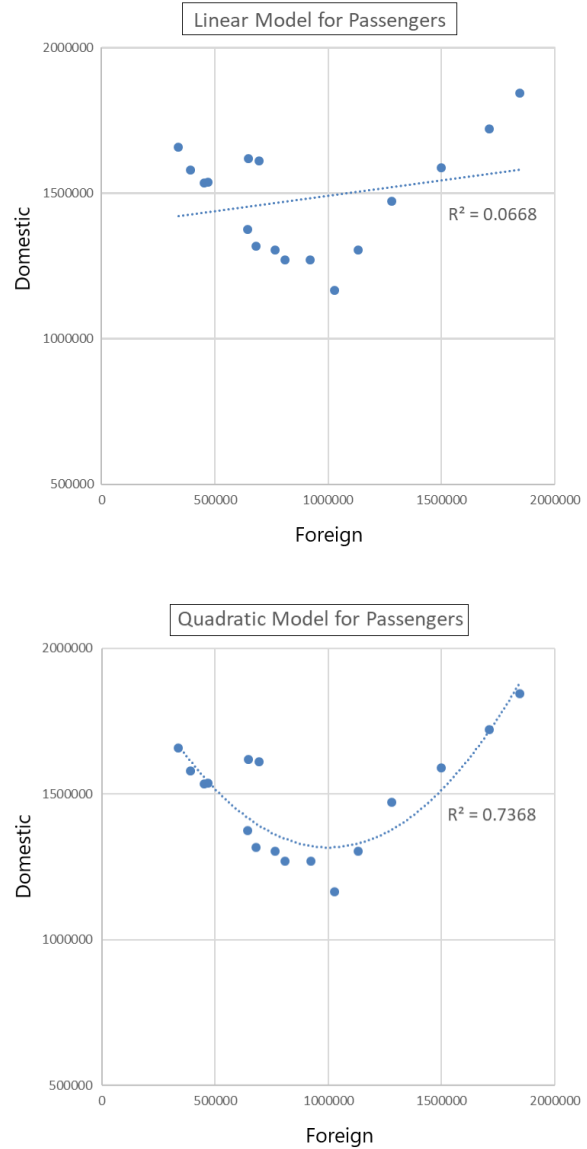


Figure 5: Base function alternatives for bootstrap regression.

In other respects, the data set shows a tendency to a polynomial (quadratic) model below:

$$y_b = A_b + B_{b1}x + B_{b2}x^2 \quad (11)$$

The functional (quadratic) regression model has been bootstrapped by using the independent variable foreign as fixed and resampling from the residuals  $E_i$  of the fitted regression. For this application, 1000 replications were selected and the identically distributed residuals are considered. Table 2 summarizes the simulated regression model along with the base alternatives with the performances.

Table 2: Base and bootstrapped regression models.

Model	Regression Equation	Relative Error (RE%)
Linear (Fig.5)	$y = 1000000 + 0.1071x$	24.88
Base Quadratic (Fig.5)	$y = 2116844 + 1.59654x + 0.0000007965x^2$	4.86
Bootstrapped Quadratic	$y = 2109975 + 1.58958x + 0.0000007923x^2$	4.73

DISCUSSION

The data sets denote a long period and partial fluctuations resourced from internal and external factors encountered in Serbia. Table 1 gives a summary of the input data. The CV values calculated in Table 1 indicate that the variability levels for Foreign and Domestic arrivals are analogous. As a high-performance robust estimator, the MCD has a respected capacity to determine the outliers. Figures 2 and 3 indicate the masking effect: conventional (Mahalanobis) identification was affected by outliers and the diagnostic based on the MD can no longer detect the outlying observations. On the other hand, the MCD-based estimator has resistance against the outliers.

As seen in Figures 6 and 7, the MCD has better parallelism and accuracy and can also be employed to flag the outliers. In particular, Fig 7 illustrates the comparative evaluation based on Eigenvalues. It should be noticed that the robust distance measure in Eq. (2) has no sensitivity to the masking effect and to perform reliable data analysis (location and scatter) in an uncertain environment including fluctuations, the robust MCD is preferred.

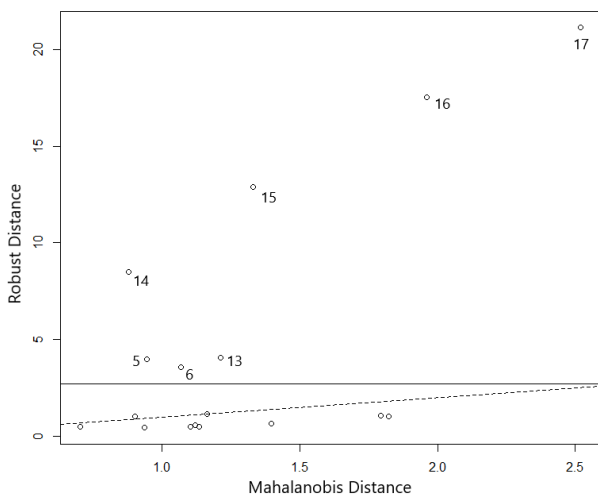


Figure 6: "MCD versus Mahalanobis plot" for passenger arrival data.

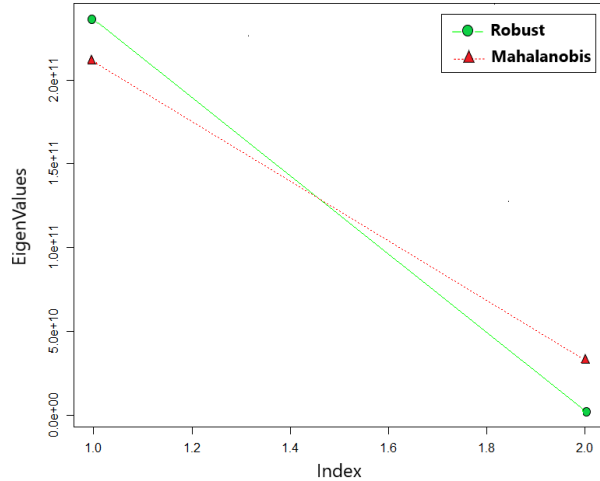


Figure 7: Performance of MD and RD based on eigenvalues.

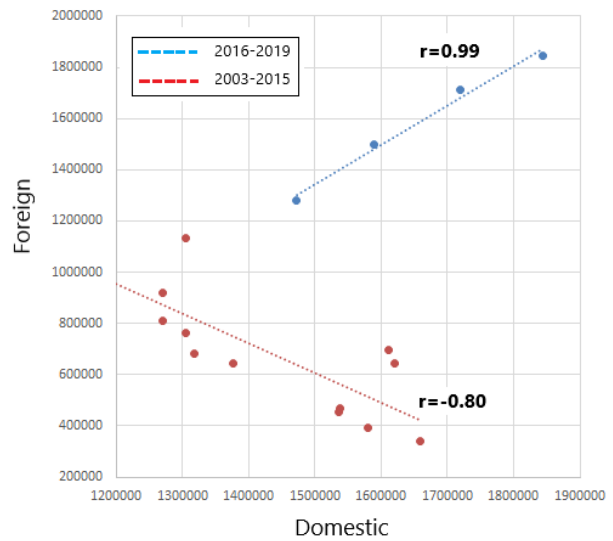


Figure 8: Two-piece trend models based on time.

The studies on correlation coefficient indicated that this indicator has many fluctuations. Therefore, instead of a conventional measure, the robust measure would be preferable for a data diagnostic. It should be highlighted that although Figure 5 and Table 2 give us a general perspective, there is a big difference between the functional correlations in Figure 5 and the MCD-based bootstrapped correlations in Figure 4. If we zoom in on the data set, we can identify two different periods for foreign arrivals. The simulations presented in Figure 4 clearly exhibited this two-piece analysis



requirement. Even though domestic arrivals have been just steady between the years 2003-2015 and a relatively constant trend has been recorded between domestic and foreign arrivals, a dramatic increase in foreign arrivals and relatively different trends have been recorded in recent years. Therefore, a two-piece regression model would be more realistic. The difference between these two periods is presented in Figure 8.

In the last step of the implementation, the coefficients used in the regression model have been optimized by bootstrapping. Because the number of data is limited and a requirement on exhibiting the improvement provided by bootstrapping is tested, all the measurements in the data set were employed in the regression analyses. Figure 9 depicts the variabilities and also densities of the coefficients. As seen in Figure 8, the simulations produced nearly normal distributions

for all parameters. It should be noticed that this study did not prefer scaling and no data transformation has been employed in the simulation studies.

The results showed that nonlinear robust bootstrapping reveals exact findings to understand the relationship between foreign and domestic arrivals in Serbia. A negative correlation and functional relationship have been recorded. One of the important findings explored by the MCD diagnosis is the trend of outliers recorded for the last 4-5 years before the Covid-19 pandemic. A strong increase and the accompanying linear trend show the improved international relationships (tourism, trade, meeting, etc) for Serbia. However, future investigation is required with more data and a long period to exhibit the relationships among the sub-dynamics.

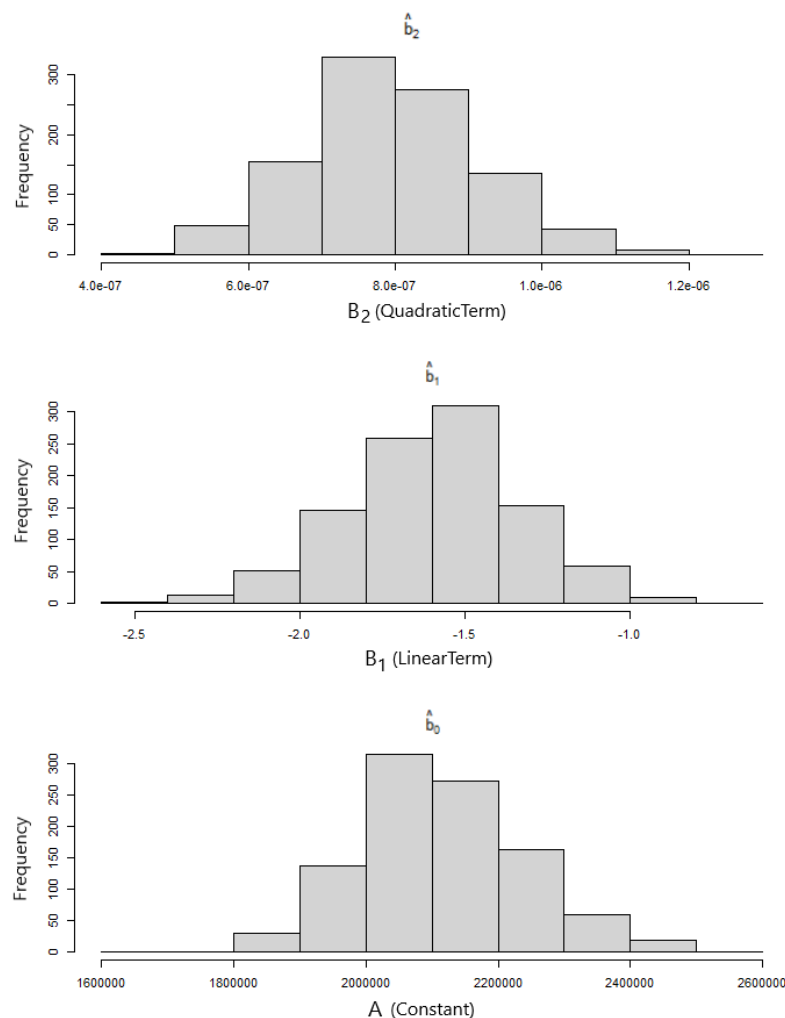


Figure 9: Histograms of bootstrapped regression parameters.

## CONCLUSIONS

Air travel management is a case-special process since it includes different types of uncertainties such as qualitative (uncontrollable personal and passenger behaviour) and quantitative (fluctuated records, variable costs, international trends, etc.) factors as well as ungovernable parameters like the Covid-19 pandemic. Hence, sustainable management requires strong numerical tools such as robust statistical analyses. The MCD has been used to analyse the mobility of air passengers because conventional estimators do not take into account the key difficulties. It is a very robust estimator of location and dispersion as well as a fast method. The experimental studies were performed based on three methodological grounds: illustrating the superiority of the suggested robust estimator compared with the conventional ones, improving the accuracy of the correlation coefficient using the MCD-based bootstrapping, and regression parameter optimization via bootstrapping regression. The algorithmic procedures were examined by using Serbia air passenger arrival data and some useful results have been provided. The suggested approach is not sensitive to outliers and more accurate and explainable outcomes can be provided. The correlations and coefficients for entire and two-piece structures have been produced and discussed.

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## “BOOTSTRAPING” METODA BAZIRANA NA MINIMALNOJ KOVARIJANSNOJ DETERMINANTI ZA PROCENU PODATAKA O DOLASCIMA PUTNIKA U VAZDUŠNOM SAOBRAĆAJU

Upravljanje vazdušnim putovanjima je specifičan proces jer uključuje različite vrste neizvesnosti kao što su nekontrolisana mobilnost putnika, varijabilni troškovi, kao i vanredna ograničenja poput pandemije Covid-19. Zbog toga je potrebna upotreba robusnih i ponovljivih statističkih evaluacija u uslovima nesigurnosti. Kamen temeljac ove studije je prilagođavanje pokretanja i robusne procene parametara zasnovane na minimalnoj kovarijansnoj determinanti (MCD) u okviru heterogenog procesa. Pored toga, studija uključuje novu implementaciju “bootstrapping” regresije. Metodološki razvoji testirani su podacima o vazdušnom saobraćaju Srbije. Rezultati su pokazali da kombinovanje robusnog estimatora i “bootstrapping” sistema pruža neke prednosti za određivanje odstupanja, a takođe i za izradu napredne dijagnostike. Tako je uveden najsavremeniji pristup zasnovan na tačnosti, ponovljivosti i transparentnosti i prikazana je njegova upotrebljivost u procesu mobilnosti u vazdušnom saobraćaju.

**Ključne reči** : Putovanje avionom; Robust estimator; Bootstrapping; Korelacija.