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МЕЂУНАРОДНИ ЧАСОПИС
ЗА ЕКОНОМСКУ ТЕОРИЈУ И ПРАКСУ И ДРУШТВЕНА ПИТАЊА

ЕКОНОМИКА

Часопис излази четири пута годишње Година LXXII, I-III 2026, број 1

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START-UPS AND OPPORTUNITY ENTREPRENEURSHIP IN DIGITAL ENVIRONMENT: GEM BASED

Abstract

Entrepreneurship is a very complex process, and regardless of motivation, factors such as environment and perception play a significant role. In the digital era, digital technology creates specific circumstances that enable a new nature of entrepreneurship. As a result, digital era provides specific conditions for the creation of entrepreneurial ventures and changes to the context of entrepreneurship. The use of digital technologies opens up new opportunities for entrepreneurs to launch new business ventures and stimulate new entrepreneurial activities - start-ups. Consequently, high levels of social, economic, and technological development within an economy creates a business environment that provides greater opportunities for opportunity-driven entrepreneurship and start-up activities. The main goal in this paper is to identify the role of the digital business environment and opportunity-driven entrepreneurship to generate start-up activities. In this research area, 18 variables were grouped into three constructs to investigate the previously mentioned three research units. In the paper, three new variables were generated in the form of a regression factor result by grouping the previously mentioned individual variables. To verify the research hypothesis, multiple regression was used, in which all independent variables are simultaneously entered into the equation, which then evaluates the predictive power of each variable individually. The paper used a sample of 49 countries classified into three groups according to the methodology of the World Economic Forum (WEF). The GEM project was used for the purposes of quantitative procedures in this paper regarding the mentioned variable groups. As a result of the previously defined research model and functional dependencies between the variables, where Start-ups represent the function of Opportunity Entrepreneurship and Digital Environment, the basic research

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hypothesis is confirmed, in that there is a positive correlation between Start-ups as a dependent variable and Digital Environment and Opportunity Entrepreneurship as independent variables at the level of statistical significance. Finally, the study offers theoretical and practical implications for increasing intentions toward digital entrepreneurship and launching start-ups based on opportunities. Furthermore, findings contribute to the understanding of entrepreneurship in the digital environment. The limitation is reflected in the business environment as well as the degree to which the economy develops, which determine the availability of the digital environment, typical for countries with a high level of development.

Key words: *Entrepreneurship, Opportunity Entrepreneurship, Start-up, Digital Environment*

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ПОЧЕТНИ ПРЕДУЗЕТНИЧКИ ПОДУХВАТИ И ПРЕДУЗЕТНИШТВО ЗАСНОВАНО НА МОГУЋНОСТИМА У ДИГИТАЛНОМ ОКРУЖЕЊУ: ЗАСНОВАНО НА ГЕМ ПРОЈЕКТУ

Апстракт

Предузетништво је веома сложен процесс, независно од мотивације, оно се налази под утицајем фактора као што су окружење и индивидуална перцепција. Дигитална ера омогућава сасвим нову природу предузетништва креирајући специфичне околности засноване на дигиталнолној технологији, мењајући на тај начин контекст предузетништва и креирајући специфичне услове за креирање предузетничких подухвата. Дигиталне технологије креирају могућности за предузетнике у сврху покретања нових пословних подухвата и стимулишу нове предузетничке активности Тако већи степен друштвено, економског и технолошког развоја једне привреде креира пословно окружење које пружа боље услове и пословне прилике за оппортуниту – дривен ентрепренеурсхип и генерисање старт-упс активности. Основни циљ који се поставља у овом раду представља идентификовање улоге дигиталног пословног окружења и предузетништва заснованог на могућностима на генерисање старт-упс активности. Подручје истраживања чине претходно поменуте три истраживачке истражене помоћу 18 варијабли груписаних у три конструкта. У раду су у виду регресионог факторског резултата генерисане три нове варијабле груписањем претходно наведених појединачних варијабли док је помоћу вишеструке регресије као основне методе спроведена провера истраживачке претпоставке, чија је основна специфичност да се све независне променљиве истовремено уносе у једначину чиме се оцењује предиктивна моћ сваке независне променљиве појединачно. У раду се користио узорак од 49 земаља разврстаних у три групе према методологији Њорлд Ецономиц Форум (ЊЕФ). База која је коришћена у раду за потребе квантитативних поступака када су у питању наведене групе варијабли ГЕМ пројекат. На основу претходно дефинисаног модела истраживања и дефинисања функционалних зависности између одабраних варијабли где

Старт-упс представља функцију Оппортуниту Ентрепренеурсхип и Дигитал Енвиронмент потврђена је основна истраживачка претпоставка, односно као резултат истраживања може се навести постојање позитивне корелационе везе на нивоу статистичке значајности између Старт-упс као зависне променљиве и Дигитал Енвиронмент и Оппортуниту Ентрепренеурсхип као групе независних варијабли. На крају, студија пружа теоријске и практичне импликације за повећање намера ка дигиталном предузетништву и покретању стартапова заснованих на препознатим приликама. Такође, резултати доприносе разумевању предузетништва у дигиталном окружењу. Ограничење се огледа у природи пословног окружења и степену привредне развијености националне економије што одређује услове доступности дигиталног окружења, што је типично за земље са вишим нивоом развоја.

Кључне речи: *Предузетништво, Предузетништво засновано на могућностима, Почетни пословни подухвати, Дигитално окружење*

Introduction

As a result of the shift towards digital products and processes during the last decade, the economic system and innovation activities have undergone a significant transformation (Porter & Heppelmann, 2015). This emerging digital paradigm is characterized by the reproducibility, distributedness and generativity of digital objects, which has boosted the global growth of start-ups in the high-tech (digital) sector (Nambisan et al., 2019). With the help of ICT, digital businesses can bring sustainability through new entrepreneurial opportunities (Faludi, 2023). With the digital revolution, open search and business models have undergone a significant change in recent years (Guo, 2023).

Researchers have identified the need for greater attention to entrepreneurship within the digital context for the development of knowledge through innovative concepts, constructs and models regarding the creation of digital start-ups (Fernandes et al., 2022). Global business environments are being transformed by digital transformation (Qasim et al., 2024). Digital transformation is changing many aspects of how people work (Schwarzmüller et al., 2018). Moreover, digital transformation requires leaders to quickly adapt existing approaches in today's highly dynamic environment. Business and IT leaders need to collaborate (since technology and leadership skills are complementary), and new approaches should be adapted to respond to changes in the competitive and technological environment (Hansen et al., 2011; Ko et al., 2022; Philip & Gavrilova Aguilar, 2022). Entrepreneurs can create and exploit new types of business opportunities, such as the development of innovative products and services, the creation of innovative business models as well as venture financing, by leveraging digital technology, including digital platforms and digital infrastructure (Berger et al., 2021). Consequently, digital technology strongly influences new ventures' business approaches within the entrepreneurial process in order to initiate changes and generate income, based on growing flexibility and openness, encouraging implementation, reducing uncertainty, and developing and improving digital innovations continuously (Berger et al., 2021).

It has been demonstrated in previous research that the continuous evolution of digital technologies has significantly influenced entrepreneurial conditions, entrepreneurial processes, and entrepreneurial outcomes, which has had a significant impact on how entrepreneurship is implemented in practice. In this way, the digital environment provides business opportunities and conditions for opportunity entrepreneurship, which previously affected the creation of start-up activities.

The aim of the paper is to identify the role of a high-tech (digital) environment and opportunity entrepreneurship in encouraging start-up activities.

Defining a model as the basis for this study is considered a major contribution to research originality. This is accomplished by combining three selected constructs that are both specific and mutually conditioned, namely digital environment, opportunity-based entrepreneurship, and start-up activities. In this model, three complementary constructs explain how the digital environment creates conditions for opportunity-based entrepreneurship, which in turn leads to start-ups.

Three basic sections make up the structure of the paper, along with an introduction and conclusion. In Section 2, the theoretical foundation for the research area is described within the framework of the conceptual model created with research units such as low-tech (digital) environments, opportunity entrepreneurship, and start-up activities. In Section 3, the methodology used in the paper based on the *Regression factor score* is described to generate new variables, as well as a standard multiple regression based on the conceptual framework. Section 4 contains the analysis and interpretation of the research results, while Section 5 provides concluding considerations.

Theoretical Background

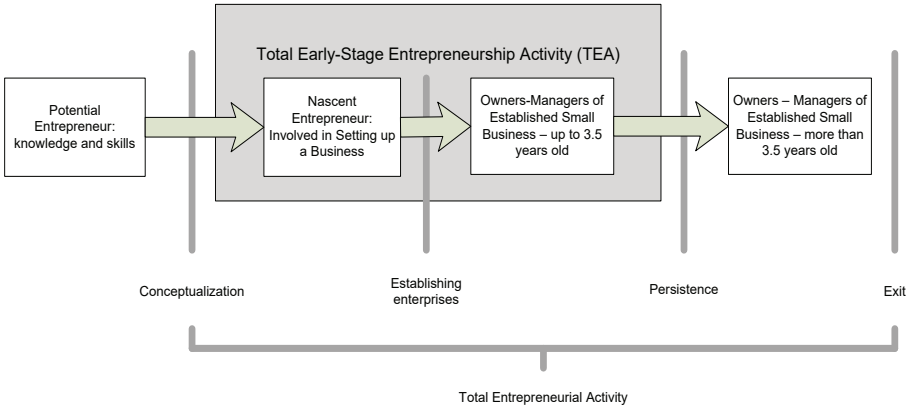
Start-ups are organizations in the early stage of the development process, or entrepreneurial ventures in the initial stage of the entrepreneurial process. As compared to start-ups and new ventures, large companies/corporations have larger resources, but are more inert and slower to react to changing environments (Muliawan et al., 2022). On the other hand, start-ups are naturally flexible and in the short term utilize the opportunities presented by their operating environment due to a lack of resources as a limiting factor for growth and business (Jayanagara & Wuisan, 2023). By learning from others' experiences and failures, start-ups increase their chances of success and speed up their learning (Hegeman et al., 2024). The following characteristics are attributed to start-ups by some authors: founded less than a decade ago, have a significant increase in employment and/or sales or have an aspiration towards the mentioned goals, and/or are innovative in terms of the technology they use as well as in terms of the business model (Kollmann, et al., 2023). According to Parthasarathy (2022), start-ups are viewed as a form of entrepreneurship emphasizing their ability to find innovative solutions to problems as well as their fundamental contribution to the growth of individual countries and the global economy. Inegbedion et al. (2024) additionally point out that production innovation and differentiation serve as a significant incentive for the growth of SMEs and competitiveness. Since the data collected and presented by the GEM (Global Entrepreneurship Monitor, 2025) project will be used to test hypotheses and scientific conclusions in this paper, the same approach will be applied to defining and understanding start-up organizations or activities within a more broadly defined entrepreneurial process.

By doing so, the entire scientific paper becomes consistent, increasing the importance and relevance of the study results.

Start-Ups and Digital Environment

Today, digital entrepreneurship is a growing phenomenon. A growing body of literature has attempted to understand this phenomenon, but it has largely focused on free market digital start-ups. It is unclear, however, how a startup could digitally transform its business through entrepreneurial actions in order to overcome regulatory challenges and barriers (Dong, 2019). Identifying entrepreneurs as bearers of entrepreneurial activity and the entire entrepreneurial process - from identifying a business opportunity, creating an entrepreneurial venture (nascent, start-up), to acquiring ownership and management of an established company, are precisely defined phases within the framework of observing the entrepreneurial process according to the GEM methodology, and in particular identifying, delimiting, and defining start-up activities. The flow chart in Figure 1 illustrates all of the above. As it can be seen, start-ups refer to Total Early-Stage Entrepreneurial Activity (TEA), which includes emerging and nascent ventures as well as established ventures/organizations up to 3.5 years old. The above mentioned is depicted in gray in Figure 1.

Figure 1. GEM approach to defining the entrepreneurial process



Source: GEM Project

It is true that many influential companies, such as Apple, Google, Amazon, Facebook, Uber, were founded as digital start-ups by taking advantage of digital technologies and doing exactly what Schumpeter described. As a result, companies were founded, achieved significant, and above all, rapid growth, and disrupted a number of existing organizations operating in stable and balanced conditions in different economic sectors. The entrepreneur is the central figure in all of these events (Leković & Marić, 2017).

Generally, the basic advantage of start-ups in the innovation process is reflected in appropriate response and behavior, while the basic limitation is related to the issue of resources (Leković & Marić, 2016). Consumers have played a pivotal role in startups' success thanks

to digital technology (Chen, 2023). However, entrepreneurs often lack the knowledge and experience to create a sustainable business strategy based on a digital platform that would guarantee success for new products and services on the market during the commercialization process (Ajah, 2023). Accordingly, the above-mentioned shortcoming is identified in the majority of entrepreneurs, regardless of the level of technological advancement of the entrepreneurial venture and digitization of businesses. Entrepreneurial ventures (start-ups), through their creation and dissolution, introduce a dynamic imbalance or state of disequilibrium, enabling them to sometimes outperform larger, established entities (Leković & Marić, 2012). Digital entrepreneurship emphasizes openness, but it is unclear how digital startups, which build their business models around digital artifacts, actually realize value from OSC engagement (Lin, & Maruping, 2021). The paper explains that digital startups develop in liminal spaces where founders experience disorientation, ambiguity and uncertainty continuously.

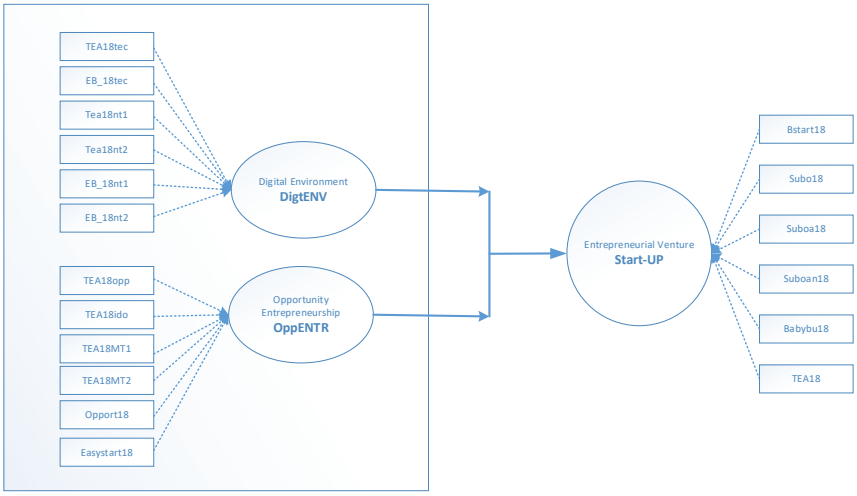
Opportunity Entrepreneurship and Digital Environment

Increasingly mature digital technologies, such as AI, big data, and the Internet of Things, have driven a new wave of innovation and entrepreneurship across the globe (Wang et al., 2022). Opportunity Entrepreneurship is unerring in identifying and realizing value-creating business opportunities through innovative solutions (Carayannis et al., 2012). There are two categories of entrepreneurial activities described by the GEM project as two extremes - necessity entrepreneurship and opportunity entrepreneurship (Block & Wagner, 2010). Despite having other employment options, opportunity entrepreneurs usually engage in entrepreneurship to increase their own income (Sautet, 2013). When the business environment is unfavorable, citizens may need to turn to necessity entrepreneurship, even in an informal way, as a survival strategy (Williams et al., 2017). Accordingly, the extent of opportunity-driven entrepreneurship in a country is determined by its economic development. The development of technology plays an important role in enabling entrepreneurship (Afawubo & Noglo, 2022), while digitization plays a crucial role in stimulating the development of business ideas. Digital technologies create opportunities for entrepreneurs to launch new business ventures and stimulate new entrepreneurial activities (Del Giudice & Straub, 2011). When it comes to start-up organizations, there is a special complementarity between entrepreneurship, especially opportunity-driven entrepreneurship, and ICT. Thus, a wide range of economic branches are being transformed, in that a single, significantly changed business environment is created that is conditioned by the mentioned technology. The digital business environment is a result of the development of the aforementioned technologies, which cannot be stopped, so business adaptation and evolution become crucial. Therefore, digital technologies become indispensable tools for entrepreneurs to maximize resources and generate value (Gomes & Lopes, 2022).

Furthermore, digital technologies play a crucial role in ensuring economic growth and increasing productivity (Higón, 2017). Businesses can gain a competitive edge in today's business environment by integrating digital technologies, which provide them with a valuable and diverse source of resources (Zhang & Li, 2018). Digital technology simplifies numerous business operations, generating the basis for the development of entrepreneurship, especially opportunity entrepreneurship, across various economic sectors. In the first place, digital technologies help identify and develop new ideas and opportunities, such as expanding businesses into new markets and forming business partnerships, while they also engage

entrepreneurs in continuous innovation (Alderete, 2017). Moreover, digital technologies ensure communication and facilitate networking with suppliers, which are essential components of entrepreneurial success. The use of digital technologies in business operations can optimize business processes, reduce transaction costs, and facilitate information exchange. However, a growing number of successful digital startups and their performance in commercialization remain influenced by a number of factors, such as a lack of qualified personnel, a lack of financial resources, unfavorable government regulations, and a digital divide in rural areas. Entrepreneurs can create sustainable competitive advantages thanks to high-quality and extensive information provided by digital technologies. In knowledge-based economies, actual entrepreneurs are also involved in the dissemination and acquisition of knowledge, which is the key to transforming and integrating knowledge into competitive advantages (Cuevas-Vargas et al., 2022). By creating specific circumstances based on digital technology, the digital era has enabled a completely new form of entrepreneurship, changing the context of entrepreneurship and creating specific conditions for entrepreneurial ventures (Marić et al., 2023). Entrepreneurs are capitalizing on the mentioned opportunities in the digital age, which signifies a shift towards high-tech sectors. In other words, technology-based entrepreneurship refers to businesses that change their business models from traditional to digital. A broader understanding can refer to the continual change of our civilization, facilitated by technology, in this case digital one, which results in the digitization of the economy and society as a whole (Boneva, 2018).

Figure 2: Conceptual Framework



Source: the authors

(1) Start-UP = f (DigENV, OppENTR)

We gain a better understanding of start-up activities using digital technologies thanks to the theoretical framework developed in this study. In addition to offering theoretical and empirical insights, it provides valuable guidance for researchers. In particular, it outlines practical strategies for digital businesses and market penetration, helping digital startups become sustainable and successful.

Methodology

Using the available database of the GEM project as a secondary source, research was conducted on a sample of 49 countries, which were divided into three different categories based on their economic development status, based on the WEF (World Economic Forum, Schwab 2009) methodology. One group comprises factor-driven economies with low income (less than $25,000) which make up 14.28% of the sample; the second group consists of efficiency-driven economies with medium income (between $25,000 and $50,000) which make up 20.40% of the sample; and the third group of innovation-driven economies with high income (greater than $50,000), which make up 61.22% of the sample. In the mentioned database, the first group of variables reflects the digital environment, the second group reflects opportunity entrepreneurship, and the third group reflects start-up activity. A list of 18 variables from three research units was selected for the research. Considering the large number of variables, the variables were selected in accordance with the research concept, followed by a quantitative analysis using the Regression Factor Score to group the variables. Based on the analysis of the mentioned method, three factors (groups of variables) were identified, i.e. three new variables were formed: Digital Environment, Opportunity Entrepreneurship, and Start-ups. The advantage of creating new variables using the regression factor lies in its ability to represent new, more complex variables in the form of economic or social phenomena, as opposed to available regression analyses that focus on the relationships between individual characteristics.

The construct **highly technological (digital)** comprises individual variables within REGR factor score 1:

Table 1. High technology (digital) environment – DigitENV

TEA_tec	TEA: Active in technology sectors (high or medium)
EB_tec	EB: Active in technology sectors (high or medium)
Tea_nt1	TEA: Uses very latest technology (only available since last year)
Tea_nt2	TEA: Uses new technology (1 to 5 years)
EB_nt1	EB: Uses very latest technology (only available since last year)
EB_nt2	EB: Uses new technology (1 to 5 years)

Source: GEM Project Database

The analysis considers all 49 cases valid, which is 100.00% of the sample. Cronbach Alpha for this variable is 0.676 suggesting marginal reliability and internal consistency of the Digital Environment scale for this sample. A value of 0.70 is considered acceptable, but a value over 0.80 is preferred.

The construct **Opportunity Entrepreneurship** comprises individual variables within REGR factor score 2:

Table 2. Opportunity Entrepreneurship – OppENTR

TEA18opp	TEA and Opportunity motive
TEA18ido	Improvement Driven Opportunity motive: independence or increase income
TEA18MT1	Opportunity motive: increase income
TEA18MT2	Opportunity motive: independence
Opport18	Good conditions to start business next 6 months in area I live
Easystart18	Easy to start a business

Source: GEM Project Database

According to the analysis, 43 out of 49 cases are valid, which represents 87.80% of the sample. Cronbach Alpha for this variable is 0.738 suggesting acceptable reliability and internal consistency of the Opportunity Entrepreneurship scale for this sample. A value of 0.70 is considered acceptable, but a value over 0.80 is preferred.

The construct **Start-ups** comprises individual variables within REGR factor score 3:

Table 3. Start-ups – StartUPS

Bstart18	YES: Currently involved in business start-up
Subo18	Currently starts business and will be (part) owner
Suboa18	Starts business, active past year and will be (part) owner
Suboan18	START-UP/NASCENT (SU): active past year, (part) owner, no wages yet
Babybu18	BABY BUS OWNER (BB): owns-manages business with income<3.5 year
TEA18	Setting up firm or owner of young firm (SU or BB)

Source: GEM Project Database

The analysis considers all 49 cases valid, which is 100.00% of the sample. Cronbach Alpha for this variable is 0.936 suggesting acceptable reliability and internal consistency of the Start-ups scale for this sample. A value of 0.70 is considered acceptable, but a value over 0.80 is preferred.

These new variables result from the high linear interdependence of the individual measures within the three factors, which is indicated by the high value factors.

The method of standard multiple regression, used in this paper, enables a set of predictor variables to predict a certain outcome. As a result, a model presents the functional interdependence between variables Digital Environment and Opportunity Entrepreneurship, and identifies which variable represents the best predictor, considered individually. Furthermore, this method can be used to determine how much of the unique variance of the dependent variable, in this case Start-ups, is explained by each independent variable.

Following the previously defined model (Figure 1), where *Start-ups* represent the function of *Opportunity Entrepreneurship* and *High-Tech (Digital) environment*, we set the following basic research hypothesis:

H1: There is a positive direct correlation at the level of statistical significance between the volume of Start-up activities as a dependent variable and Opportunity Entrepreneurship and Digital Environment as a group of independent variables.

Research Results and Discussion

Prior to interpreting and analyzing the results of the quantitative research, it is necessary to check whether the assumptions are met for multiple regression. Consequently, the reliability of quantitative procedures is ensured as well as confirmation of set conceptual models and reasoning processes that are based on research findings. When it comes to evaluating the mentioned assumptions, an emphasis should be placed on the correlation between variables within the set model. As long as a group of independent variables have a weak correlation of 0.3 or higher with a dependent variable, the conditions are satisfied. Even a weak correlation between the variables and the dependent variable is preferred. In this case, DigitENV and OppENTRE, with coefficients 0.276 and 0.332, respectively, meet the stated condition, since a minimum of 0.3 is preferred. Moreover, the independent variables should not show strong correlations. As a result, variables with correlations exceeding 0.7 should not be included in the analysis, and these variables do not exist in this case. Correlation matrix data does not show collinearity between variables, a condition that needs to be checked when there is multiple correlation. The results of this type of analysis are presented in the table Coefficients in the *Tolerance* and *VIF (Variance inflation factor)* columns. *Tolerance* shows how much of the dependent variable is not explained by the variances of the independent variables in the model. A small value (less than 0.1) indicates a significant correlation with other variables, i.e. multicollinearity. According to the values obtained from the table in the specified columns, the mentioned problem of this type does not exist. The next essential condition includes atypical points, normality, linearity, and homogeneity of variance. The Normal P-P Plot diagram shows that all the points are grouped around a straight diagonal line from the lower left to the upper right corner, indicating that there is no significant deviation from normality. It is also important to pay attention to the scatter plot of the standardized residuals or *Scatterplot*. There is a rectangular distribution of residuals and most of the results cluster in the center, which indicates that none of the assumptions of the model are violated.

Table 4 Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.455[a]	.207	.167	.91254593

a. Predictors: (Constant), REGR factor score 1 for analysis 3_DigitENV, REGR factor score 1 for analysis 2_OppENTRE

b. Dependent Variable: REGR factor score 1 for analysis 1_Start-Ups

Source: the authors

Having verified the assumptions of the quantitative method model, the process of model evaluation can begin. When evaluating the model, the starting point is the squared value of the coefficient of determination, presented in this paper in Table 4 titled Model Summary in the R Square column, which in our case is $r^2 = 0.207$. This coefficient shows how much of the variance of the dependent variable *Start-ups* is explained by the set model that includes the group of independent variables *Digital Environment* and *Opportunity Entrepreneurship*. The value of this indicator is 20.70%, meaning that the model set in this paper explains 20.70% of the variance of *Start-ups*, which is an acceptable result for this

sample size. Due to all the characteristics of the sample, it is not necessary to include the adjusted value of the given indicator (Adjusted R Square).

Table 5 ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.690	2	4.345	5.218	.010[b]
	Residual	33.310	40	.833		
	Total	42.000	42			

a. Dependent Variable: REGR factor score 1 for analysis 1_Start-Ups

b. Predictors: (Constant), REGR factor score 1 for analysis 3_DigitENV, REGR factor score 1 for analysis 2_OppENTRE

Source: the authors

Table 5, ANOVA - analysis of variance, presents statistically significant coefficients of determination for the presented model, and the null hypothesis test results, where $r^2=0$. Since the value of Sig p = 0.010, which actually means that p<0.05, the model reaches statistical significance. In order to determine the contribution of each variable in the model for predicting the dependent variable *Start-ups*, the values presented in Table 6 Coefficients, in the Beta column, in the segment standard coefficients, must be analyzed. Our first step is to determine which independent variable is contributing the most, which is *Opportunity Entrepreneurship* with a Beta value of 0.364. This means that this variable contributes to the explanation of the dependent variable in a relative amount of 36.40%. By adding p = 0.014 from column Sig., we conclude that this individual contribution is statistically significant in predicting the dependent variable.

Table 6 Coefficients[a]

Model		Unstandard Coefficients		Standard coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Toler	VIF
1	(Constant)		.139	.000	1.000		-.281	.281					
	REGR factor score OppENTRE	.364	.142	.364	2.569	.014	.078	.650	.332	.376	.362	.990	1.01
	REGR factor score DigitENV	.313	.142	.313	2.211	.033	.027	.599	.276	.330	.311	.990	1.01

a. Dependent Variable: REGR factor score 1 for analysis 1_Start-Ups

Source: the authors

Digital Environment is the next largest variable based on the set model and correlation coefficient, with a Beta coefficient of 0.313, contributing to 31.30% of the predicted dependent variable. Based on the Sig column value p = 0.033, we conclude that there is statistical significance in the individual contribution in predicting the dependent variable. As a result of the previous analysis of the results, the set research model can be fully confirmed. According to our findings, digital platforms have played a key role in entrepreneurship, answering research questions and clarifying key events leading to

digital entrepreneurship. Accordingly, the findings build on those of Taylor-Wesselink and Teulon (2021), as well as Makarainen-Suni (2021), providing an in-depth theoretical analysis of the factors that motivate entrepreneurs to pursue innovative business opportunities on digital platforms. Hence, the results support the view that digital platforms facilitate crowdsourcing for product co-creation, which will create economic value for all parties (Hein et al., 2020). This paper, therefore, adds to the literature by showing how the openness and convergence of digital platforms have transformed the entrepreneurial process and extended market reach. The findings of this study advance knowledge in several other ways as well; it is further confirmed by conceptualizing the liminal experiences of digital entrepreneurs who engage in entrepreneurship in a digital context. Especially noteworthy is that the study echoes Ajah's (2024b) findings in that liminal experiences of founders during the development of digital startups are filled with ambiguity, disorientation, and uncertainty as a result of different environmental structures. The findings provide new insights into digital entrepreneurship by conceptualizing collaboration, adaptability, avoidance of problem investors, and cognitive engagement as the steps third-party developers can take to overcome challenges.

Conclusion

Previous research has demonstrated that the continuous evolution of digital technologies has greatly impacted the conditions, the process, and the outcomes of entrepreneurship, which has also significantly altered the way entrepreneurship is implemented in practice. Thus, the digital environment creates business opportunities and creates conditions for opportunity entrepreneurship, which previously affects the creation of start-up activities (Berger et al., 2021). Technology, in this case digital technology, and its improvement change the existing business conditions by providing new opportunities for some market actors and imposing limitations on others.

In fact, business opportunities within the digital business environment are not exclusively aimed at the IT sector, as their influence is spreading across the whole economy as well. In other economic branches, digital technologies are helping to eliminate traditional forms of business by innovating products and services, business models, and business processes. Considering the research conducted within the conceptual model and the research results, the conclusion is that the research hypothesis is confirmed, as evidenced by the fact that start-ups as a dependent variable and digital environment and opportunity entrepreneurship as independent variables have a positive correlation at the level of statistical significance. Additionally, the results of the research indicate the general goal of the paper, which is encouraging start-up activities based on opportunity entrepreneurship due to the development of a business environment based on digital technologies that encourages start-up activities.

Our conclusion follows from the results obtained from applying the basic method of multiple regression used in the paper, primarily as the square coefficients of determination, *R Square*, r^2=0.207. We conclude from the results interpretation that the group of independent variables in this study explains 20.70% of the variance of the dependent variable, in this case Start-up activities.

This paper interprets the presented research results in accordance with previous research findings, whose conclusions and values are presented as facts here, in order to

demonstrate that the digital business environment creates conditions for entrepreneurship and encourages start-up activities.

Finally, the study provides theoretical and practical implications for increasing digital entrepreneurship intentions and launching startups based on identified opportunities. Furthermore, the results contribute to a better understanding of digital entrepreneurship in digital environment.

The limitation is reflected in the nature of business environment as well as the degree to which the economy develops, which determine the availability of the digital environment, typical for countries with a high level of development. This limitation has direct implications for the GEM project, which for research purposes uses the WEF (World Economic Forum) classification of countries. Countries are classified into Factor-driven economies, Efficiency-driven economies, and Innovation-driven economies based on their GDP per capita as a classification criterion. A different level of economic development means different business opportunities based on the digital environment, and this can lead to different perceptions when interpreting the results if the research outcomes are not precisely delineated.

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CHALLENGES AND SOLUTIONS IN SUPPLY CHAIN RISK MANAGEMENT IN THE PETROLEUM INDUSTRY – A REVIEW

Abstract

This paper aims to analyze the key challenges and risks affecting supply chains in the petroleum industry. Through a systematic review of numerous scientific studies, including the state-of-the-art studies, the main factors that may disrupt the stability of supply chains have been identified. The study summarizes existing risks, such as geopolitical, environmental, climatic, market, economic, and technological factors. Additionally, the paper aims to propose potential solutions to mitigate the negative impact of these risks on the petroleum industry supply chains. Considering the increasing complexity of global energy markets and the growing emphasis on sustainability, enhancing the resilience of supply chains is essential for maintaining operational efficiency and long-term competitiveness in the industry. The originality of this review is that it brings geopolitical, environmental, economic, technological, and reputational risks into a single framework and supports the analysis with comparative tables of mitigation strategies, offering a more integrated view of petroleum supply chain risks.

Key words: *SC, petroleum industry, risk, SCM*

JEL classification: *L0*

ИЗАЗОВИ И РЕШЕЊА У УПРАВЉАЊУ РИЗИЦИМА У ЛАНЦИМА СНАБДЕВАЊА У НАФТНОЈ ИНДУСТРИЈИ – ЛИТЕРАТУРНИ ПРЕГЛЕД

Апстракт

Овај рад има за циљ да анализира кључне изазове и ризике који утичу на ланце снабдевања у нафтној индустрији. Кроз систематски преглед бројних научних студија, укључујући и најновија истраживања, идентификовани су главни фактори који могу нарушити стабилност ланаца снабдевања.

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Студија сумира постојеће ризике, као што су: геополитички, еколошки, климатски, тржишни, економски и технолошки ризици. Поред тога, рад има за циљ да предложи потенцијална решења за ублажавање негативног утицаја ових ризика на ланце снабдевања у нафтној индустрији. С обзиром на све већу сложеност глобалних енергетских тржишта и растући значај одрживости, јачање отпорности ланаца снабдевања кључно је за одржавање оперативне ефикасности и дугорочне конкурентности у овој индустрији. Оригиналност овог рада огледа се у томе што сагледава геополитичке, еколошке, економске, технолошке и репутационе ризике у оквиру једне целине и употпуњује анализу прегледним табелама, пружајући јаснији и целовитији увид у ризике у ланцима снабдевања у нафтној индустрији.

Кључне речи: *Ланци снабдевања, нафтна индустрија, ризик, менаџмент у ланцима снабдевања*

Introduction

One of the most important raw materials in the world is oil. It has been one of the leading energy sources in the period of the last seven decades, and it also significantly affects the growth of other industries (Lisitsa et al., 2019). Besides oil, gas represents one of the most important drivers of industrial processes. According to (Gardas et al., 2019) supply chains of the oil and gas industry are very long. In all sectors of the petroleum industry, upstream, midstream, and downstream, supply chains can be considered as the backbone but also the bottlenecks. Numerous service companies have to work together in order to achieve the final tasks of all three sectors. Moreover, these sectors need to be connected and work together to accomplish the main task of the petroleum industry: distribution of the final product to the end users. Assuming everything said, the oil and gas industry has to have a great collaboration among different sectors' supply chains. (Piya et al., 2022; Raut et al., 2017).

A variety of risks that might negatively affect various operations in the petroleum industry can be identified. The risks that range from logistical disruptions, across geopolitical threats and environmental incidents, to market instability, have the potential to disrupt business continuity, increase costs, and threaten the viability of the industry. Supply chain risks can be classified as one of the most notable risks in the petroleum industry because supply chains can be considered as very fragile. For instance, supply chain disruptions in the petroleum industry can be provoked by political instability in certain countries that are among the leading ones in the world in terms of oil and gas distribution to end users, which is happening nowadays. Moreover, global crises can affect supply chains as well. The COVID-19 crisis has affected the supply chains of almost every industry, including the petroleum industry. (Milenković & Milovanović, 2024; Piya et al., 2022). Additionally, modern environmental legislations have to be implemented in traditional supply chains that need to balance economic and operational efficiency and environmental standards (Ahmad et al., 2017).

Moreover, the development of digital technologies, such as the Internet of Things (IoT), artificial intelligence (AI) and blockchain, has opened up new opportunities for

improving risk management in supply chains (Shahzadi et al., 2024). IoT sensors enable monitoring of critical points in real time, artificial intelligence supports predictive analysis to identify potential risks, while blockchain contributes to transparency and security in procurement and delivery processes. However, despite these technological advances, dealing with risks in supply chains requires a comprehensive and integrated approach, which combines traditional risk management strategies with innovative technological solutions.

Supply chain risk management (SCRM) defines, evaluates and reduces potential risks in supply chains in order to minimize risks of possible hazards, thus enhancing resilience. The petroleum industry is a high-investment industry, which means that financial risks are common, so the need for prediction and mitigation of potential risks is high (Fazli et al., 2015). This systematic approach addresses risks specific to the petroleum industry, including supply-side disruptions, logistical inefficiencies, and operational hazards. As already said, the COVID-19 pandemic reshaped the industry sectors drastically (Szczygielski et al., 2022), so it emphasized the importance of improving powerful mechanisms to manage all the challenges, expected and unexpected ones. Moreover, complex supply chains, such the ones in the petroleum industry, are more vulnerable that the simpler ones (Fazli et al., 2015; Miner et al., 2024).

The supply chains of the petroleum industry require a thorough approach that considers evolving standards and technologies to be able to ensure adaptive resilience in the face of diverse challenges.

The aim of this paper is to investigate and analyse the key risks in the supply chains of the oil industry, identify opportunities for improving the management of those risks and analyse the potential of digital technologies in the optimization of supply chains. This paper provides a theoretical contribution to risk management research in the context of the petroleum industry. The analysis will include a literature review, a discussion of current challenges, and a proposal for strategies to improve the resilience and sustainability of supply chains. Research results can be useful both for the scientific community and for practitioners in industry, providing them with concrete guidelines for risk reduction and process optimization.

Accordingly, the central research question of this review paper is: How can the petroleum industry effectively identify and mitigate risks in supply chains in order to enhance resilience and sustainability in a rapidly changing global environment?

Methodology

Review Process

To conduct a comprehensive and adequate literature review, Google Schoolar, KoBSON and ResearchGate have been used. Moreover, some information were collected from the websites sucha as IEA and UN. The process of writting this paper began with searching and downloading the scientific articles related to supply chains (SC), supply chain management (SCM), supply chain risk management (SCRM), green supply chain management (GSCM), oil and gas (O&G) industry and sustainability. Duplicate papers were subsequently removed. A detailed reading of articles have been performed in order to identiy

studies that are relevant to the topic of this paper. This research is based on 59 references: 2 from 2015, 5 from 2016, 3 from 2017, 2 from 2018, 5 from 2019, 3 from 2020, 3 from 2021, 6 from 2022, 8 from 2023 and 22 from 2024. Taking into consideration the fact that more than 61% of the references used in this paper have been published in the previous 3 years, and more than 81% of it have been published in the last 6 years, it can be said that this paper represents a-state-of-the-art review paper. More than one-third of the primarily downloaded articles were found incompatible for this research and have been ignored.

Literature Eligibility Criteria

Inclusion criteria were: studies published in peer-reviewed journals or conference proceedings, written in English, and focusing on supply chain risks in the petroleum industry, particularly those published in the last 5–6 years. Exclusion criteria included papers outside the energy sector, studies without clear methodological grounding, non-scientific sources (reports, news articles), and papers older than 10 years unless considered seminal works.

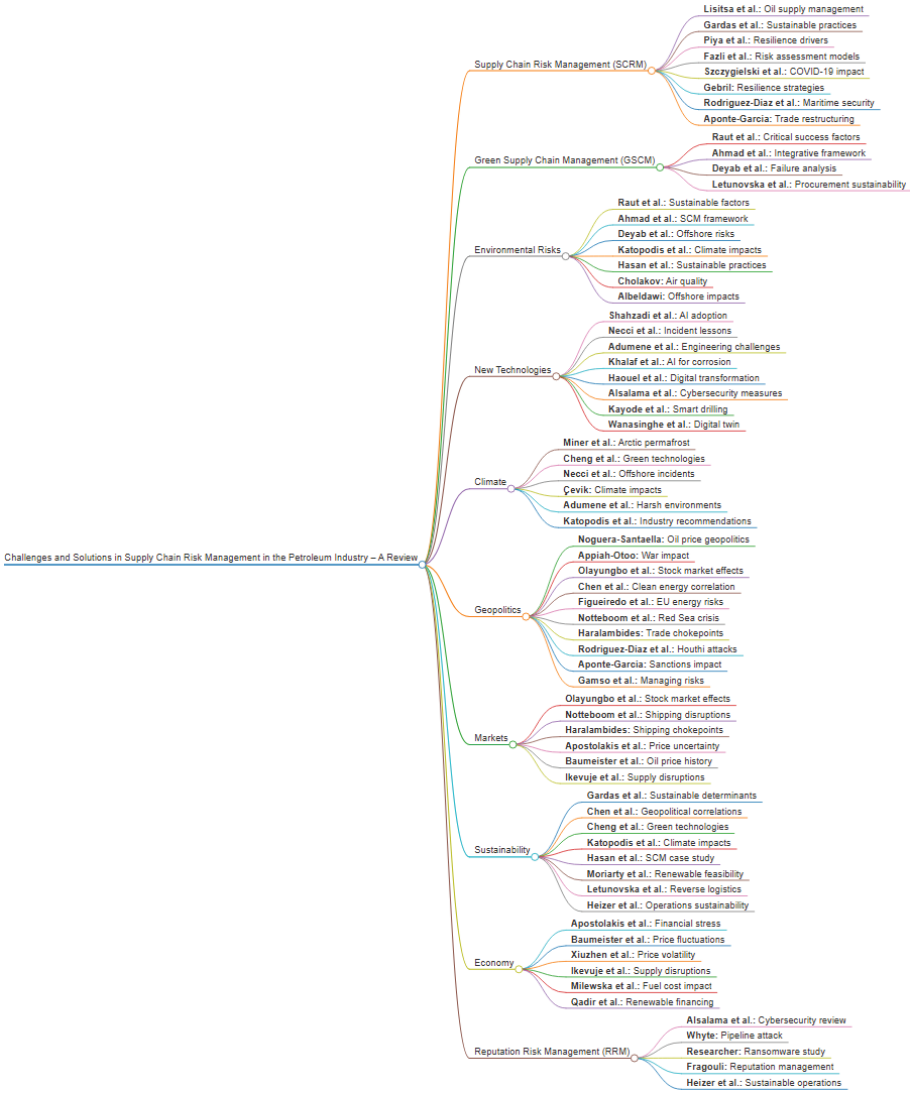
The mind map (Figure 1) illustrates the thematic structure of the paper "*Challenges and Solutions in Supply Chain Risk Management in the Petroleum Industry – A Review*" by organizing references under key thematic areas.

The central topic is the **Challenges and Solutions in Supply Chain Risk Management in the Petroleum Industry**, branching into ten key thematic areas:

1. **Supply Chain Risk Management (SCRM)**: Focuses on strategies, resilience drivers, and risk assessment models.
2. **Green Supply Chain Management (GSCM)**: Highlights sustainable practices and procurement frameworks.
3. **Environmental Risks**: Covers impacts from climate change, offshore operations, and air quality.
4. **New Technologies**: Includes advancements like AI, digital twins, and cybersecurity.
5. **Climate**: Discusses climate change effects, Arctic permafrost, and extreme weather challenges.
6. **Geopolitics**: Analyzes impacts from oil price wars, conflicts, and chokepoints like the Red Sea.
7. **Markets**: Examines oil price fluctuations, shipping disruptions, and stock market effects.
8. **Sustainability**: Addresses green technologies, reverse logistics, and renewable energy impacts.
9. **Economy**: Reviews financial stress, fuel costs, and renewable energy transitions.
10. **Reputation Risk Management (RRM)**: Focuses on cybersecurity, ransomware incidents, and reputation management.

Each branch includes references summarized with concise keywords that highlight their contribution to the topic. The structure clearly visualizes how different risk dimensions contribute to supply chain vulnerabilities in the petroleum industry.

Figure 1. The mind map.



The "References" section below contains the list of references for particular literary sources.

Review Results

This section presents a synthesis of literature findings on key categories of supply chain risks in the petroleum industry, while their broader implications and possible mitigation strategies are described and analysed in the Discussion section.

The petroleum industry represents one of the main factors in the world economy system because the demand and supply of petroleum products are vital for determining the state of the world economy, which means that changes in oil price will affect other markets (Abd El Ghany Gebril, 2024; Appiah-Otoo, 2023; Noguera-Santaella, 2016; Olayungbo et al., 2024). As already said, supply chains in the petroleum industry are complex systems that include many sectors that are tightly connected. Due to the nature of the petroleum industry, which relies on global operations and complex infrastructure networks, these chains are particularly vulnerable to various types of risks. The key risk factors in the petroleum industry will be analysed and discussed in this chapter.

Table 1: Categories of Supply Chain Risks in the Petroleum Industry

Risk category	Key authors	Main insights
Geopolitical risks	Figueiredo et al. (2022); Gamso et al. (2024); Heizer et al. (2020)	Wars, sanctions, market instability; diversification and exit strategies as mitigation
Climate & environmental risks	Çevik (2024); Katopodis & Sfetsos (2019); Miner et al. (2024); Necci et al. (2019)	Arctic challenges, extreme weather, logistics and safety issues
Market & economic risks	Baumeister & Kilian (2016); Olayungbo et al. (2024); Attia et al. (2019)	Oil price volatility, inflation, investment risks
Technological risks	Alsalama & Alzahrani (2024); Haouel & Nemeslaki (2023)	Cybersecurity vulnerabilities, AI and IoT adoption challenges
Reputational & social risks	Fragouli (2016); Arora & Lodhia (2017); Ahmad et al. (2023)	ESG standards, loss of community trust, brand damage

Geopolithical Risks

According to (Chen et al., 2024), international political events can have a great influence on the economy and global market, so it can be concluded that geopolitical risks are one of the key factors that can disrupt smooth business operations in the petroleum industry. These risks can influence petroleum exploration, production, transportation, refining and pricing mechanisms, and can be provoked by political, economic and social instabilities which can lead to international tensions (Figueiredo et al., 2022). According to (Cheng et al., 2023), detailed understanding of these types of risks is crutial in order to develop strategies that will minimize their potential negative consequenses.

Political instability in oil- or gas-producing regions, or in the regions that serve as a transit for hydrocarbons transportation, can affect SC in many different ways: conflicts, civil and political unrest, regime changes etc. Due to the political instabilities and military conflicts, such as the ones in Ukraine and Gaza, which have affected the logistics and shipping dynamics on one of the main routes for oil and gas transportation (Notteboom et al., 2024). For instance, the Red Sea crisis that started in October 2023 had a huge impact on maritime logistics and SC of many industries, including the petroleum industry (Haralambides, 2024). The Red Sea and the Gulf of Aden represent one of the most important interoceanic passages, with 8.8 million barrels of oil per day, which

represents 8.7% of daily global demand (Notteboom et al., 2024). The Bab al-Mandab Strait represents one of the keypoints for international trading of hydrocarbons because it is one of the two marine entrances to the Red Sea that is fairly important for importing of Persian Gulf oil to Europe (Haralambides, 2024). The hydrocarbon supply chain in the region of the Gulf of Aden and Bab al-Mandab Strait is highly vulnerable because of its location. The Gulf of Aden constantly faces issues such as piracy and smuggling, which is bad for the stability of secured trading (Haralambides, 2024; Notteboom et al., 2024). Moreover, the entire region of the Red Sea, including the Suez Canal, is the chokepoint for the traders because of the Houthi attacks, which led to a drastic decrease in shipping activities in this region because of the security issues (Rodriguez-Diaz et al., 2024).

Geopolitical rivalries can lead to economic sanctions. Previously mentioned, the Russia-Ukraine conflict can serve as a great example of geopolitical instability, destabilizing not only hydrocarbon supply chains in Europe but also in the world. As a response to the sanctions, Russian Federation has changed its policy for hydrocarbon commerce by transferring exports to non-sanctioning countries (Aponte-Garcia, 2024). It is well known that Russia is one of the greatest hydrocarbon producers in the world, and it is responsible for about 12% of the world's oil supplies. The military conflict that started in February 2022 had a huge impact on the oil price. Before the conflict, in January 2022, the oil price was around 74.17 USD per barrel, while in March of the same year, the price rose by around 73%, which equals 129.02 USD per barrel (Https:// Tradingeconomics.Com/Commodity/Crude-Oil, n.d.; Olayungbo et al., 2024). This increase directly disrupted the oil supply from the Russian Federation to the world's market, which affected global supply chains (Olayungbo et al., 2024).

Climate and Environmental Risks

Global warming, climate change and natural environmental hazards can have a dramatic influence on the petroleum supply chains, especially in upstream and midstream sectors (Çevik, 2024; Deyab et al., 2018; Necci et al., 2019). A great amount of petroleum reservoir rocks is located in coastal and offshore regions, as well as areas that are vulnerable to extreme weather conditions such as hurricanes, floods, droughts, high winds, low temperatures etc. (Adumene et al., 2023; Katopodis & Sfetsos, 2019).

Due to global warming, the icemelting is happening, making the Arctic and Sub-Arctic hydrocarbon reserves more and more accessible to the oil and gas companies. But the processes of exploration and extraction of hydrocarbons in such extreme weather conditions require well-organized logistics systems (Necci et al., 2019). The transportation of special and sophisticated equipment represents a big challenge for petroleum industry supply chains and risk management. Moreover, extreme weather conditions can dramatically affect employees. Because of this, it is crucial to predict and prevent possible situations that can negatively affect the integrity of the equipment and the workers' health. Disruption in one part of a supply chain will cause delays and possibly halts in the entire supply chain, so SCRM has to deal with these problems that can provoke financial losses for a company (Çevik, 2024). All the possible vulnerabilities have to be predicted and adequately treated to decrease any possibility of fatal accidents in terms of safety and financial losses in the extreme weather conditions. High winds, low

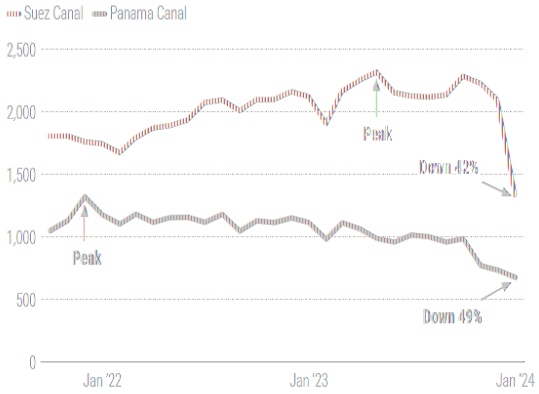
temperatures and storms are not the only challenges that supply chain risk management system has to deal with. Limited visibility and darkness, moreover presence of sea ice are also the challenges that need to be taken into consideration (Miner et al., 2024; Necci et al., 2019).

According to (Necci et al., 2019), the climate in the far northern parts of our planet is getting worse in terms of the strength of storms due to the climate change, which represents new environments for the upstream operations that SCRM has to deal with. This is confirmed by the statement of the authors (Deyab et al., 2018), who claim that equipment failure risk is directly related to the extreme weather conditions of the working environment, so the special risk management measures have to be implemented to stop or reduce hazardous events in the extreme weather conditions.

Moreover, global trend of rising temperatures can significantly impact oil and gas business in permafrost areas where melting of permafrost is happening which can lead to damage of exploitation and transportation infrastructure that have been build upon the permafrost (Miner et al., 2024).

When talking about climate effects, the Panama Canal is facing the problem of a decrease in the freshwater levels, especially in 2023 and 2024, which can dramatically affect SC of all the industries worldwide, including the petroleum industry. This issue can negatively affect the companies that want to ship their products all around the globe. Wait times are prolonged and tolls are higher, which represents another challenge to SCM of the petroleum industry (Notteboom et al., 2024).

Figure 2. This figure highlights how maritime chokepoints concentrate global petroleum flows, meaning that disruptions in only a few locations can create cascading effects worldwide. For the petroleum industry, this underlines the vulnerability of long supply chains to both geopolitical tensions and environmental shocks.



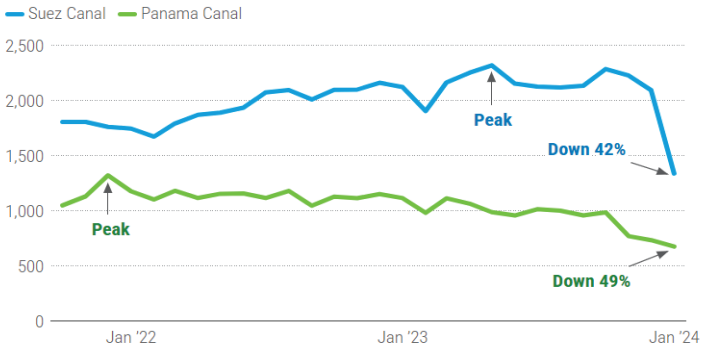
(Source: https://Periscopeglobal.Substack.Com/p/Revenge-of-Geography-Maritime-Chokepoints, n.d.)

It can clearly be seen from Figure 2 that the Panama Canal, Suez Canal and Bab el Mandab Strait are some of the key points for the shipping of petroleum products.

Drought in the Panama Canal and the Red Sea crisis, combined together, represent the event that gives the SCRM of the petroleum industry serious challenges that need to be solved while keeping financial losses as low as possible. This is the situation when multiple factors (geopolitical and climate) can affect SC in the same way.

Transits in the Panama and Suez canals in January 2024 have decreased by about 40% from their highest points since October 2021. While transits via the Panama Canal have been down for the past few years, the Suez Canal has seen a significant reduction as well (Figure 3) (https://Unctad.Org/Publication/Navigating-Troubled-Waters-Impact-Global-Trade-Disruption-Shipping-Routes-Red-Sea-Black?Utm_source=chatgpt.Com, n.d.).

Figure 3. The decline of transits through the Panama and Suez canals directly illustrates the impact of combined climate and geopolitical risks on petroleum supply chains. Reduced capacity in these routes leads to higher shipping costs, delivery delays, and ultimately market instability, showing how infrastructure bottlenecks translate into global supply chain risks. (October 2021 - January 2024)



(Source: https://Unctad.Org/Publication/Navigating-Troubled-Waters-Impact-Global-Trade-Disruption-Shipping-Routes-Red-Sea-Black?Utm_source=chatgpt.Com, n.d.)

Besides all the climate challenges that SCRM of the petroleum industry faces each day, it has to deal with environmental legislations such as the Kyoto Protocol and the Paris Agreement that require companies to adopt more sustainable and greener practices. The oil and gas industry has always been known as one of the biggest polluting industries in the world (Gardas et al., 2019). Compliance with new environmental protection measures usually requires significant investments in the operational procedures and technology, adding complexity and extra cost to SCM (Hasan et al., 2024).

Market and Economic Risks

All the risks discussed earlier, that can affect SC of the petroleum industry, can lead to market and economic instabilities that can provoke disruption in oil and gas industry supply chains. If market and economic instabilities, due to various occasions, are at high levels, it can potentially lead to financial loss that SCM needs to deal with. Situations like oil price volatility, demand-supply imbalances, inflation and geopolitics can provoke

market and economic instabilities, so the risks (Apostolakis et al., 2021). The global petroleum market, represented by a very complex structure can provoke instabilities in value chains, so the SCRM has to be at a very high level (Gardas et al., 2019).

Oil price fluctuations, which are usually very difficult to predict (Baumeister & Kilian, 2016), can be considered as one of the biggest issues that SCRM needs to deal with (Gunasekaran et al., 2015). This critical risk factor (price volatility) can be provoked by multiple events, such as global demand and supply imbalances, geopolitical events, global crises etc (Baumeister & Kilian, 2016; Xiuzhen et al., 2022). We have witnessed the global crisis that happened due to the COVID-19 pandemic, which drastically affected the oil market and the oil price (Apostolakis et al., 2021). Such declines in oil prices can reshape all three sectors of petroleum industry (upstream, midstream and downstream) in terms of investment in exploration and exploitation activities, profitability, transport costs and revenues (Attia et al., 2019; Augusta Heavens Ikevuje et al., 2024; Gunasekaran et al., 2015). On the other hand, price spikes that can happen due to supply disruptions can be presented as a new challenge for SCM of petroleum industry. High prices can put the pressure especially on downstream operations and simultaneously elevate costs across the value chain. The oil price spikes can have a very positive effect on the profits of the oil-exporting countries, thus the income overcomes the production costs, while for the oil-importing countries it can have the opposite effect (Apostolakis et al., 2021).

Inflation is one of the main economic factors that can be considered as a high-risk for the petroleum SC and it can be provoked by oil price shock (Apostolakis et al., 2021). Inflation can significantly impact the costs in upstream, midstream and downstream operations by raising labor wages, higher material and equipment costs, increasing transportation and working machinery rental expenses etc. All these issues can lead to higher exploration, production, transportation and distribution costs. Logistic expenses due to inflation can rise sharply, contesting the financial sustainability of industrial processes (Milewska & Milewski, 2022). SCRM of the oil and gas companies has to mitigate the effects of inflation by implementing strategies such as cost optimization and supplier diversification.

Renewable energy could be considered a long-term economic risk for oil and gas companies. According to (Moriarty & Honnery, 2020) renewable energy is getting more and more present in everyday life accounting for 14% of global produced energy, while on the other hand, according to IEA (Https://Www.Iea.Org/Reports/World-Energy-Balances-Overview/World, n.d.), we still need combustion of the fossil fuels due to the fact that we get more than 81% of globally produced energy from fossil fuels (Cholakov, 2016). The global economies are heading towards more sustainable future, but the process of transition to 'cleaner energy' requires significant investments (Çevik, 2024; Hussein Khalaf et al., 2024; Letunovska et al., 2023; Necci et al., 2019; Qadir et al., 2021). Additionally, market players have to balance these investments with the continuous demand for conventional fuels, which presents both financial and strategic difficulties (Qadir et al., 2021). This problem can be overcome by implementing sustainable supply chain management (SSCM) practices. SSCM represents the integration of environmental legislations and policies in supply chains, which can be done by implementing green practices, such as reverse logistics (Gardas et al., 2019; Letunovska et al., 2023). According to (Gardas et al., 2019) the implementation of SSCM measures increases profits, reputation, and customer loyalty of the company while positively affecting the environment by reducing oil spills, flaring, and disasters caused by humans.

Technological Risks

Technological advancements are constantly transforming the oil and gas industry, enabling more efficient operations and bigger production capabilities. However, all the advancements have also introduced a range of risks, such as system and cybersecurity vulnerabilities. In this section, a comprehensive discussion of the key technological risks in the oil and gas industry has been reviewed.

As the complexity of new technologies increases, the likelihood of system failures increases as well. Modern technologies implemented in oil and gas sector, such as drilling automation, corrosion monitoring systems, robotics, etc. are crucial to oil and gas operations nowadays in terms of increasing hydrocarbon recovery and equipment maintenance (Haouel & Nemeslaki, 2023; Hussein Khalaf et al., 2024).

Continued investment is needed to keep up with technological advancements, which can be one of the challenges for the petroleum industry. Moreover, management of the companies that want a high level of digitalization has to find a way to introduce new technologies to employees but also to hire highly qualified experts that can lead future projects and manage future risks (Haouel & Nemeslaki, 2023). The oil and gas industry is vulnerable to cyberattacks because it operates with very sensitive data about new projects, petroleum reserves, production capacities, financials, etc. (Alsalama & Alzahrani, 2024). In some way, all the companies, including petroleum ones, are forced to implement state-of-the-art machine learning (ML) and artificial intelligence (AI) technologies to mitigate the effect of new developing cyberattack technologies, which are, according to (Alsalama & Alzahrani, 2024) one of the main threats that can ruin smooth business operations. This is very important step in the process of digitalization in terms of infrastructure; moreover, supply chains could be disrupted by cyberattacks if a company does not have professionals and well-developed defense mechanisms (Haouel & Nemeslaki, 2023). The Colonial Pipeline ransomware attack that happened in 2021 is one of the examples of the importance of cybersecurity. The Colonial Pipeline is one of the main suppliers in the USA, contributing 45% of the East Coast's fuel supplies. The system integrates 37 facilities for storage that are capable of storing 7.7 million barrels. The attack that happened in 2021 dramatically affected supply chains across 13 states (Researcher, 2024; Whyte, 2024).

According to (Researcher, 2024), the operational shutdown that lasted for 6 days had a huge impact on supply chains of the East Coast, directly affecting more than 50 000 000 consumers and the financial damage exceeded 2.1 billion USD (Researcher, 2024). Such cyberattacks can have a negative impact on company's reputation as well (Alsalama & Alzahrani, 2024; Researcher, 2024; Whyte, 2024).

Reputation and Social Risks

The reputation of the company is a very important thing when it comes to collaboration with other companies. Bad reputation and lack of collaboration in the petroleum industry can negatively affect supply chains of the oil and gas company. Because of that, it is highly important for a company to have a good reputation, which will strengthen the bonds with other companies; without which, usually, a single company

cannot survive the modern and challenging market environment. Fruitful collaboration between different petroleum companies positively affects the supply chains.

Environmental incidents and ethical violations can seriously damage the reputation of a company (Fragouli, 2016). Negative media reports on environmental incidents, which are such a big risk in the petroleum industry due to the fact that the oil and gas industry has always been in the top three polluting industries (Gardas et al., 2019), can negatively affect investor relations, market value and supply chains. In order to maintain competitiveness on the market and supply chain stability, reputation management has become one of the most crucial parts for international petroleum companies (Fragouli, 2016).

As already said, reputational and social risks in the petroleum industry are strongly intertwined with supply chain resilience (Feria-Domínguez et al., 2016). For example, suppliers and contractors may distance themselves from companies that suffer reputational crises, leading to supply chain disruptions provoked by delays and cost overruns. This is particularly visible in global supply chains where international partners must comply with strict ESG (Environmental, Social, and Governance) standards, and any association with reputationally damaged companies can harm their own businesses (Ahmad et al., 2023).

A well-known case is the BP Deepwater Horizon disaster in 2010, which not only caused severe environmental damage, but also reputational damage for the company. According to (Arora and Lodhia, 2017) relied heavily on social and environmental disclosures on its website to manage reputation risk during the crisis. Instead of focusing on concrete remedial actions, BP emphasized its world-class facilities, management strategies and plans to resolve the accident employing a corrective and bolstering strategy to divert attention from the massive environmental damage. This approach emphasizes the importance of prioritizing the reputation of the company even in the most challenging situations in order to preserve partnerships and partners' trust (Feria-Domínguez et al., 2016).

Such cases illustrate that reputational damage could directly affect supply chain risk management by weakening the trust of the local communities (Ukhurebor et al., 2023), increasing regulatory scrutiny and potentially discourage collaboration with new partners.

Taking into consideration everything mentioned in this chapter, supply chain risk management strategies must include reputational and social risk assessments as integral components. Building the reputation of a company help maintain supply chain stability and can reduce vulnerability to crises that periodically occur.

Discussion

Building upon the review results, this section provides a critical discussion of their significance and explores potential strategies for risk mitigation and supply chain resilience.

Addressing the diverse risks associated with supply chains in the petroleum industry requires a very detailed strategic approach. The complexity of modern SCM systems is underscored in previous chapters in which geopolitical uncertainties, environmental

and climate-related risks, market volatility, technological advancements, reputational risks and social pressures have been analysed. To give the possible solutions to these risks, effective mitigation strategies that integrate proactive planning and innovation and collaboration across stakeholders have to be implemented to ensure adaptability and resilience.

Potential solutions for each identified risk category have been presented in this section, emphasizing the importance of a systematic literature review approach. By leveraging advanced technologies, fostering sustainable practices and engaging with local and global communities, companies can navigate these challenges while enhancing operational efficiency and maintaining stakeholder trust. These potential solutions aim to provide practical frameworks for managing unstabilities and to ensure long-term success in a challenging industrial environment.

Most authors agree that geopolitical and climate risks are the main factors that disrupt supply chains in the petroleum industry (Çevik, 2024; Chen et al., 2024). On the other hand, fewer studies deal with technological risks and cybersecurity (Alsalama and Alzahrani, 2024), which shows that digital threats are still underestimated in the literature. Many papers examine oil price volatility and market instability (Baumeister and Kilian, 2016; Olayungbo et al., 2024), but they usually look at these risks separately. There are not enough studies that analyse how financial, technological, and reputational risks are connected and how they can occur at the same time. Also, a large number of papers are based on case studies of specific regions, such as the Russia–Ukraine war or the Red Sea crisis. This limits the possibility to make general conclusions for the whole industry. Finally, many studies focus only on one part of the supply chain (upstream, midstream, or downstream), while there are fewer works that show how risks spread through the entire chain (Attia et al., 2019; Miner et al., 2024). Because of that, the literature still lacks an integrated approach that includes all categories of risks together in one framework.

Table 2: Critical Review of the Literature – Coverage and Gaps

Area	What is well covered	What is missing (gap)
Geopolitical risks	Many studies on wars/conflicts	Few long-term, cross-regional analyses
Climate risks	Arctic & extreme weather well studied	Weak links with other risk categories
Market risks	Oil price volatility deeply analysed	Few works integrate financial + technological + reputational risks
Technological risks	Cybersecurity issues identified	Mostly conceptual, few empirical validations
Reputational risks	ESG, case studies (e.g. BP)	No systematic frameworks connecting reputation & SC resilience

Potential Solutions to the Geopolytical Risks

As already said, many geopolitical risks threaten to disrups SC of petroleum industries; they also have a powerful influence on shaping the future of energy markets (Figueiredo et al., 2022). To fight and mitigate the impact of these risks, SCMS have to act wisely by implementing different strategies.

Table 3: Risk Categories and Mitigation Strategies

Risk category	Mitigation strategies	Key authors
Geopolitical	Diversification, exit strategy, ownership separation	Gamso et al. (2024); Heizer et al. (2020)
Climate	Contingency plans, specialized equipment, weather forecasting	Necci et al. (2019); Çevik (2024)
Market	SSCM, supplier diversification, cost optimization	Gardas et al. (2019); Qadir et al. (2021)
Technological	AI, IoT, predictive maintenance, cybersecurity	Alsalama & Alzahrani (2024); Haouel & Nemeslaki (2023)
Reputational	ESG compliance, transparent communication	Arora & Lodhia (2017); Ahmad et al. (2023)

According to (Gamso et al., 2024), risk diversification and proactive positioning could be the strategies to mitigate the potential negative consequences of geopolitical risks. For example, the identification and exploitation of new opportunities, such as spreading investments and resources and entering more stable markets can enhance business stability. Moreover, SCM has to consider the strategy of consciously preparing an exit plan in the event of a bad geopolitical situation. One more strategy that can be fruitfully implemented is separating ownership control from operational management (Gamso et al., 2024). This strategy enables owners to keep ownership and profits while transferring operational duties to managers who are more equipped to handle external risks such as political instability. Because operational choices can be made more quickly by individuals with experience in handling such difficulties, this technique helps to lessen the influence of geopolitical concerns and ensures economic stability even in unpredictable times (Heizer et al., 2020). These strategies enable petroleum companies to reduce vulnerability to geopolitical turbulence and can ensure long-term profitability if implemented wisely.

Potential Solutions to the Climate and Environmental Risks

To mitigate the risks associated with climate change and natural environmental hazards impacting petroleum SC, particularly in the upstream and midstream sectors, several strategic measures are recommended by the authors (Çevik, 2024; Https://Unctad.Org/Publication/Navigating-Troubled-Waters-Impact-Global-Trade-Disruption-Shipping-Routes-Red-Sea-Black?Utm_source=chatgpt.Com, n.d.; Katopodis & Sfetsos, 2019; Miner et al., 2024; Necci et al., 2019). Special attention should be given to transportation, equipment handling and worker's health, as challenges posed by high winds, low temperatures, storms, and sea ice in regions like the Arctic and Sub-Arctic are significant (Necci et al., 2019). Establishing contingency plans that account for these

risks, along with specialized equipment for operating in harsh climates, is essential for minimizing operational disruptions. Advances in technology, such as weather forecasting, remote monitoring and early-warning systems, can provide early warnings and enable companies to adjust their operations proactively, which lowers the risk of accidents and equipment failure (Çevik, 2024; Katopodis & Sfetsos, 2019).

A better understanding of risks is crucial for diminishing climate change and environmental effects on the oil working facility. It's also critical to invest in infrastructure that can survive severe weather conditions. Permafrost melting threatens transportation and extraction infrastructure; hence, specific building methods that take into account ground stability and the possibility of changing topography as a result of thawing permafrost have to be used (Katopodis & Sfetsos, 2019; Miner et al., 2024).

Addressing the combined effects of geopolitical and climate-related risks requires a coordinated response. As already said, essential chokepoints for the global petroleum industry are the Suez Canal, Bab al-Mandab Strait, and Panama Canal. In order to maintain the flow of goods and minimize financial losses, disruptions in these areas brought on by political unrest or climate change must be managed through diversified supply routes and improved international cooperation (Https://Unctad.Org/Publication/Navigating-Troubled-Waters-Impact-Global-Trade-Disruption-Shipping-Routes-Red-Sea-Black?Utm_source=chatgpt.Com, n.d.).

When talking about environmental regulations, according to (Hasan et al., 2024), petroleum companies have to implement GSCM measures. Moreover, oil and gas companies are investing in renewable energy sources and diversifying their business models in order to become a more environmentally friendly industry and to meet modern environmental standards (Wang et al., 2022).

Through the implementation of a comprehensive strategy that integrates cutting-edge risk management techniques, infrastructure modification, and technological advancement, the petroleum sector can more effectively lessen the influence of environmental and geopolitical hazards on its supply chains.

Potential Solutions to the Technological Risks

By incorporating cutting-edge technologies like ML and AI, operations in the oil and gas sector can be optimized by enhancing efficiency and precision (Oladiran Kayode Olajiga et al., 2024). Automated drilling systems and digital twins also improve safety and efficiency in oil and gas operations (Wanasinghe et al., 2020). Although technological developments have increased oil and gas industry efficiency, they have also brought about risks such as cybersecurity vulnerabilities and system failures. To manage these difficulties and maintain operational stability, significant investments, knowledgeable workers, and effective cybersecurity measures are needed. According to (Https://Www.Api.Org/-/Media/Files/Policy/Cybersecurity/2018/Defense-in-Depth-Cybersecurity-in-the-Natural-Gas-and-Oil-Industry.Pdf, n.d.), petroleum companies should invest in cutting-edge technologies and put in place thorough cybersecurity measures to reduce technological risks in the oil and gas sector. Moreover, the same author claims that enhancing resilience against cyber threats can be achieved by implementing a defense-in-depth strategy, which consists of several layers of security controls.

Potential Solution to the Reputational Risks

As already said, environmental incidents and ethical violations followed by negative media reports can dramatically damage a company's reputation, leading to disruptions in SC and financial losses. In order to increase or maintain a high reputation, risk and reputation management of the companies has to implement comprehensive strategies that prioritize environmental responsibility, ethical practices, and transparent communication with stakeholders (Albeldawi, 2023). Moreover, the same authors emphasize the importance of controlling and managing polluting emissions and discharges in order to minimize negative impacts of the companies' operations, which can lead to building trust in the company that implements these measures (Fragouli, 2016).

Conclusions

Addressing the diverse risks associated with SC in the petroleum industry requires a comprehensive and proactive approach. This paper has identified and analysed the major risk factors, including geopolitical, environmental, climatic, market, economic, technological, and reputational risks, each of which poses significant challenges to the stability and efficiency of petroleum supply chains. By systematically reviewing the literature and examining various mitigation strategies, this study has highlighted the importance of integrating risk management practices, technological advancements, and strategic planning to enhance supply chain resilience.

To mitigate geopolitical risks, companies must diversify investments, establish contingency plans, and separate ownership control from operational management to ensure stability in volatile regions. Addressing environmental and climate-related risks demands advanced monitoring technologies, infrastructure adaptation, and compliance with evolving regulatory frameworks to reduce operational disruptions. Technological risks, particularly cybersecurity threats, require substantial investments in AI, ML, and robust security frameworks to ensure operational continuity. Furthermore, reputational risks can be minimized through ethical business practices, environmental responsibility, and transparent communication with stakeholders.

The findings emphasize that a multi-layered risk management approach, combining innovation, strategic partnerships, and sustainability initiatives, is crucial for securing long-term profitability and competitiveness in the petroleum industry. Future research could explore the dynamic interdependencies of these risks and the effectiveness of emerging technologies in mitigating their impacts. By implementing an integrated and forward-looking strategy, petroleum companies can navigate uncertainties in SC, optimize SC performance, and contribute to a more resilient and sustainable energy sector.

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THE EFFECTS OF EMPLOYEE E-READINESS ON THE INTEGRATION OF E-COMMERCE IN INTERNATIONAL TRADE

Abstract

To assess the impact of employee e-readiness on companies operating in international markets and their adoption of e-commerce, a survey was conducted with a sample of 154 Serbian SME exporters in collaboration with the Serbian Association of Employers at the end of 2024. The online questionnaire examined how employee e-readiness influences SMEs' willingness to engage in exports, particularly through e-commerce. Seven factors of employee e-readiness were identified as independent variables, while eight factors related to e-commerce application in international trade were defined as dependent variables. Business owners and managers, the targeted respondents, evaluated these statements using a Likert scale. The results revealed a significant impact and strong interrelation between the variables, with digital competency and technology adaptability identified as key factors influencing e-commerce adoption in international trade. Additionally, global market access, online marketplaces, and channel access were recognized as crucial factors for international trade success. The findings of this study contribute to the literature on internationalization, network effects, cost efficiency, and institutional frameworks, offering valuable insights for SMEs seeking to leverage e-commerce in the global marketplace.

Key words: *international trade, digital era, e-readeness, online commerce, internationalization theory, Serbia.*

JEL classification: *F153, F02, F44, J24.*

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ЕФЕКТИ ДИГИТАЛНЕ ПИСМЕНОСТИ ЗАПОСЛЕНИХ У ИНТЕГРАЦИЈИ ЕЛЕКТРОНСКЕ МЕЂУНАРОДНЕ ТРГОВИНЕ

Апстракт

Да би се проценио утицај дигиталне писмености запослених на компаније које послују на међународним тржиштима и њихово усвајање онлајн трговине, спроведено је теренско истраживање на узорку од 154 српских предузећа- извозника у сарадњи са Удружењем послодаваца Србије 2024. године. За независну варијаблу- дигитална писменост запослених дефинисано је 7 тврдњи, а зависну- примена електорнске трговине у међународној трговини 8 тврдњи. Власници и менаџери предузећа, као циљани испитаници, оцењивали су ниво утицаја дефинисаних тврдњи две варијабле једне на другу, коришћењем Ликертове скале. Резултати су показали постојање значајног утицаја и јаке међусобне повезаности варијабли, при чему су дигиталне компетенције запослених и прилагодљивост технологије идентификовани као кључни фактори који утичу на усвајање е-трговине у међународној трговини. Поред тога, приступ глобалном тржишту и каналима продаје су препознати као кључни фактори за успех међународне трговине. Налази ове студије доприносе литератури о области теорије, интернационализације, инситуционализације, теорије умрежавања, нудећи драгоцене увиде предузећима желе да унапреде свој положај на међунаорндим тржиштима послујући онлајн преко унапређења дигиталне писмености запослених.

Кључне речи: *међународна трговина, дигитална ера, е-читање, онлајн трговина, теорија интернационализације, Србија*

Introduction

In the digital era, international trade has become increasingly vital for economic growth and development. The rise of new technologies, e-commerce, and digital platforms has transformed the way businesses engage in global commerce. Digitalization enables the real-time exchange of data and goods across borders, improving efficiency, transparency, and competitiveness (Špiler et al., 2023; Jevtić et al., 2020; 2024). This allows countries and businesses to offer products and services more cost-effectively while fostering innovation, collaboration, and knowledge exchange, driving advancements across industries worldwide (Ćurčić & Grubor, 2023; Srebro & Jevtić, 2024; Srebro et al., 2024). Overall, international trade in the digital era enhances economic integration, market access, productivity, and sustainable growth. In 2023, developed economies experienced a 2.8% decline in exports, with sharp decreases in Saint Pierre and Miquelon (-76.9%), Andorra (-34.6%), Norway (-30.5%), and Russia (-28.4%). The decline was even greater in developing economies, which fell by 6.2%, amounting to $10.5 trillion in global export values. Serbia's merchandise exports, however, grew by 6.5% in 2023 (UNCTAD, 2025). Globally, developed economies remained the largest exporters, contributing $13.3 trillion.

E-commerce plays a pivotal role in bridging geographical gaps and enabling businesses to access international markets. Platforms streamline cross-border transactions, offering secure payment systems, real-time communication, and digital marketing solutions. They allow firms to connect directly with international buyers, manage inventories across borders, and provide localized experiences while scaling operations globally. As e-commerce evolves, it drives the digital transformation of international trade, making it more accessible, cost-effective, and efficient for businesses and consumers alike. Since the early 2000s, online shopping has expanded dramatically, with global users rising from under 100 million to approximately 2.3 billion by 2021. Sales on the top 35 e-commerce platforms increased from $2.6 trillion in 2019 to over $4 trillion in 2021. Across 43 developed and developing countries, e-commerce transactions grew from $17 trillion in 2016 to $27 trillion in 2022, with international transactions gradually gaining momentum (UNCTAD, 2024).

Studying e-readiness and its impact on e-commerce in international trade is essential, particularly for businesses in developing economies. **E-readiness** refers to the preparedness of individuals, firms, and nations to leverage digital technologies, including internet-based marketing strategies, online retail channels, and digital supply chain solutions. It encompasses digital infrastructure, technological capabilities, employee skills, and regulatory frameworks. High levels of e-readiness enable smoother cross-border transactions, improved logistics, enhanced customer experiences, and greater competitiveness. Conversely, insufficient e-readiness can hinder firms' ability to adapt to fast-paced digital trade environments, limiting their participation in global commerce. Understanding and improving e-readiness is therefore critical for policymakers, business leaders, and researchers seeking to foster effective e-commerce adoption and sustainable growth in the global digital economy.

The purpose of this research is to explore the perspectives of export representatives on the impact of e-readiness, highlighting its significance for the successful implementation of e-commerce in export activities. The study is structured as follows: an introduction outlining the subject matter, a review of the literature, a presentation of materials and methods, a discussion of the findings, and a conclusion, followed by references.

Literature review

To ground the research, the authors examined a range of established theoretical frameworks and conceptual models, including:

- Transaction Cost Theory, which investigates the expenses involved in conducting economic transactions, such as negotiating, monitoring, and enforcing agreements. This theory suggests that firms aim to minimize these costs when determining operational and market strategies, offering insights into how businesses manage transaction costs in cross-border operations, particularly in the context of digital transactions and international regulations (Williamson, 1981).
- Organizational Structure Theory, which emphasizes the role of institutions in guiding the decisions and actions of organizations (Scott, 1995).
- Theory of Relational Dynamics, which examines the dynamics of social and economic networks, highlighting how connections and interactions between

participants foster transactions, generate value, and ultimately influence business performance and success.

- Strategic Asset Framework, which focuses on how a company's unique assets—such as technology, brand equity, customer insights, and logistics infrastructure—contribute to securing competitive advantage (Barney, 1991). Applied to e-commerce and global business, this framework explains how firms leverage distinctive strengths to develop effective online strategies and expand internationally.
- Foreign Market Penetration Approaches, which encompass strategies that firms adopt to enter international markets (Root, 1994). Examining these strategic pathways provides insight into their relevance and effectiveness, particularly within the context of e-commerce and global business operations.
- Online Retail Consumption Patterns, which highlight the importance of understanding consumer behavior in e-commerce environments. This knowledge is essential for designing effective marketing strategies and enhancing digital user experiences (Kotler & Keller, 2016).
- Theory of Gradual International Expansion, which explores how firms incrementally enter foreign markets, shaped by internal capabilities, experiential learning, and network ties (Johanson & Vahlne, 1977). Applied to the digital context, particularly in e-commerce, this framework helps explain how online enterprises develop cross-border strategies and scale their operations globally.
- Connected Digital Environments, which have transformed the business landscape, making it essential to study their structure, network effects, and value co-creation in platform-driven commerce. This perspective provides important insights into strategic operations and challenges within digital ecosystems and is further enriched by regional academic perspectives (Parker et al., 2016; Jevtić & Srebro, 2024; Miškić et al., 2025; Popović & Jevtić, 2020; Radović et al., 2017; Vrbanac et al., 2023).

In the context of e-commerce, these frameworks collectively offer a solid foundation for analyzing international business dynamics and understanding the strategic, organizational, and technological factors that influence global online trade.

Methodology

To assess the impact of employee e-readiness on companies engaging in or intending to engage in international trade through online retail, a sample of 154 Serbian SME exporters was surveyed via an online questionnaire conducted at the end of 2024, in collaboration with the Serbian Association of Employers. Seven factors of employee e-readiness, serving as the independent variable (P), were identified: Cross-Border Communication Skills, Cybersecurity Awareness, Digital Competency and Technology Adaptability, E-Commerce Platform Management, Regulatory Compliance Knowledge, Analytical, Problem-Solving, and Decision-Making Skills, and Supply Chain and Logistics Efficiency. Additionally, eight factors representing the application of e-commerce in international trade, defined as the dependent variable (Q), were identified: Reduction in

Trade Barriers, Increased Speed and Efficiency, Automation of Trade Processes, Data-Driven Decision Making, Improved Customer Engagement, Supply Chain Transparency, Access to Global Markets and Online Marketplaces, and Enhanced Payment Solutions. The study aims to investigate whether employee e-readiness (P) significantly influences e-commerce application in international trade (Q). The research hypotheses are:

- H0: Employee E-Readiness for E-Commerce Adoption (P), does not affect the International Trade in digital era (Q).
- Ha: Employee E-Readiness for E-Commerce Adoption (P), affects the International Trade in digital era (Q)

The survey targeted business owners and managers, who provided their assessments on five statements (1 – Extremely improbable, 2 – Unfavorable, 3 – Inconclusive, 4 – Plausible, and 5 – Almost certain) related to two predefined research variables. The focus was on employee e-readiness factors influencing SME export propensity, with particular emphasis on e-commerce implementation (as defined in Table 1). The study employs correlation and regression analyses to derive the final results. Based on these analyses, specific claims were formulated regarding employee e-readiness for e-commerce adoption in international trade. (Table 1):

Table 1. Values of respondents' attitudes for statements (variables P and Q)

	Claims	**Mean**	**Std Dev**
P	**Independent variable: Employee E-Readiness for E-Commerce Adoption**		
P1.	Employees should possess proficiency in international business communication, digital correspondence, and customer engagement across different cultures and languages.	4.3441558442	0.5759887223
P2.	Employees are required to possess knowledge of data protection, secure online transactions, and compliance with cybersecurity standards in global trade.	4.3636363636	0.5695793864
P3.	Employees must have readiness to embrace new digital systems, update skills, and adopt innovative e-commerce technologies.	4.525974026	0.6973155993
P4.	Employees should be able to operate and manage e-commerce platforms, including product listings, online payments, and customer service.	4.1948051948	0.8407740137
P5.	Employees should have an understanding of international trade laws, digital taxation, and e-commerce regulations across different markets.	4.4480519481	0.723482932
P6.	Employees must have capability to interpret online sales data, customer behavior, and market trends to improve e-commerce strategies.	4.2532467532	0.662355554
P7.	Employees must have knowledge of digital supply chain management, cross-border shipping, and fulfillment processes.	4.4155844156	0.7813286714
Q	**Dependent variable: International Trade in the Time of Digitalization**		
Q1.	Reduction in trade barriers refers to the lowering or elimination of tariffs, customs duties, and regulatory restrictions that hinder international commerce.	3.9545454545	0.5156493348
Q2.	Digital technologies streamline trade processes, allowing for faster transactions, better communication, and real-time tracking of shipments, what reduces the time needed for cross-border trade and improves operational efficiency	4.1623376623	0.5419738703

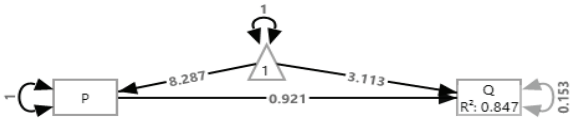
Q3.	Automation tools such as AI, machine learning, and blockchain technology are transforming supply chain management, customs procedures, and payment systems.	4.3311688312	0.5369387303
Q4.	Data analytics empowers businesses to make informed decisions in pricing, inventory management, and market expansion.	4.3636363636	0.50898055
Q5.	Tech-based resources enhance communication with international customers, allowing businesses to cater to diverse needs and improve customer satisfaction.	4.6233766234	0.627037042
Q6.	Digitalization provides visibility and transparency across supply chains, helping businesses track the origin of materials, monitor logistics, and ensure compliance with international regulations and standards.	42402597403	0.8007773577
Q7.	The digital revolution, through blockchain simplifies regulatory compliance and cross-border transactions by automating customs procedures, reducing paperwork, and facilitating smoother trade flows.	4.7597402597	0.4436213837
Q8.	Digital payment systems such as cryptocurrencies, digital wallets, E-invoicing, and online banking solutions transaction.facilitate secure and efficient cross-border payments, reducing currency exchange barriers and minimizing	4.4935064935	0.5629840343

Source: Authors

Results

Category **P3** exhibits the highest mean value, accompanied by a slightly higher standard deviation compared to the other categories, indicating that although the average level is high, the data are more dispersed. In contrast, P4 has the lowest mean and the highest standard deviation, suggesting substantial variability and lower consistency within this category. Categories P1, P2, and P7 display similar mean values and standard deviations, implying relatively uniform and stable distributions. Overall, the results indicate notable differences in both average values and variability across categories, with P3 demonstrating the highest average performance, while P4 shows the lowest mean alongside the greatest dispersion. Among the Q categories, Q7 records the highest mean and the lowest standard deviation, indicating consistently high and uniform outcomes. Q5 also exhibits a relatively high mean but with greater variability, suggesting more dispersed or inconsistent results. Q1 has the lowest mean value; however, its relatively small standard deviation indicates that the data are consistent, albeit at a lower level compared to other categories. Notably, Q7 has the highest mean across all categories in both tables, while Q6 shows the highest standard deviation among the Q variables, reflecting the greatest variability. As illustrated in Figure 1, the evaluation of the conceptual framework model reveals a strong explanatory power. The R^2 value of 0.847375 indicates that approximately 84.74% of the variation in (Q) is explained by changes in (P). Furthermore, the high association between the variables is confirmed by the correlation coefficient, with (P) accounting for 0.92053 of the variation in (Q), demonstrating a very strong positive relationship.

Figure 1. Standard system model contribution quantities for (PQ)



Source: Authors

The p-value, as shown in Table 2, stands at [F(1,152)=843.9066, p<0.0001].

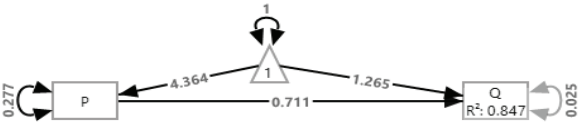
Table 2. ANOVA vor variable (Q)

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	21.557945	21.5579	843.9066
Error	152	3.882903	0.0255	Prob > F
C. Total	153	25.440848		<0.0001

Source: Authors

The findings *validate the alternative hypothesis (Ha), indicating that (P) influences (Q)*. The assessed average for (P) is. 4,364. The dispersion of values for (P) is quantified at 0.277, and the extent of fluctuation in (Q) equals 0.025 (F.2).

Figure 2. Irregular input magnitudes for (PQ)



Source: Authors

Based on the data from (Figure 2), Equations 1 and 2 articulate the functional relationship among the variables:

$$y = 1.265437 + 0.710562 \cdot x \quad (1)$$

or

$$(Q) = 1.265437 + 0.710562 \cdot (P) \quad (2)$$

Discussion

The empirical findings support the alternative hypothesis (H_a), confirming that employee e-readiness for e-commerce adoption (P) has a statistically significant and positive effect on international trade performance in the digital era (Q). Consequently, the null hypothesis (H_0), which assumes no relationship between employee e-readiness and international trade outcomes, is rejected. The mean value of P (4.364) indicates a relatively high level of employee preparedness for e-commerce adoption, suggesting

that employees possess the necessary digital skills, technological awareness, and organizational readiness to engage in digital trade processes. The observed dispersion of P (0.277) reflects moderate heterogeneity among employees, which is consistent with previous studies emphasizing unequal digital skill distribution within firms and across sectors. In contrast, the low variability in Q (0.025) indicates a stable international trade outcome, suggesting that improvements in digital readiness translate into consistent trade performance gains. The estimated regression results reveal a strong and positive linear relationship between P and **Q**, demonstrating that higher levels of employee e-readiness significantly enhance firms' ability to participate in international trade through digital platforms. This finding aligns with earlier research showing that human capital readiness is a key enabling factor for successful e-commerce adoption and cross-border digital trade (Kraemer et al., 2006; Molla & Licker, 2005). Similar empirical evidence is reported by Zhu and Kraemer (2005), who found that organizational and human e-readiness significantly improve e-business assimilation and firm performance in global markets. Likewise, Huy et al. (2012) demonstrated that employee digital competence and organizational readiness positively influence export performance through e-commerce channels. More recent studies confirm that workforce digital readiness enhances firms' integration into international digital value chains, particularly in emerging and transitional economies (UNCTAD, 2021; WTO, 2020). Overall, the results validate the proposed theoretical framework and reinforce the view that employee e-readiness is a critical determinant of international trade competitiveness in the digital era. These findings contribute to the growing body of literature emphasizing the role of human and organizational digital capabilities as foundational drivers of e-commerce-enabled international trade.

Conclusion

The authors of the study have examined various conceptual frameworks and paradigms that establish a robust foundation for the research. These frameworks provide structured approaches to understanding the research variables and their interrelationships, guiding the analysis and interpretation of the findings. In summary, digitalization has revolutionized international trade by enhancing accessibility, reducing barriers, improving efficiency, and providing businesses with the tools for competition. E-commerce began emerging as a key facilitator of international commerce, spurred by the expansion of internet connectivity and the development of secure online payment system (Dedjanski, Jevtić & Grozdanić, 2024; Vučković & Čučković, 2024). Finidngs support the strong correlation between e-readeness, ecommerce and international trade, as well as factors contributed to the importance of online commerce to global trade digitalization. Employee E-readiness for E-commerce adoption in international trade have to include the development of cross-border communication skills, technology adaptability, knowledge on e-commerce platform management, regulatory compliance, and supply chain and logistic efficiency. Future research could adopt longitudinal designs to examine how changes in employee e-readiness influence international trade performance over time, capturing learning and organizational adaptation effects. Further studies may also investigate the moderating role of institutional quality, digital

infrastructure, and regulatory environments, particularly in developing and transition economies (Molla & Licker, 2005; UNCTAD, 2021; WTO, 2020). Expanding the framework to include advanced digital technologies such as artificial intelligence, big data analytics, and blockchain would deepen understanding of employee readiness for intelligent trade systems (OECD, 2021). Comparative cross-country and cross-sectoral analyses could additionally refine e-readiness measurement frameworks and enhance their applicability across diverse economic contexts.

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DEVELOPMENT OF THE CARBON MARKET AND THE GREEN CERTIFICATE MARKET: ROMANIA, POLAND, AND GERMANY

Abstract

Purpose – This paper investigates the evolution and effectiveness of carbon markets and green certificate systems as key mechanisms for achieving climate sustainability goals. By focusing on Romania, Poland, and Germany between 2015 and 2025, it aims to evaluate the regulatory, economic, and technological factors that shape these environmental markets and their contribution to climate neutrality objectives.

Research design/method/approach – The study combines time-series econometric analysis with an extensive literature review to assess the development and performance of carbon trading and green certificate markets. It examines the interaction between cap-and-trade schemes and renewable energy certificate systems, identifying both synergies and conflicts in their design and implementation. In addition, the research considers the influence of digitalization and blockchain technologies on market transparency and efficiency.

Practical implication – The results provide actionable insights for policymakers seeking to design transparent and effective market-based environmental policies. Understanding how these mechanisms interact helps refine regulatory strategies to enhance market integrity, efficiency, and alignment with European climate goals.

Originality/Value – This paper contributes to the growing literature on environmental economics by offering a comparative, multi-country analysis of carbon and green certificate markets in Central and Eastern Europe. It integrates policy, econometric, and technological perspectives, highlighting innovative pathways toward achieving climate neutrality through market-based instruments.

Key words: *carbon market, green certificates, cap-and-trade, climate neutrality, blockchain technology*

JEL classification: *Q41, Q48, O13*

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РАЗВОЈ ТРЖИШТА УГЉЕНИКА И ТРЖИШТА ЗЕЛЕНИХ СЕРТИФИКАТА: РУМУНИЈА, ПОЉСКА И НЕМАЧКА

Апстракт

Сврха – Овај рад истражује еволуцију и ефикасност тржишта угљеника и система зелених сертификата као кључних механизама за постизање циљева климатске одрживости. Фокусирајући се на Румунију, Пољску и Немачку између 2015. и 2025. године, циљ му је да процени регулаторне, економске и технолошке факторе који обликују ова тржишта животне средине и њихов допринос циљевима климатске неутралности.

Дизајн/метод/приступ истраживања – Студија комбинује економетријску анализу временских серија са опсежним прегледом литературе како би се проценио развој и учинак тржишта трговине угљеником и зелених сертификата. Испитује интеракцију између шема ограничења и трговине емисијама и система сертификата за обновљиве изворе енергије, идентификујући и синергије и сукобе у њиховом дизајну и имплементацији. Поред тога, истраживање разматра утицај дигитализације и блокчејн технологија на транспарентност и ефикасност тржишта.

Практична импликација – Резултати пружају практичне увиде креаторима политике који желе да осмисле транспарентне и ефикасне тржишно засноване политике заштите животне средине. Разумевање како ови механизми међусобно делују помаже у усавршавању регулаторних стратегија за побољшање интегритета тржишта, ефикасности и усклађености са европским климатским циљевима.

Оригиналност/Вредност – Овај рад доприноси растућој литератури о економији животне средине нудећи упоредну анализу тржишта угљеника и зелених сертификата у Централној и Источној Европи у више земаља. Он интегрише политичке, економетријске и технолошке перспективе, истичући иновативне путеве ка постизању климатске неутралности путем тржишно заснованих инструмената.

Кључне речи: *тржиште угљеника, зелени сертификати, ограничење и трговина емисијама, климатска неутралност, блокчејн технологија*

Introduction

Considering global imperatives for mitigating climate change, carbon markets and green certificate systems emerge as innovative solutions for reducing greenhouse gas emissions and promoting sustainability (Nguyen et al., 2023; Busu and Trica, 2019). These mechanisms, through their operational and regulatory frameworks, aspire to mobilize investments in clean technologies and encourage the adoption of sustainable practices at both corporate and individual levels (Zhang et al., 2023). However, the effectiveness of these markets can vary significantly depending on the regional political and economic context, which necessitates a comparative analysis among different national systems to identify the most effective practices and approaches.

Focusing on Romania, Poland, and Germany during the period 2015-2025, this article applies a time-series econometric analysis to assess the evolution and impact of these markets, providing a detailed perspective on the regulatory framework, economic efficiency, and challenges encountered (Coria & Jaraite, 2023). Additionally, the paper investigates how emerging technologies, such as digitalization and blockchain, can reshape the dynamics of green certificate and carbon markets, addressing potential synergies and conflicts between cap-and-trade schemes and green certificate markets in the context of achieving climate neutrality (Wang et al., 2024).

Findings of this research are intended to contribute to the specialized literature, providing a solid foundation for future policy decisions in environmental regulations and market technologies.

Literature Review

Carbon markets have been recognized as a crucial economic instrument in the global effort to mitigate climate change. Originating from the principles established in the Kyoto Protocol, these markets employ a cap-and-trade system designed to reduce greenhouse gas (GHG) emissions in a cost-effective manner (Zhou et al., 2022). The cap sets a maximum limit on emissions, which is progressively reduced to ensure steady environmental improvements. Companies that cut their emissions faster than required can sell surplus allowances to those facing higher abatement costs, creating a financial incentive for innovation in emission reduction technologies (Zhang et al., 2023; Aldy & Stavins, 2023).

The success of carbon markets depends largely on the robustness of the cap-setting process, the inclusiveness of covered sectors, and the system's adaptability to evolving economic conditions. Numerous studies have shown that well-functioning carbon markets not only help reduce emissions but also stimulate innovation in clean technologies and support long-term decarbonization goals (Bayer & Aklin, 2020). For instance, the European Union Emissions Trading System (EU ETS) has played a pivotal role in accelerating the transition toward low-carbon energy production and sustainable industrial practices (Watson, 2022).

In parallel, green certificate systems serve as complementary regulatory mechanisms to promote renewable energy production and consumption. These certificates—commonly referred to as Renewable Energy Certificates (RECs)—are issued to producers for each unit of renewable energy generated and can be traded separately from the physical electricity (Li et al., 2023; Busu, 2020). Green certificates enhance the economic viability of renewable projects by providing additional income streams and by promoting diversification within the energy mix (Heffron & McCauley, 2021). This approach helps mitigate intermittency issues and encourages a more decentralized energy system, while maintaining market flexibility and responsiveness to policy changes (Kumar et al., 2023; Raihan & Bari, 2024).

Despite these advantages, both carbon markets and green certificate systems face several challenges that can affect their efficiency and credibility. The complexity of international coordination, inconsistent national policies, and price volatility often undermine investor confidence. Market fluctuations, in particular, can deter long-term investment in renewable technologies by introducing uncertainty into expected returns (Chen & Chen, 2024; Koch et al., 2023). Moreover, institutional quality, transparency,

and political stability play decisive roles in ensuring the effectiveness and sustainability of market-based environmental instruments (Nguyen et al., 2023).

Recent research also highlights the growing importance of digital technologies such as blockchain and artificial intelligence in enhancing market transparency, traceability, and efficiency. Blockchain-enabled systems offer new opportunities to track emissions and ownership of certificates with higher accuracy and lower transaction costs, reducing fraud and improving regulatory compliance (Wang et al., 2022). Such technologies can strengthen public trust and enable a more secure, data-driven foundation for global carbon trading and renewable energy certification systems.

Regulatory frameworks provide the essential structure for the operation and governance of carbon markets and green certificate systems. In carbon markets, these frameworks determine the cap level, the allocation of allowances, and the enforcement of compliance penalties. The EU ETS serves as a leading example of an evolving regulatory structure that has undergone several revisions to address issues of market oversupply and price instability, thereby improving efficiency and responsiveness (Watson, 2022; Levi & Flachsland, 2023).

Similarly, in the case of green certificate systems, regulations define certification criteria, supplier obligations, and trading rules. These frameworks are vital for ensuring that certificates accurately represent renewable energy generation and contribute effectively to national and EU-level sustainability targets (Li et al., 2023).

Finally, market mechanisms embedded within these frameworks—such as cap-and-trade schemes and renewable quota systems—play a critical role in aligning economic incentives with environmental outcomes. By making it financially advantageous for firms to invest in cleaner technologies, these mechanisms support both emissions reductions and the expansion of renewable energy capacity (Busu et al., 2019; Chen & Chen, 2024). However, achieving meaningful decarbonization requires continuous monitoring and adaptive policy adjustments to maintain strong and credible market signals (Raihan & Bari, 2024).

Recent empirical literature increasingly emphasizes that the effectiveness of carbon pricing mechanisms depends not only on allowance prices, but also on their interaction with parallel renewable energy support instruments. Several studies highlight that overlapping policies — such as feed-in tariffs, green certificates, and investment subsidies — may either reinforce or partially offset the price signal generated by emissions trading systems (Fischer et al., 2019; Schmalensee & Stavins, 2020; Koch et al., 2023).

While renewable support schemes accelerate capacity deployment and reduce emissions directly, they may simultaneously reduce demand for emission allowances, thereby exerting downward pressure on ETS prices if cap adjustment mechanisms are weak or delayed. This phenomenon, often described as policy "cannibalization" or interaction effects, has been documented particularly in EU member states with ambitious renewable targets (Bayer & Aklin, 2020; Levi & Flachsland, 2023).

For Central and Eastern European countries, where energy systems remain carbon-intensive and institutional frameworks are still evolving, the coordination between carbon markets and green certificate systems becomes even more critical. Empirical evidence suggests that inconsistent regulatory changes and unstable support schemes can undermine investor confidence and weaken long-term decarbonization incentives (Koch et al., 2023; Raihan & Bari, 2024).

Research Design, Methodology, Research Tasks and Hypothesis

The research questions resulted from the literature review are:

Q1: How does the regulatory framework influence the adaptability and efficiency of carbon and green certificate markets in the three countries studied?

Q2: What specific economic and technological challenges are identified in implementing these markets, and how can they be overcome?

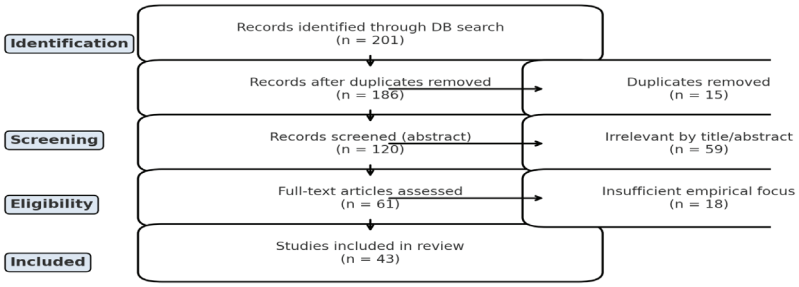
Q3: What is the role of digital technologies, including blockchain, in enhancing the efficiency of carbon and green certificate markets?

Q4: How do cap-and-trade schemes interact with green certificate markets to promote or inhibit the achievement of climate neutrality objectives?

The research employed a structured literature review following PRISMA guidelines to examine academic sources related to carbon markets, green certificate systems, and environmental policy frameworks. The initial pool of articles consisted of 201 peer-reviewed publications sourced from major databases (ScienceDirect, Scopus, Web of Science, and Google Scholar) spanning the years 2010–2025. Inclusion criteria focused on relevance to ETS implementation, green certificate mechanisms, and the role of digital technologies (e.g., blockchain, IoT, AI). Exclusion criteria included duplicate entries, purely theoretical papers without policy application, and studies focused exclusively on non-European contexts.

After applying these filters, and removing studies lacking empirical or regulatory focus, the final sample included 43 core articles. These served as the analytical foundation for regulatory mapping, historical policy trajectories, technological trends, and economic performance indicators in Romania, Poland, and Germany.

Figure 1. Prisma flowchart



Source: European Environment Agency (EEA)

The second methodological pillar of this research builds upon a fixed-effects panel regression model, developed to quantify the impact of market-based instruments-namely the EU Emissions Trading System (ETS) and green certificate mechanisms-on CO_2 emissions per capita. The analysis spans a balanced panel of three countries (Romania, Poland, and Germany) across the period 2015 to 2024, leveraging both cross-sectional and time-series dimensions of the data.

The dependent variable is the national CO_2 emissions per capita (in tonnes/year), while the independent variables include the average annual ETS price (€/tCO_2), the share of renewable energy in final energy consumption (%), and GDP per capita (in euros). To capture potential synergistic or overlapping effects between market mechanisms, an interaction term—ETS price multiplied by renewable energy share—was included. This enables the model to account for complex dynamics, such as policy cannibalization or reinforcement between carbon pricing and renewable subsidies. The estimation was conducted using Ordinary Least Squares (OLS) with fixed effects for countries. This specification controls for unobserved, time-invariant structural differences across countries, such as geographical features, legacy energy infrastructure, or institutional maturity, allowing the model to focus on within-country variation over time. Robust standard errors (HC3) were applied to correct for potential heteroscedasticity and ensure the reliability of inference.

The regression model is expressed formally as:

$$CO2_{it} = \alpha + \beta_1 ETS_{it} + \beta_2 Renew_{it} + \beta_3 GDP_{it} + \beta_4 (ETSxRenew)_{it} + \gamma_i + \epsilon_{it}$$

where γ_i represents the fixed effect for each country and ϵit is the error term.

The full model was implemented in Python 3.11, using the stats models and linear model libraries for panel data estimation. Data preparation and manipulation were handled with pandas, while matplotlib and seaborn were used for diagnostic plotting. Multicollinearity was evaluated using Variance Inflation Factor (VIF), with all predictors scoring below the threshold of 5, indicating no collinearity concerns. Residuals were visually inspected through residuals-versus-fitted plots, which confirmed the assumptions of homoscedasticity and correct model specification. Post-estimation, marginal effects were calculated to interpret the direct influence of each explanatory variable on emissions, providing intuitive policy-relevant insights.

Research results and Discussion

The effects of the carbon price (ETS), the share of renewable energy, GDP per capita and synergies/interactions between market instruments were assessed.[4]

Table 1. *Key indicators of carbon markets & green certificates (2015 – 2025)*

	Romania	*Poland*	*Germany*
ETS average price (€/tco₂)	Approx. identical: between 7 → 85	Idem	Idem
ETS Verified Emissions (Mt CO_2e)	~65–70	~180–200	~300–350

[4] Note on data sources and methodology: The indicators presented in Tables 1–4 are based on official datasets and aggregated reports. Sources include the European Environment Agency (EEA), Ember Climate, the European Energy Exchange (EEX), Eurostat, IRENA, OPCOM (Romania), TGE (Poland), the World Bank, and OECD databases. Figures reflect multi-year averages (2015–2023), depending on data availability and consistency across countries. Where needed, expert-based approximations and national reports were used to supplement missing entries.

Ets revenue (2022)	~€2 billion	~€6 billion	~€10–12 billion
% Renewable energy (2022)	~42%	~22%	~49%
No. Of active ETS operators	~200–250	~600	>1500
Active green certificates?	Yes (with changes)	From (premium feed-in')	Yes (EEG – with feed-in tariff)
Centralized marketplace for resume?	OPCOM	TGE	EEX
Ets/cv digitalization	Medium (MM portal, OPCOM)	Medium (KOBiZE, TGE)	Advanced (DEHSt, EEX blockchain)
Blockchain projects in energy	<5	5–10	>20
ETS legislative framework	GEO 115/2011 + Law 155/2020	Act ETS + PKEE	BImSchV + national legislation

Source: European Energy Exchange (EEX)

The price of ETS allowances is common to all EU ETS countries, yet the budgetary and industrial impacts vary considerably. Germany dominates in terms of ETS volume and revenues, but its economy is already more decarbonized, while Poland remains heavily dependent on coal. Romania, by contrast, has a functioning but modified and unstable green certificate system, which undermines investor confidence. In terms of governance, digitization is well advanced in Germany and partially implemented in Poland, whereas Romania is still in the process of modernization.

Table 2. Indicators for green certificates and renewable energy (2015–2025)

	Romania	**Poland**	**Germany**
% renewable energy (2022)	42%	22%	49%
Green energy production (TWh, estimated)	16–18	30–35	220–240
Number of green certificates (2022)	≈7 million	≈15 million	>80 million
Average price of green certificate (€)	25–30	10–15	10–18
Share of renewables in total energy consumption	39%	23%	50%

Source: OECD databases

Table 3. Economic efficiency indicators and legal framework

	Romania	*Poland*	*Germany*	*Indicator Type*
Emissions-adjusted GDP/capita (€/ tco_2)	~650	~500	~1200	Derivative calculation
Marginal cost of CO_2 reduction (€/ tco_2 avoided)	35–45	30–40	20–30	Range
Market regulation index (oecd pmr)	2.7	3.1	1.6	Score (OECD)
Degree of transposition of EU ETS legislation (%)	90%	95%	100%	Official estimate

Source: OECD databases

Table 4. Digitalization and Blockchain Technologies

	Romania	**Poland**	**Germany**
Energy/climate blockchain projects	<5	5–10	>20
Digitalisation of ETS authorities	average	average	High
Market transparency	average	medium-high	Elevated

Source: OECD databases

Although the average price of ETS allowances is harmonized across EU countries (Table 1), its impact on emissions and fiscal revenues varies greatly. Germany, with over 300 Mt CO_2e in verified emissions, generated more than €10 billion in ETS revenues in 2022, compared to Romania's ~€2 billion despite having the same allowance price. This reflects structural differences in industrial output and decarbonization maturity. Romania and Poland have both implemented green certificate systems (Table 2), but with distinct approaches and levels of market transparency. Germany's feed-in tariff model under the EEG has supported a stable renewable trajectory, now covering approximately 50% of total energy use. In contrast, Romania's scheme has undergone multiple regulatory adjustments, possibly undermining investor confidence and slowing renewable capacity growth. As shown in Table 3, Romania and Poland both exhibit lower economic efficiency in decarbonization, as captured by lower GDP per tonne of CO_2 and higher marginal abatement costs. Moreover, Germany scores significantly better in regulatory quality (OECD PMR: 1.6) and has fully transposed the EU ETS framework, compared to Romania's partial alignment (90%). Digitalization of carbon governance (Table 4) also reflects this disparity: Germany has implemented advanced electronic registries and blockchain-enabled transparency tools (DEHSt, EEX), while Romania's infrastructure remains under development.

This multidimensional heterogeneity across countries and policy tools highlights the necessity for a quantitative econometric model, capable of isolating the effects of ETS pricing, renewable energy penetration, and economic indicators on carbon emissions. The next section will detail the methodology and results of a panel regression analysis spanning 2015–2024.

We had a panel data approach with fixed effects, applied to a sample of Romania, Poland and Germany for the period 2015–2024. The dependent variable analysed is CO_2 emissions per capita, and the explanatory variables include the price of ETS emission certificates, the share of renewable energy in total consumption and GDP per capita.

Table 5. Variables in the model

	Symbol		
CO_2 emissions/capita	CO2_it	Dependent	CO_2 tons/capita/year
ETS Price	ETS_it	Independent	€/tonne CO_2
Renewable energy (%)	Renew_it	Independent	% of total energy
GDP/capita	GDP_it	Control	€/person
ETS Interaction × Renew	ETS_it × Renew_it	Interaction	Synergies/conflicts

Source: own research

We applied an OLS model with fixed effects on countries to control for constant structural characteristics. The model has an R^2 of 0.995 and reveals a negative relationship between renewable energy and CO_2 emissions.

Table 6. Fixed-effects regression

	coeff.	*p-val*
Intercept	16.55	<0.001
Poland (dummy)	-5.72	<0.001
Romania (dummy)	-9.5	<0.001
ETS	-0.0046	0.092
Renew	-0.0561	0.021
GDP	-0.0001	0.005
ETS × Renew	0.0003	0.007

Source: own research

The empirical results obtained in this study are broadly consistent with existing evidence on the effectiveness of renewable energy deployment as a primary driver of emissions reduction. The statistically significant and negative coefficient associated with the share of renewable energy mirrors findings reported by Bayer and Aklin (2020) and Koch et al. (2023), who document substantial emission reductions linked to renewable expansion under the EU ETS framework.

In contrast, the relatively weak and only marginally significant effect of the ETS price aligns with prior research highlighting the limited short-term responsiveness of emissions to allowance price fluctuations, particularly during periods of high price volatility or policy uncertainty (Koch et al., 2023; Aldy & Stavins, 2023). This suggests that carbon pricing alone may be insufficient to drive rapid decarbonization without complementary regulatory and investment-oriented instruments.

Importantly, the positive coefficient associated with the interaction between ETS prices and renewable energy share supports the policy-interaction hypothesis advanced in the literature. Similar interaction effects have been identified by Levi and Flachsland (2023), who argue that overlapping climate policies can generate unintended distortions if not properly coordinated. The present results extend this insight to a comparative Central and Western European context, demonstrating that policy coherence remains a decisive factor for market efficiency.

Multicollinearity was assessed using the Variance Inflation Factor (VIF). All VIF values are well below the commonly accepted threshold of 5, suggesting that the independent variables (ETS price, renewable energy share, and GDP per capita) are not significantly correlated with each other. This indicates that the model is structurally stable and that estimated coefficients are interpretable. An analysis of residuals was conducted to examine potential violations of the OLS assumptions. No major issues of non-normality or heteroscedasticity were observed visually. The residuals appear randomly distributed around zero, and their variance does not increase with the fitted values. Overall, the diagnostic tests support the robustness and reliability of the econometric estimations.

Table 7. VIF Score

Variable	*VIF Score*
ct.	**9.36**
ETS	**1.42**
Renewables (%)	**2.39**
GDP per capita	**1.84**

Source: own research

The diagnostic tests confirm the structural soundness of the regression model.

Variance Inflation Factor (VIF) scores are all well below the critical threshold of 5, indicating the absence of multicollinearity among independent variables. The residuals vs. fitted values plot reveals a random dispersion of residuals around zero with no discernible patterns, supporting the assumption of homoscedasticity and model correctness. These findings collectively indicate that the model estimates are statistically reliable, and the core OLS assumptions are not violated.

Table 8. Marginal effects of market instruments

Variable	**Marginal effect ΔCO_2/capita**
ETS price (€)	0.004434
Renewable energy (%)	-0.045417
GDP/capita (€)	-0.000149

Source: own research

Table 9. Predictions for 2025

Country	**ETS (€)**	**Renew (%)**	**GDP (€)**	**Forecast CO_2 emissions/capita (t)**
Romania	90	49	15750	2.77
Poland	90	30	18165	6.78
Germany	90	56	50400	6.9

Source: own research

From the econometric model we could observe that a higher share of renewable energy has a strong and consistent effect in reducing CO_2 emissions per capita, confirming its central role in decarbonization. GDP per capita also contributes to lower emissions, though with a smaller effect, likely because more developed economies have greater capacity to invest in cleaner technologies. The ETS price shows only a marginally significant negative impact, suggesting that while higher carbon prices do help curb emissions, the effect is modest and may be partially offset by national policies. Moreover, the interaction between ETS and renewables (ETS × Renew) reveals a small positive coefficient, indicating that when the share of renewables is already very high, a rising carbon price can sometimes create unintended overlap or "cannibalization" effects, such as double counting or distortions between the two markets, unless carefully managed.

To evaluate the robustness of the model specification, several standard diagnostic tests were performed. Multicollinearity was assessed using the Variance Inflation Factor (VIF), with all independent variables scoring below the commonly accepted threshold of 5. This result indicates a low risk of excessive correlation among predictors and confirms the structural stability of the estimated model. Residual distribution was visually inspected using a Residuals vs. Fitted Values plot to detect potential violations of OLS assumptions. The residuals appear symmetrically distributed around zero, with no evidence of heteroscedasticity or model misspecification. However, the slightly curved shape of the LOWESS line suggests a potential non-linearity or a modest increase in variance at higher levels of fitted values. These findings imply that alternative model specifications — such as including nonlinear terms or applying log transformations — may further improve model fit.

To assess the practical significance of the explanatory variables, marginal effects of key market instruments were calculated (Table 8). These reflect the estimated change in CO_2 emissions per capita associated with a one-unit variation in each predictor. The results show that the share of renewable energy exerts the strongest mitigating effect on emissions, with a marginal impact of –0.045 tCO_2 per capita for each additional percentage point of renewable energy. This finding is statistically significant and confirms the direct effectiveness of renewables in driving decarbonization.

The marginal effect of the ETS price is unexpectedly positive (+0.0044), which may indicate the presence of policy overlap or market inefficiencies, especially in countries where ETS mechanisms coexist with other support schemes. This is consistent with the positive sign of the ETS × Renewables interaction term in the main regression model.

GDP per capita exhibits a small but negative marginal effect (–0.00015), suggesting that more developed economies tend to emit less per capita — possibly due to greater energy efficiency and advanced decarbonization infrastructure.

Based on the model coefficients, emissions forecasts for 2025 were generated for Romania, Poland, and Germany (Table 9). The estimates indicate that Romania will report the lowest level of CO_2 emissions per capita (2.77 t), while both Germany and Poland are projected to exceed 6 t. These variations reflect not only differences in economic structure, but also in the depth of renewable integration and the overall coherence of national climate strategies.

To support and visualize the relationships identified in the econometric model, three simple linear regression plots were generated, capturing the bivariate interactions between CO_2 emissions per capita and each major explanatory variable: renewable energy share, ETS price, and GDP per capita.

Figure 3 shows a clear inverse relationship between CO_2 emissions and the share of renewable energy in the energy mix. The downward trendline, coupled with a relatively narrow confidence band, indicates a strong and robust correlation: expanding renewables is consistently associated with lower per capita emissions. This result aligns with the statistically significant negative coefficient obtained for Renewables in the econometric model.

Figure 4 illustrates the relationship between CO_2 emissions and the price of ETS allowances. While a negative trend is visible, the effect appears weaker and accompanied by greater uncertainty, as reflected in the wider confidence interval. This observation supports the regression result, where ETS Price had only a marginally significant coefficient. Cross-country implementation differences and varying market responses may explain the variability.

Figure 5 shows a negative relationship between GDP per capita and CO_2 emissions, indicating that more developed economies tend to emit less CO_2 per person. This may be due to higher energy efficiency, a cleaner energy mix, or a greater capacity for investment in low-carbon technologies. Although the coefficient in the regression model is relatively small, the visual trend is consistent and supports the conclusion that economic growth, when combined with effective climate policies, contributes to emission reduction.

Collectively, these visual representations validate the econometric findings and provide an intuitive understanding of the key dynamics between the variables analyzed.

Beyond regulatory design, the findings also underline the growing importance of digital governance in environmental markets. Advanced digital registries, automated monitoring, and blockchain-based tracking systems can substantially reduce transaction costs, enhance transparency, and mitigate fraud risks in both ETS and green certificate markets (Wang et al., 2022). Germany's more advanced digital infrastructure — including integrated registries and emerging blockchain pilots — appears to support higher market transparency and regulatory credibility compared to Romania and Poland.

As climate policies become increasingly data-intensive, digitalization is likely to play a critical enabling role in aligning market-based instruments with climate neutrality objectives. This suggests that future policy effectiveness will depend not only on price levels or support schemes, but also on the technological architecture underpinning market governance.

Conclusion

This article investigated the dynamics of carbon markets and green certificate systems in Romania, Poland, and Germany over the 2015–2025 period, using a combination of econometric modeling and literature-based policy analysis. The findings highlight the pivotal role of renewable energy integration and institutional coherence in reducing CO_2 emissions per capita and enhancing the efficiency of market-based climate instruments.

The econometric model confirms that a higher share of renewables in final energy consumption has a statistically significant and consistent negative effect on emissions. In contrast, the standalone effect of the ETS price is relatively weak and marginally significant, suggesting that carbon pricing alone is insufficient to drive meaningful decarbonization unless it is embedded within a broader and well-coordinated policy framework. The positive interaction between ETS pricing and renewable energy share reveals potential policy overlap, raising concerns about market cannibalization or double-counting in climate performance metrics.

Graphical analyses reinforce these conclusions, clearly illustrating the inverse relationships between CO_2 emissions and renewable energy, ETS price, and GDP per capita. Emissions forecasts for 2025 indicate that Romania — despite lower economic output — may outperform its regional peers in per capita emission reduction, primarily due to its renewable energy penetration.

At a broader level, the study emphasizes the need for harmonized climate governance, stable regulatory frameworks, and digital integration (e.g., blockchain, IoT) to ensure transparency and market integrity. The results call for a redesign of policy

interactions between carbon trading schemes and renewable support mechanisms, aiming to maximize synergies while avoiding inefficiencies.

Future research may expand the analysis by incorporating additional countries, sector-specific emissions, or dynamic models that account for feedback loops between policy variables and investment behavior. Additionally, the long-term role of emerging technologies in decarbonization pathways warrants closer empirical investigation.

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MEASURING BUSINESS PERFORMANCE THROUGH A FINANCIAL PERSPECTIVE: CHALLENGES AND OPPORTUNITIES FOR IMPROVEMENT IN MODERN ORGANIZATIONS

Abstract

Modern business environments are shaped by rapid change, growing importance of intangible assets, and increased pressure to deliver sustainable financial performance. This paper examines the measurement of business performance from a financial perspective, identifying core challenges—limited recognition and valuation of intangibles, poor data quality, misaligned KPIs, and narrow reliance on traditional financial metrics—and proposes pathways for improvement. It argues for integrating financial and non-financial measures through strategic frameworks such as the Balanced Scorecard, which complements historical financial results with leading operational indicators. The paper also recommends enhanced valuation of intangibles, adoption of advanced analytics and automated data collection, and stronger linkage between measurement systems and strategy to improve managerial decision-making and long-term value creation.

Key words: *Financial perspective, Performance measurement, Balanced Scorecard, Intangibles, Advanced analytics*

JEL classification: *M21, G32*

МЕРЕЊЕ ПОСЛОВНИХ ПЕРФОРМАНСИ КРОЗ ФИНАНСИЈСКУ ПЕРСПЕКТИВУ: ИЗАЗОВИ И МОГУЋНОСТИ ЗА ПОБОЉШАЊЕ У САВРЕМЕНИМ ОРГАНИЗАЦИЈАМА

Апстракт

Модерна пословна окружења обликују брзе промене, растући значај нематеријалне имовине и појачан притисак да се оствари одржива финансијска

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успешност. Овај рад испитује мерење пословних перформанси из финансијске перспективе, идентификујући кључне изазове — ограничено признавање и вредновање нематеријалне имовине, лош квалитет података, неусаглашене КПИ и преуску ослоњеност на традиционалне финансијске метрике — и предлаже путеве за унапређење. Аутор заговара интеграцију финансијских и нефинансијских мера кроз стратешке оквире као што је Уравнотежени систем показатеља (Баланцед Сцорецард), који историјске финансијске резултате допуњава водећим оперативним индикаторима. Рад такође препоручује унапређено вредновање нематеријалне имовине, примену напредне аналитике и аутоматизовано прикупљање података, као и снажније повезивање система мерења са стратегијом ради побољшања менаџерског одлучивања и дугорочне креације вредности.

Кључне речи: *Финансијска перспектива; Мерење перформанси; Баланцед Сцорецард; Нематеријална имовина; Напредна аналитика.*

Introduction

Modern business environments are characterized by accelerated changes and the increasing importance of intangible assets, which today constitute a significant part of the value of leading companies and global value chains (Wang et al., 2025). Under competitive pressure and stakeholder expectations, organizations are forced to achieve sustainable financial performance while simultaneously managing non-financial resources and risks (Ikerd, 2024).

This paper examines the measurement of business performance from a financial perspective, focusing on the main challenges that hinder reliable measurement and interpretation of results (Pérez Estébanez & Sevillano Martín, 2025). Among the key problems are the limited recognition and valuation of intangible assets, which distorts the full picture of the real value of the company; it leads to an underestimation of intellectual capital, brand and data as a resource. Also, poor data quality and insufficient automation of information collection reduce the reliability of analyzes and make it difficult to implement advanced analytics in decision-making (Kumar et al., 2024).

In addition, over-reliance on traditional financial metrics and KPIs' inconsistency with strategic goals prevent management from recognizing early signals of business change. In response to these challenges, the work promotes an integrated approach — combining financial and non-financial indicators through strategic frameworks such as the Balanced Scorecard, which supplements historical financial results with leading operating indicators ((Chehimi & Naro, 2024; Hristov et al., 2019).

In the continuation of the work, technical and organizational ways of improvement will be discussed in more detail: better valuation of intangible assets, application of advanced analytics and automated data collection systems, and a tighter connection between performance measurement systems and strategic management to improve managerial decision-making and permanent value creation.

Strategy in Conditions of Accelerated Technological Change: Theory and Practice

Accelerated technical and technological progress over the past half century, along with a continual increase in the complexity and uncertainty of the external environment, has posed numerous intriguing challenges to many theorists and practitioners when it comes to effective organizational management. The problem of creating — but also of sustaining — competitive advantage thus arises. The very mechanism for achieving such advantages is, in fact, the subject of strategic management theory, which over many years has gone through various stages of development and has only recently become a serious and independent scientific discipline (Rumelt et al., 1994). One of the central questions concerning the evolution of strategic management as a new paradigm at the beginning of the 21st century is how to follow the dynamics of competition under conditions of the accelerated formation of a post-industrial society (Prahalad & Hamel, 1994; Lowendahl & Revang, 1998). What is most important is to make an appropriate choice of management strategies that provide the foundation for building competitive advantage.

Competitive advantage, by its nature, involves striving to gain an advantage over others. In an effort to create a sustainable competitive advantage, organizations try to find a way to stand out from the rest and be competitive. In order to achieve this, organizations implement their competitive strategy, where they lay the foundations for improving and strengthening their competitive advantage, whether it is found in unique resources or, in some other, different capabilities. Porter (1985) states that the appropriate competitive strategy is precisely the one that is based on the competitive advantage of an organization and which can come from having the lowest costs in its activity or having significant desirable differences compared to competitors.

BSC as a Framework for Strategy Implementation and Performance Evaluation

BSC is successfully used worldwide in many institutions, such as government units, manufacturing enterprises, service organizations and non-profit companies. Kaplan and Norton understood the requirements of modern organizations and their need for effective strategy implementation and the creation of a comprehensive system of performance improvement and management, and introduced a new management system, the BSC system. The BSC management system, as a comprehensive framework for evaluating performance and progress in strategy, establishes a balance between short-term and long-term goals.

BSC is a proven framework that explains and implements organizational strategy (Niven, 2006). Today, it represents a strategic management system for managing organizational performance (Brudan, 2010). Also, this approach has at its root the principle of motivational action - the action of an individual and a group to contribute with their abilities and knowledge to the implementation of the organization's strategy (Nair, 2004).

Today's organizations have realized that 80% of their value is created through intangible assets, including human capital (the knowledge and skills of employees),

organizational capital (the organizational culture and values that govern it), and intelligence (sources of information and statistical data) and they no longer conduct a comprehensive performance assessment relying solely on tangible assets (Kaplan & Norton, 2004).

The BSC is designed for organizations of all sizes and industries. This approach helps organizations find answers to the following questions:

- Consumer perception?
- Future focus?
- Capacity for continuous improvement of strategy?
- Shareholder perception?

Selection and Implementation of Key Performance Indicators (KPIs) Within the Balanced Scorecard Approach

The performance evaluation process assesses progress towards achieving set goals and includes information on the efficiency of the transformation of offered products and services and customer satisfaction, achievements and effectiveness of activities in accordance with specific goals.

The greatest challenge in developing a BSC approach is the selection of indicators, which stands out as the necessary identification and development of key (critical) success factors (KSFs) and their associated key (critical) success indicators (KPIs).

Key success factors are approaches to strategically related actions, competitive opportunities and business outputs, which every company must achieve or must focus on achieving in order to be competitive and financially successful.

The success of any performance management program depends on the selection of the right key success indicators (KPIs). The selection of appropriate indicators, which must be oriented towards continuous improvement, is usually a very complex problem on which the success of the implemented KPI depends. “The difficulty of the task in developing a BSC model is not in identifying enough indicators of success, but in selecting a very small number of the most important indicators” (Neely, 2002). “The determination of indicators is one of the main obstacles to the effective implementation of the BSC” (Bryan & Murphy, 2007).

KPIs and their associated KPIs must be linked to the organization’s strategy. It often happens that KPIs and KPIs are an end in themselves and represent the end result, and are not used to improve the system. This choice of performance indicators must be left to the organization. The process of choosing KPIs should involve all employees who will be the users of the developed measures, as well as managers whose work contributes to the strategy.

Performance measurement and control systems are considered to be formal information processes and procedures, the axis that managers use to maintain or modify organizational activity patterns. According to this definition, every performance evaluation system has four main objectives (Simons, 2000):

- The objective of all performance measurement and control systems is to transmit information.
- Performance measurement and control systems demonstrate formal processes and procedures.

- Performance measurement and control systems must be designed for managers.
- Managers use a performance management and measurement system to maintain or modify organizational activity patterns.

Once an organization has determined the areas in which performance measurement is needed, it is time to define key organizational performance indicators (KPIs). After that, the intended results and goals in the identified areas (which are measured by means of established performance measurement indicators) are determined, as well as the manner in which the measurement will be performed.

KPIs (Key Performance Indicators or Key Process Indicators) do not have precise dates of origin, nor do they even have a precise definition, indicating how they can be understood. The fact is that they have two meanings. To begin with, KPIs are a subset of key performance indicators; however, there is also a fundamental misunderstanding about the very essence of the concept: some consider KPI necessarily as a non-financial indicator, while on the other hand, some see KPI as any other number, i.e. an indicator that describes the business.

Performance Monitoring Systems: From Data Quality to Actionable KPIs

Performance monitoring depends on good, quality information, which can only be achieved through a systematic process to ensure consistent data collection, both within and outside the organization (Pierce, 2022). One tool that is often used to help monitor and measure performance and can subsequently contribute to performance improvement is key performance indicators (KPIs).

Some authors believe that all KPIs should influence a business decision within a certain time period. This makes the decision-making process more difficult for decisions made without time constraints. Organizations should identify the areas of business processes that are most critical to the financial success of the organization (Skibniewski & Ghosh, 2009).

KPIs can be valid and effective when applied in a consistent and comprehensive manner. Also, financial performance must be respected as a critical measure of success for any business, but financial KPIs are a closely related set of operational metrics (Bean & Geraghty, 2003). Wherever possible, KPI targets should be based on concrete data and some manipulative formulas. Also, there should be a direct link between KPIs and objectives, from objective to objective, and from objectives to strategies (Griffin, 2004).

There are five criteria for an effective KPI (Hursman, 2010):

- Specificity;
- Measurability;
- Availability;
- Relevance;
- Time-boundness

Metrics are a powerful force that can drive organizational change, but only if the right metrics are developed and implemented well. The wrong metrics can impact

organizational processes and demoralize employees. What characterizes good KPIs is the following (Eckerson, 2009):

- The fewer KPIs, the better.
- Drill-down capability, users can drill down into the details.
- Simple: users understand the KPIs.
- Actionable: users know how to influence outcomes.
- Ownership: KPIs have an owner.
- Users can review the origin and context.
- KPIs lead to desired outcomes.
- Balanced: KPIs consist of financial and non-financial metrics.
- Alignment: KPIs do not undermine each other.
- Validated: employees cannot bypass the KPIs.

BSC as a strategic framework for integrated performance measurement

The starting point of the BSC methodology is that you cannot manage what you cannot measure, but you cannot measure what you cannot describe (Kaplan et al., 1996; Anthony et al., 2007).

The BSC model is a well-known performance management system that divides an organization's objectives into four operational and quantifiable perspectives: internal business processes, financial perspective, customer perspective, and learning and growth (Brzaković et al., 2022; Kaplan & Norton, 1992).

As previously stated, the BSC strategy includes metrics for internal business operations, customer relations, organizational learning and development, and financial success. The organization's aims and strategy should be reflected in the BSC measurements that each business unit creates. While some of these metrics will be specific to each business unit, others will be shared by all participants, or units (Brzaković et al., 2022; Gascho et al., 2000).

The four main perspectives of the BSC approach are (Hannabarger et al., 2011):

- Financial perspective – measures the company's success in increasing shareholder value, i.e. whether the organization's strategy contributes to improving the organization's financial condition.
- Customer perspective – measures how the organization's customer-oriented strategies and activities affect customer loyalty and higher profitability.
- Internal business process perspective – measures how processes within the organization should be carried out in order to increase the organization's efficiency.
- Learning and development perspective – measures how innovation, education and employee satisfaction contribute to the achievement of strategic goals.

The four perspectives listed above do not eliminate each other, but rather support the goals of various management techniques (such as strategic planning, Total Quality Management), which have been used in the years since the BSC appeared. Each perspective contains and is viewed through four parameters, which are:

- Objectives – What needs to be done to achieve success?
- Measures – What parameters will be selected and monitored to demonstrate business success?
- Target values – What quantitative values will we use to determine the success of the measurement?
- Initiatives: What needs to be done to achieve the set goals?

According to the BSC concept, all financial and non-financial measures should be included and be part of the information system at all levels of the organization (Kaplan & Norton, 2006).

The BSC approach contributes to improving organizational performance by enabling the existence of four main elements, which, compared to other frameworks, distinguish strategic management and learning (Kaplan & Norton, 2007):

- Clarification of the vision and mission for all employees within the organization.
- The role of communication as a factor in integrating all efforts of individual business units to meet organizational goals.
- Focus on the importance of the approach as a tool that enables a revised strategy.
- Focus on strategic feedback, by including expert knowledge about changes in the competitive environment.

It would be desirable for the BSC approach to be implemented in all organizations as a system for measuring and improving performance. In this way, the organization, based on a set of different financial and non-financial indicators, would know where it stands in relation to its set and planned goals (Kaplan & Norton, 1996).

The BSC approach provides the opportunity for strategic goals to be transparent and transformed into goals for all segments of the organization, as well as all employees. The strategy should be defined in such a way that each organizational unit, each segment, each process owner, and even each employee, can and must recognize its role in the defined strategic goals and thus determine its own goals and activities towards their fulfillment and improvement of the organization's performance indicators themselves.

The role of the BSC approach is that it contains the right mix of measurement and evaluation of processes and added value for customers, which can lead us to the desired and planned financial results (Niven, 2010).

Financial Perspective

Generally speaking, financial performance measures can be considered the most important component in the implementation of a company's strategy (Al-Hosaini et al., 2023). This is due to the main role of supporting and improving the organization. The goal of the main financial perspective is to increase shareholder value, growth and profitability.

The financial strategy is typically the first step in creating the strategy map itself. As previously said, this viewpoint seeks to expand the company, boost sales, and enhance shareholder value. Entering new markets, providing new goods and services, or drawing in new clients are all ways to boost revenue. Another strategy is to improve the value of current clients by fortifying existing ties through the expansion of the offer. There are often two approaches to productivity: the first is lowering direct and indirect costs to improve the cost structure, and the second involves lowering working and fixed capital to better utilize current assets.

Since making a profit is the main objective that any corporation aspires to, the financial viewpoint is the most crucial component of business. In order to maximize profits, the BSC approach's financial perspective comprises objectives and metrics that

serve as the organization's ultimate gauge of success. Setting goals that measure financial performance in conjunction with a variety of other activities that can be used to engage employees can help achieve long-term financial growth. This is because achieving goals in the learning and development perspective, internal business processes, and customer perspectives results in a financial perspective that highlights the significance of financial performance indicators, but not as the only indicator of achieving organizational goals. Organizations should take non-financial aspects into account if they wish to use the BSC strategy to gain the most advantage. Organizations may develop short-term goals and overlook long-term value and investments if they only concentrate on attaining short-term financial results. They may also overlook the significance of intellectual and intangible assets, which are crucial to an organization's development (Kaplan et al., 1996). It is suggestive that the following financial metrics can be employed: return on investment, return on invested capital, gross margin percentage, and cost reduction in critical sectors (Kaplan et al., 1996; Collis et al., 2012).

In addition to the above measures, it is recommended that organizations consider indicators that reflect the economic value created above the cost of capital — eg. Return on Invested Capital (ROIC) or Economic Value Added (EVA) — because they better reflect a company's long-term ability to generate new value for shareholders, especially when compared to the average cost of capital. These metrics help distinguish growth that truly creates value from growth that is financially neutral or destructive.

For financial indicators to be useful in practice, they must be clearly linked to management actions and sources of value defined in other BSC perspectives. In other words: we must have an explicit "cause and effect" path (strategy map) that shows how improvements in learning and growth, process optimization or customer experience lead to increased revenue, reduced costs or better utilization of assets, and then to financial performance. This enables management to plan initiatives that are simultaneously actionable and measurable.

Special attention should be paid to the choice of reference values and targeting methodology: target values for financial KPIs should be set based on benchmarking (comparable industry indicators), historical performance and realistic business scenarios. Using unique, manipulative or unrealistic goals leads to loss of trust and "gaming" behavior; on the other hand, transparent, data-driven goals encourage alignment and accountability. Also, it's useful to combine absolute financial goals (eg EBIT, net profit) with relative measures (eg revenue growth by segment, margins vs competition) for the bigger picture.

Intangible assets — human capital, information resources, and organizational capital — often make up the majority of a firm's future value; therefore, organizations must actively measure and manage those drivers through KPIs from a learning and growth perspective. The BSC tools allow to map that "intangible" value to concrete initiatives (eg competence development, knowledge management systems, IT investments) and to monitor how changes in those areas affect financial results. Otherwise, financial indicators remain reactionary and do not explain the source of long-term growth.

Finally, the practical implementation of the financial perspective requires an integrated reporting system — dashboards that enable drill-down analysis, regular KPI audits and data validation mechanisms. It is recommended that financial KPIs are not set in isolation, but that they be part of a dynamic set of indicators that are revised quarterly,

with clearly defined owners and mechanisms for corrective action. This reduces the risk of focusing only on short-term financial results and increases the chance of achieving sustainable growth.

Financial performance is most commonly assessed by a set of financial ratios — for example ROE, ROA, return on capital, return on sales (ROS) and operating margin — which synthesize information taken from a company's financial statements to give a multi-faceted view of its condition (Gilchris, 2013). Ratios allow analysts to standardize and compare core economic relationships (profitability, efficiency, leverage and market valuation) across time and between firms, so they provide a broader perspective than absolute numbers alone.

Because these indicators are calculated from balance-sheet and income-statement items, the emphasis of financial performance analysis naturally falls on variables that originate in formal financial reporting. Practical groupings of ratios commonly used in analysis include liquidity ratios (which assess short-term cash availability and the firm's ability to meet immediate obligations), activity or efficiency ratios (which show how rapidly assets are converted into sales or cash), debt or solvency ratios (which reflect long-term financing structure and capacity to service obligations), profitability ratios (which measure how well assets and sales generate returns), and market ratios (which capture investors' valuation of the firm and shareholder returns).

Analysts typically do not rely on individual ratios, but link them into comprehensive decompositions—a classic example is DuPont's analysis—to break down return on equity (ROE) into the components of margin, asset turnover, and leverage. In this way, it is possible to more precisely determine whether changes in performance result from improvements in operational efficiency, stronger ability to form prices or changes in the capital structure, instead of drawing conclusions from isolated numbers.

Advanced Financial Metrics

Advanced financial metrics shift the focus from simply tracking revenue and expenses to measures that quantify value creation, capital allocation efficiency, and growth sustainability. Among the most important measures that management uses today are Return on Invested Capital (ROIC) — an indicator of the efficiency of investment of funds in business, useful for assessing whether a business unit achieves returns above the cost of capital; accurate calculations of NOPAT and invested capital are crucial to the interpretation of ROIC.

One widely used value-based performance metric is Economic Value Added (EVA) — a measure that has gained considerable attention for assessing corporate performance and promoting shareholder value. EVA was developed and championed by Stern Stewart & Company as a managerial tool to quantify a firm's economic profit and thereby support better managerial decision-making (Chen, and Dodd, 1997).

A related and conceptually important measure is Economic Value Added (EVA), i.e. economic profit, which measures profit after tax minus the "cost" of capital (WACC × invested capital) — EVA directly indicates whether the company has created surplus value for shareholders. EVA is useful for drill-down analyzes by business units and for evaluating investment decisions.

For the operational and liquidity dimension, the Cash Conversion Cycle (CCC) and cash flow indicators (e.g. Free Cash Flow — FCF) are key: CCC reveals how quickly inventory and receivables are converted into cash, and FCF shows the company's actual ability to finance growth and pay dividends without additional capital. A shrinking CCC and stable positive FCF are often direct predictors of a company's resilience in a crisis.

The Cash Conversion Cycle (CCC) is a widely used performance metric that evaluates how effectively a firm manages its working capital by measuring the timing of cash inflows and outflows associated with operations. It is calculated as the sum of Days Inventory Outstanding (DIO) and Days Sales Outstanding (DSO) minus Days Payables Outstanding (DPO), and thus directly links inventory management, receivables collection and payables management into a single, actionable indicator. (Asman et al., 2022)

Effective working-capital management—reflected in a shorter CCC—helps firms improve liquidity, reduce short-term financing needs and support profitability goals. Although research on CCC has a long history, academic and practitioner interest has grown recently as firms' operating models and supply-chain dynamics have evolved, so the CCC observed in practice can change significantly over time and across industries.

In empirical work, researchers commonly use the CCC components (DSO, DIO, DPO) as independent variables and probe their relationship with firm performance proxies such as Return on Assets (ROA) and Return on Equity (ROE); many studies document an inverse relationship—i.e., reductions in CCC (faster cash conversion) tend to be associated with higher profitability—although the relationship can be complex and sometimes non-linear depending on firm characteristics, industry context and sample period.

Consequently, a conceptual framework that links CCC components to performance (controlling for size, leverage and asset structure) is useful for clarifying causal pathways and guiding empirical tests. This study therefore frames DSO, DIO and DPO as the key independent constructs and ROA/ROE as primary outcome measures, contributing to the literature by outlining a structured approach for analysing how variations in the CCC translate into firm performance.

Over the years, a number of authors have examined how working capital management affects profitability, with results often varying across industries, time periods, and methodologies. For example, a study by Sugathadas (2018) for the manufacturing sector on the Colombo Stock Exchange indicates a negative association between a longer CCC and firm performance, meaning that a shorter cycle often goes hand in hand with better profitability.

On the other hand, Margaretha and Oktaviani (2016) in a study of Indonesian companies find a heterogeneous impact of CCC — a negative association with ROA, but at the same time a positive correlation with ROE — which shows that different financial measures may respond differently to changes in CCC. due to this heterogeneity of results in different studies, it is necessary to cautiously interpret the general conclusions and take into account the specificities of the sample, sector and used indicators when drawing implications for the practice and policy of working capital management.

Composite and decomposition techniques, such as DuPont analysis, help break down ROE into margin, asset turnover, and leverage—allowing managers to recognize whether ROE growth is due to improved operating efficiency, better asset utilization, or increased debt risk.

It is important to note the limitations: many of these metrics require adjustments to accounting items and precise estimation of WACC; some are less applicable in intensive-intangible industries (eg software) without additional indicators for intellectual capital. Combining value-based measures (ROIC, EVA), cash-oriented indicators (FCF, CCC) and decomposition frameworks (DuPont) provides a comprehensive and practical set for making strategic decisions and monitoring long-term growth sustainability.

Limitations of Relying Solely on Financial Analysis in Evaluating Performance

Relying exclusively on financial analysis when evaluating business performance has several serious drawbacks that can lead to wrong conclusions and bad managerial decisions. First, financial reports are retrospective — they reflect past events and do not catch early signals of change in market trends, innovations or service quality, so relying on them alone often leads to delayed reactions (Brzaković, 2018).

Second, financial analysis is suitable for quantitative assessment, but ignores the intangible resources that make up most of the modern value of a company (knowledge, brand, organizational capital). Such a "raw" focus can encourage a short-term approach (maximizing profits today) to the detriment of long-term investments in development and innovation.

Third, accounting data may be subject to manipulation or different interpretations due to accounting policies and estimates (eg, depreciation, inventory valuation), which reduces the objectivity of financial indicators and makes comparisons between firms or periods difficult.

Fourth, a focus only on financial quotas often neglects operational and process aspects — for example, problems in product quality, customer satisfaction, or process efficiency will not be immediately reflected in profit margins, but in the long term they impair the sustainability of the business.

Fifth, overreliance on financial indicators can create perverse incentives: managers may "optimize" indicators by short-term cost cuts or delaying investments to show better quarterly results, instead of working to actually improve value.

Due to all of the above, financial analysis should be the foundation, but not the only instrument — it must be complemented by systematic monitoring of non-financial indicators and quality information processes so that management can get a complete, dynamic and reliable picture of performance.

There are two basic types of performance: financial and non-financial. According to one common approach, a company's overall operations can be viewed through three dimensions — productivity, profitability, and market premium. Productivity refers to a firm's ability to efficiently convert inputs into outputs; profitability measures how much revenues exceed costs; while the market premium describes how much the company's market value exceeds its book value (ie the "market premium") (Walker D.,2001).

It is important to emphasize, however, that financial indicators often behave as backward (retrospective) indicators — they reflect what has already happened and may lag behind real changes in the business or market. Therefore, relying solely on financial metrics can lead to missing early signals (eg declining service quality, loss of market share, or erosion of intellectual capital), leading to late or inadequate decisions.

Because of these limitations, it is advisable to combine financial and non-financial indicators: non-financial KPIs (eg customer satisfaction, employee retention rate, speed of innovation) often serve as leading indicators that explain and predict future financial results. In practice, an integrated approach (as in the Balanced Scorecard model) allows management to link operational drivers of value to financial outcomes and thereby avoid the pitfalls of relying exclusively on accounting figures.

Buyer's Perspective

In recent years, most organizations have developed their own customer-centric vision, as customer focus and satisfaction are considered important for any sector. The primary goal of an organization based on a customer perspective is to provide excellent service, quality, and customer satisfaction so that the business can maintain a good reputation among customers (Amaratunga et al., 2000).

The main leading indicator of this perspective is the satisfaction of the needs and expectations of key users, i.e. customers. Another important factor that all businesses must consider is to ensure that all products and services are delivered on time and that market conditions are classified in a way that allows for measurement of share in specific sectors (Kaplan et al., 1996).

Internal Processes

Internal processes can be used to categorize customer and organizational goals. This is achieved by measuring the company's processes to achieve the best performance outcomes. By implementing an internal process perspective, customer and financial strategic goals can be achieved (Kaplan et al., 1996).

The goals of this perspective are usually set after the financial and customer perspectives, because this segment actually identifies the processes critical to achieving customer and owner goals, and creating value for the organization.

The connection between processes and customers is very important, because here we signal two major transitions: from internal (employees, climate, processes) to external (customers), and from intangible (skills and knowledge) to tangible (customer outcomes and financial rewards). Customer outcomes signal the "what?", and internal processes provide the answer to the "how?" of strategic implementation (Niven, 2010).

Financial gains, which are based on improved business processes, occur in several phases. The first phase is cost reduction, which occurs due to improved business processes. This phase creates short-term benefits for the organization. The second phase is revenue growth based on deeper customer relationships and leads to improved financial performance in the medium term. The third phase is innovation, which can lead to long-term revenue and profit improvements. Therefore, an organization should implement all three phases in improving business processes.

Learning and Development Perspective

It has been recognized that the weakest perspective in the BSC approach is the learning and development perspective. For years, as one executive described it, the learning and growth perspective has been the "black hole of the BSC." Although companies have had generic measures of employee performance, such as employee satisfaction and morale, no company has had a metric that measures and links employee performance to the organization's strategy. Several scholars have investigated the relationship between improving human resources and improving financial performance (Becker et al., 1998; Huselid, 1995).

The learning and development perspective is the most neglected perspective in organizations. Organizational growth and development are impossible without employees. Employee satisfaction is most often measured by completing anonymous questionnaires or surveys at the organization level. The greater the satisfaction, the better their performance will be, and this can be achieved in a number of ways: by participating in the organization's actions, by providing opportunities to fulfill personal goals, by a quality work environment, by good internal communication. Employees are aware of the shared vision, mission and strategy of the organization, so they fully understand it and identify their goals with the goals of the organization (Atkinson et al., 2007).

It can be concluded that, in order to achieve ambitious goals in the first three perspectives of the BSC approach, they will depend on the organizational capabilities of the learning and growth perspective, which are the drivers of excellent achievements (Kaplan & Norton, 2010).

Advantages and Criticisms of the Balanced Scorecard (BSC): Theory, Flexibility and Limitations

According to some authors, the advantages of the BSC approach can be considered (Yongvanich & Guthrie, 2009):

- Strategy transfer throughout the organization;
- Better relationship of organizational and personal goals with reward policy;
- Improved strategic learning (control and feedback);
- Expanding the causal and effective understanding of managers' performance criteria and empowerment for strategic decision-making;
- Creating a balance between internal and external performance and financial and non-financial criteria;
- Flexibility and compatibility with any organization.

The advantage of the BSC model is certainly that it can be used by companies in any industry. However, different competitive environments require different groups of performance indicators. Therefore, they must be adapted to the vision, or purpose of the company, strategy, technology and organizational culture. The advantages can be defined through the following points (Hočevar, 2007):

- Connectivity – connects and harmonizes numerous, at first glance separate, but actually dependent areas of competitive business. By forcing managers

to consider all significant indicators simultaneously, they can prevent improvements in one area from being made at the expense of other areas.

- Strategy delivery – The essence of the BSC approach is strategy, not monitoring, as in traditional measurement methods, which arise from financial points of view, and then determine what employees should do, and then monitor their success. The BSC approach involves employees in choosing those actions that will lead to a common goal.
- Non-financial indicators – Some organizations use modern non-financial indicators to assess business performance, but have not decided which indicators are key to assessing the success of the organization as a whole.
- Usability – Users of the information provided by the BSC approach are external and internal. External users focus on the financial and customer perspectives. Internal users focus on the remaining two perspectives.

Although large organizations, as well as non-profits, have successfully adopted the BSC approach, it has been the subject of criticism from both theorists and practitioners (Norreklit, 2000).

One of the shortcomings of the BSC approach is related to the number of perspectives, which depend primarily on the needs and conditions in which the organization operates. An organization does not have to adhere to all four perspectives, i.e. the original concept, which can negatively affect it. Some organizations may also need additional perspectives. It is a mistake to use the BSC approach only as a measurement system, and not as a strategic management system (Pešalj, 2006).

Also, organizations should be aware of at least three other limiting factors of the BSC approach (Pešalj, 2006):

- Innovation – the BSC approach is not a revolutionary way of measuring business success, because non-financial indicators have already been used in practice and theory to measure business success. In addition, it is argued that it is difficult to measure effects in organizations where innovations are very important for competitiveness and where organizations must regularly adapt to new market situations (Schoenfeld, 1991).
- Incompleteness – the BSC approach covers a number of important areas of business. However, in the proposed model, the perspectives are not complete.
- Comprehensiveness – the BSC approach represents an extensive system of indicators and information and can cause difficulties in assessing the success of the organization's business as a whole, or in comparing the business of an organization with others.
- In addition, the following characteristics of the approach itself can be listed as shortcomings of the BSC approach (Lipe & Salterio, 2002):
- There is no weighting system;
- It does not consider the views of shareholders and other external stakeholders in emphasizing the formulation and implementation of strategies;
- The connections between fields are not clear;
- The attributes of the BSC model are inaccurate, subjective and linguistic, and inappropriate models are used for evaluation;
- Users subjectively integrate the results.

Despite its success in many organizations around the world, the BSC approach has sometimes been criticized, especially among a wide range of academics. The most important criticisms relate to the following:

- The characteristics of the relationships between the measurement areas in the BSC approach.
- The approach ignores the time dimension.
- The BSC's reliance on a limited number of measures (Hudson et al., 2001; Mårtensson, 2009).
- The lack of integration between top-level and operational-level measures (Akkermans & Van Oorscht, 2005).
- The overemphasis on those internal processes that deal with external processes (Akkermans & Van Oorscht, 2005).
- The BSC concept, without modification, is not effective enough to contribute to corporate sustainability (Bieker, 2003).

BSC Implementation: Problems, Consequences and Solutions

In order for organizations to successfully implement the BSC approach, they must skillfully avoid some pitfalls. The problems that organizations may encounter when implementing the BSC approach are (Brzaković, 2018; Niven, 2006):

1. Early linking of the BSC to key management processes (budgeting, compensation, corporate governance) often leads to omissions. BSC should be developed in order: first strategy communication (strategy map), then measurement, and only at the end complete transition to strategic management. Recklessly tying metrics to salaries or budgets is particularly dangerous — it can distort managers' behavior and encourage "gaming" metrics for short-term profit. Also, new or overly ambitious goals often seem unattainable and demotivate employees. The safest approach is a phased implementation: pilot projects, verification of metrics and only then carefully aligning the reward system.
2. Not every organization needs to have multiple levels of BSC — smaller firms or individual work departments can often work effectively with a single, common scorecard. However, in larger and more complex organizations it is necessary to "cascade" the corporate BSC down to lower levels in order to achieve full alignment and benefits of the system. Without such translation of goals to units and teams, front-line employees often remain disconnected from strategy: indicators from the top can motivate in the abstract, but rarely affect day-to-day operations. True integration is achieved only when each level of the organization has its own customized scorecards and when employees themselves can clearly explain how their work contributes to overall success.
3. The team's success lies in the wealth of different perspectives that members bring from their respective parts of the organization. BSC works best in teams where these different views and experiences meet through constructive discussions and argumentative debates, which gives a credible and comprehensive picture of the state of the entire organization.

4. Mere repackaging of existing measures into four perspectives does not make a quality BSC. It often happens that teams, out of habit or out of a desire to please management, take the old metrics and simply arrange them by perspective, believing that this is the new scorecard. After several reporting cycles, the results usually remain the same, so the meaning of the BSC is rightly questioned. The real value of the BSC lies in the identification of "missing" and innovative measures and their mutual interaction — only then does the scorecard become an instrument that really drives the implementation of the strategy.
5. BSC assumes the principle of balance: alignment of interests of internal and external actors, balance of short-term opportunities and long-term value creation, as well as alignment of lagging and leading indicators and financial and non-financial measures. If an organization promotes this "balance" only formally, while at the same time rewarding behaviors that go in the opposite direction, it quickly collapses the credibility and effectiveness of the system itself.
6. Organizations that expect benefits from the BSC and don't put effort into regular reporting and discussion of results are doomed to disappointment — a scorecard alone without consistent communication and analysis won't produce change. The results must be regularly available throughout the organization and included in the agenda of management meetings, in order to draw insights from the raw data, discuss the consequences and initiate concrete corrective actions. Without such a process, information remains unprocessed and the opportunity to make BSC a real tool for gaining competitive advantage is missed.
7. The lack of clear guidelines for the BSC program often leads to a superficial and ritualistic acceptance of the concept: organizations adopt the BSC because "they should", but without concrete goals and an implementation plan. If the team does not define what problems the BSC should solve and how it will measure success, the scorecard quickly becomes an addition to other initiatives rather than an independent tool for change. As a result, BSC may remain neglected or misused as just another project within existing programs.
8. It is difficult to successfully introduce a strategic management system without a clearly defined strategy; The core of the BSC approach is precisely that strategy guides decisions and ensures top-down alignment. BSC without a previously developed strategy becomes just a set of indicators without real strategic value. At the same time, the process of building a BSC often helps the organization to review and refine its strategy through detailed discussions and measurements, which promotes the achievement of better performance.
9. In the rush to implement BSC, detailed training of real users is often skipped. The organization can hold only promotional meetings and give superficial information about the model, so due to its apparent simplicity, the training remains at a high level. This leads to the expectation that employees "instinctively" create effective measures, which rarely yields good results. Practical, targeted role-based education is needed for BSC to really take off
10. Leadership is key — without clear and ongoing support from the top, the

BSC initiative is likely to stall. The process takes place in phases (decoding the strategy, setting goals, measures and initiatives, cascading, integration into managerial processes) and a "rope" is needed that holds it all together: an engaged, visible and committed leader. If such a leader does not exist or is not actively involved at every stage, the project quickly loses momentum and can stall. In short, there is no substitute for energetic and informed leadership support in implementing and maintaining a BSC.

Conclusion

This paper shows that the financial perspective remains the core of business performance evaluation because financial indicators directly measure value creation, liquidity, and the ability to finance growth and shareholder returns. However, the analysis also confirms the limitations of relying exclusively on accounting and retrospective metrics: without associated leading indicators from the areas of processes, customers and learning, financial indicators often arrive too late for management to react proactively.

In practical terms, it is recommended that management maintain a focus on key financial metrics — such as ROIC, EVA, FCF, profitability ratios, and the DuPont decomposition — because they quantify value creation and the efficiency of capital allocation. In parallel, CCC and components (DSO, DIO, DPO) should be systematically monitored due to their direct impact on liquidity and short-term financial needs. Financial KPIs must be clearly linked to management actions, have defined owners, realistic target values and audit frequency.

However, a sustainable and correct interpretation of those measures requires integration with the BSC approach: it is necessary to link financial goals with operational initiatives, customer satisfaction indicators and learning and growth indicators in order to discover causal paths leading to financial results. Also, data quality, reporting automation and regular drill-down dashboards are crucial for financial signals to become actionable. In the end, the focus on financial metrics should remain primary, but within a balanced and strategically connected KPI system — only then will financial results become an authoritative indicator of long-term value creation and sustainable success of the organization.

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INTERNATIONAL ACCOUNTING REGULATIONS – STANDARDIZATION, HARMONIZATION, CONVERGENCE

Abstract

The creation and application of accounting standards (International Accounting Standards (IAS), International Financial Reporting Standards (IFRS), American Generally Accepted Accounting Principles (GAAP)) that would have universal acceptability was the guiding idea of the most important accounting authorities when they started the process of defining and adopting accounting rules and procedures (standards). However, the existence of at least two, more or less opposing, powerful professional associations (the International Accounting Standards Board (IASB) and the US Financial Accounting Standards Board (FASB)) has resulted in their disagreement on many issues. There have been attempts to equalize the positions of the mentioned associations or, at least, bring them closer to the procedures called harmonization and/or convergence. It seems to us that the aforementioned procedures did not have a strong enough impact on overcoming the differences, which, to be honest, have been reduced but still exist.

Using the example of standards that deal with or have dealt with business combinations (IAS 22, IFRS 3, generally accepted accounting principles), we will try to explain the efforts that have been made and the results that have been achieved in the process of harmonizing and converging the rules and procedures that ensure a fair and objective way presents the financial position of the entity that is created by merger, acquisition or takeover of the so-called target companies. Of course, we will not leave out the explanation of the differences that (still) remained and for which we express doubt that they will be overcome in the foreseeable future.

Key words: *accounting standrads, harmonization, convergence, business combinations, IAS 22, IFRS 3, GAAP.*

JEL classification: *G34, M41*

МЕЂУНАРОДНА РАЧУНОВОДСТВЕНА РЕГУЛАТИВА – СТАНДАРДИЗАЦИЈА, ХАРМОНИЗАЦИЈА, КОНВЕРГЕНЦИЈА

Апстракт

Израда и примена рачуноводствених стандарда (Међународни рачуноводствени стандарди (МРС), Међународни стандарди финансијског извештавања (МСФИ), амерички општеприхваћени рачуноводствени принципи (ГААП)) који би имали универзалну прихватљивост била је идеја водиља најзначајнијих рачуноводствених ауторитета када су започињали процес дефинисања и усвајања рачуноводствених правила и поступака (стандарда). Међутим, постојање бар две, мање или више супростављене, снажне професионалне асоцијације (Међународни одбор за рачуноводствене стандарде (ИАСБ) и амерички Одбор за стандарде финансијског рачуноводства (ФАСБ)) имало је за последицу њихово неслагање по многим питањима. Постојали су покушаји да се ставови наведених асоцијација изједначе или, бар, приближе поступцима названим хармонизација и/или конвергенција. Чини нам се да наведени поступци нису имали довољно снажан утицај на превазилажење разлика које су, истини за вољу, смањене али још увек постоје.

На примеру стандарда који се баве или су се бавили пословним спајањима (МРС 22, МСФИ 3, општеприхваћени рачуноводствени принципи), покушаћемо да образложимо напоре који су учињени и резултате који су остварени у поступку усклађивања и приближавања правила и поступака којима се на фер и објективан начин презентује финансијски положај ентитета који настаје спајањем, припајањем или преузимањем тзв. циљне компаније. Наравно, нећемо изоставити ни образлагање разлика које су (пре)остале и за које изражавамо сумњу да ће у догледно време бити превазиђене.

Кључне речи: *рачуноводствени стандарди, хармонизација, конвергенција, пословна спајања, МРС 22, МСФИ 3, општеприхваћени рачуноводствени принципи.*

Introduction

The internationalization of business and the globalization of economic flows—justified by the notion that these processes realize the so-called four freedoms of Europe (the free movement of people, goods, capital, and services)—have led to attempts to define and adopt accounting rules and procedures, i.e., accounting standards "that enable the direct comparability of financial statements prepared in different accounting and legal systems" (Šević & Škobić, 2017, p. 8), with the aim of accelerating them. The intensification of both processes (globalization and the standardization of rules for compiling uniform financial statements) is linked to the final third of the 20th century. The existence of two strong—but often opposing—accounting bodies (the International Accounting Standards Board — IASB, and the Financial Accounting Standards Board

— FASB) can be said to be the sole "culprits" for why the processes of "defining and adopting accounting rules and procedures (the general theory of accounting) that would be universally acceptable" have still not reached their conclusion (Hermanson, 1987).

Using the development of standards for business combinations—which attempt to regulate the rules for preparation, recognition, and disclosure of information in the financial statements of an accounting entity formed after a business combination (merger, acquisition, and/or takeover)—we will attempt to explain the current level of harmonization and convergence of adopted standards by the aforementioned accounting bodies, the (un)bridgeable differences that still exist, and the possibilities for overcoming them.

The Beginnings of the Idea of Standardizing Accounting Rules and Procedures

The idea of creating conditions to enable "smooth business communication through information from financial reports, provided that business entities apply a uniform framework of financial reporting and consistent rules, principles, guidelines, standards, and interpretations established by competent and internationally recognized professional organizations" (Milutinović, 2015) dates back to 1966. At that time, the Accountants International Study Group (AISG) was founded with the goal of consolidating accounting information in Canada, the United Kingdom, and the United States (the accountants' associations: Canada's CICA, England's ICAEW, and America's AICPA). This initiative for forming the accountants' association was proposed by Henry Benson, President of the Institute of Chartered Accountants in England and Wales, and is regarded as a direct predecessor of the International Accounting Standards Committee (IASC), which was responsible for adopting the International Accounting Standards (IAS) until its reorganization and renaming as the International Accounting Standards Board (IASB) and IAS as International Financial Reporting Standards (IFRS). The AISG published a document titled A Statement of Basic Accounting Theory, which was "the first in a series of attempts to develop a conceptual framework that would represent a systematized foundation of accounting theory in the form of a set of guidelines for practitioners (accountants and auditors) and for other stakeholders in accounting and financial reporting" (Đorđević and Mitić, 2022).

A significant contribution to the development of the idea of uniform financial reporting also came from the directives of the former European Economic Community (EEC), especially regarding the form and content of annual reports (Fourth Directive 78/660/EEC, adopted on 25 May 1978) and consolidated financial statements (Seventh Directive 83/349/EEC, adopted on 13 June 1983). These directives were replaced by Directive 2013/34/EU, which became mandatory in 2016. This directive aimed to accelerate capital flows internationally through higher quality and comparability of financial reports, while ensuring the protection of the broader public interest (Directive, 2013).

The American accounting association attempted to introduce standards at the beginning of the 20th century, but these attempts were unsuccessful. The national American standards—Generally Accepted Accounting Principles (GAAP)—are issued

by the aforementioned board (FASB), which operates within the AICPA (American Institute of Certified Public Accountants), and become officially recognized in the U.S. once approved by the SEC, which simultaneously makes their application mandatory for all companies under its jurisdiction (Stojanović, 2016).

In the former SFRY (Socialist Federal Republic of Yugoslavia), there was a project for the development of Yugoslav Accounting Standards, adopted in the period 1990–1992. The breakup of the state resulted in the suspension of this project. In the meantime, the national accountants' association (the Association of Accountants and Auditors of Serbia) joined the International Federation of Accountants (IFAC), which tacitly implied acceptance of international professional accounting regulation. Formal confirmation of the application of this regulation in our environment occurred on 28 December 1998 at the Assembly of the then Association of Accountants and Auditors of Yugoslavia, while its legalization was accomplished in December 2002, with the adoption of the Law on Accounting and Auditing. Article 1, paragraph 1 of that law prescribed the obligation that "the conditions and method of keeping business books, preparation, presentation, delivery and disclosure of financial statements, as well as the conditions and methods of performing audits of financial statements" be carried out in accordance with professional and internal regulation (Đorđević, 2003).

Business Combinations (Mergers) – Standardization of Accounting Procedures

Implementing any form of business combination requires the creation of a new accounting entity and the preparation of its opening balance sheet, which arises from the consolidation of positions from the closing balance sheets of previously independent corporate business entities.

The "Basic Accounting Standard for Business Combinations" (Morris, 1995) in the U.S. was Accounting Principles Board Opinion No. 16 – Business Combinations, issued in 1970 by the Accounting Principles Board of the American Institute of Certified Public Accountants (AICPA).

Regarding Europe: in 1973 the International Accounting Standards Committee (IASC) was established with the aim of achieving uniformity in accounting rules, principles, and standards used globally for financial reporting. The Committee was formed by accounting associations of Australia, Canada, France, Germany, Japan, Mexico, the Netherlands, the U.K. & Ireland, and the U.S. Membership in the International Federation of Accountants since 1983 implied membership in the IASC. The Committee began working on regulating rules and procedures regarding the accounting treatment of business combinations with the issuance of Exposure Draft 22 – Accounting for Business Combinations in September 1981, followed by the publication of International Accounting Standard 22 – Accounting for Business Combinations in November. Later, the then IASC adopted IAS 22 – Business Combinations in 1993, which was subsequently revised in 1998. Alongside these standards and the aforementioned EEC directives, it's important to note that companies in the United Kingdom applied Financial Reporting Standards (FRS) No. 6 – Acquisitions and Mergers, and FRS No. 7 – Fair Values in Acquisition Accounting, issued by the Accounting Standards Board (Institute

of Chartered Accountants in England and Wales) in 1994 (Chopping & Skerrat, 1994). For member states of the European Community, the Seventh Directive of the Council of the European Communities—adopted on 13 June 1983—provided the framework for consolidated financial statements until the adoption of IAS 22.

Although IAS 22 was replaced in the early 21st century—specifically in 2004—by IFRS 3 – Business Combinations, it is considered useful to briefly recall its most important provisions:

- IAS 22 provided for two accounting methods: the Pooling of Interests Method and the Purchase Method.
- The existence of two accounting methods did not imply choice; the Pooling of Interests Method was mandatory whenever the transaction met a set of strict criteria to qualify as a "true merger," whereas in all other cases the Purchase Method had to be applied ("The pooling-of-interests method and the purchase method are not alternatives in the choice of accounting treatment for business combinations," Morris, 1994).
- The required criteria for qualification as a pooling-of-interests differed among the mentioned standards (Đorđević, 2007). According to paragraph 8 of IAS 22, a pooling of interests is a business combination in which the shareholders of the combining companies combine control over substantially all their net assets and operations to achieve a continuous mutual participation in the risks and rewards of the combined entity such that no party can be identified as the acquirer (IAS 2000). Paragraph 15 of IAS 22 stipulates that mutual participation in risks and rewards implies that the combining entities have exchanged a significant majority—or all—of their ordinary voting shares; the fair values of their assets are approximately equal; and their shareholders retain nearly the same voting rights they had in their respective entities prior to the combination..
- The Purchase Method, on the other hand, was used for transactions aiming for one combining company (the acquirer) to gain control over the target. The acquirer could decide on all major matters relevant to the target's business—from financial and business policy to appointing or dismissing board and management members (Đorđević, 2007). Under the Purchase Method, book values were adjusted to fair values, and the difference between the fair value of identifiable assets and liabilities and the fair value of consideration transferred was recognized as goodwill. In most transactions goodwill was positive, capitalized, and recognized as an intangible asset in the acquirer's balance sheet. However, the amortization of goodwill was a contentious issue, with proposed useful lives ranging from 5 to as much as 40 years. Negative goodwill was very rare and occurred in cases of a "bargain purchase," where the acquirer paid less than the fair value of identifiable net assets (Sudarsanam, 1995; Đorđević, 2007). Paragraph 62 of IAS 22 stipulated that negative goodwill exceeding the fair value of identifiable acquired non-monetary assets was recognized as income, or otherwise amortized over the remaining useful life of those assets (IAS 2000).

Lastly, other national associations (Germany, France, Spain, the Netherlands, etc.) had their own accounting procedures for business combinations, essentially using the

same two methods but proposing different treatments—primarily regarding positive goodwill (Đorđević, 2007).

Harmonization and Convergence of Accounting Procedures Related to Business Combinations

The beginning of the 21st century, in our humble opinion, marks the initiation of the process of harmonizing professional accounting regulations, i.e., an intensified effort to establish and align (harmonize) rules for recognition and measurement of elements in financial statements, as well as how they should be presented in financial reports (Škarić-Jovanović, 2012). Regarding standards related to business combinations, the harmonization process began with the issuance by FASB of Statement No. 141 – Business Combinations, and Statement No. 142 – Goodwill and Other Intangible Assets. These were characterized by Norman Strauss (then director of accounting standards at Ernst & Young and a member of FASB) as introducing "the most significant and drastic changes to the accounting methodology dealing with business combinations" (Moehrle & Reynolds-Moehrle, 2001). Chief among these changes was the elimination of the equity (pooling-of-interests) method for consolidated financial statements, in favor of the acquisition method only, under which goodwill is not amortized (Đorđević & Mitić, 2021). Significant changes in business combinations accounting regulation, first applied in Australia, Canada, and the United States, influenced the IASB (the successor to the IASC), which in 2001 "launched a project to review IAS 22 … with the goal of improving quality and seeking international comparability in accounting for business combinations" (IFRS, 2005).

The so-called first phase of the Business Combinations project began in 2002 with the publication of Exposure Draft 2; the new IFRS 3 – Business Combinations was issued in March 2004. Besides the aforementioned major change (abolishing the equity method), key points of IFRS 3 include:

- Identification of the acquirer is required in every business combination, even when "it may be extremely difficult" (IFRS, 2005). More detailed guidelines are provided in paragraphs 20–23:, If one party's fair value is significantly higher, that party is the acquirer (par. 20a); If one party pays cash or other assets in exchange for voting shares, that party is the acquirer (par. 20b); If one party's management can appoint the board of the combined entity, that party is the acquirer (par. 20c); If a new entity is formed and issues equity interests, one of the combining entities is identified as the acquirer based on available evidence (par. 22); When more than two parties are involved, indicators include who initiated the combination and whose assets or revenues dominate (par. 23). Guidance from IAS 27 (Consolidated and Separate Financial Statements) may also apply;
- Recognition of intangible assets separately from goodwill: This change—recognizing intangible assets separately from goodwill—was perhaps the most significant, since it influences the measurement of goodwill (the difference between the acquisition cost and the fair value of identifiable net

assets). This should enhance decision-usefulness of consolidated statements. This issue was extensively addressed by accounting and audit firms in specialized guides (Castedello & Klingbeil, 2010)..

- IFRS 3 differs from IAS 22 in the calculation and treatment of goodwill that may arise as a result of a transaction in all cases where a positive difference between the fair value of identified assets and liabilities and the fair value of the consideration transferred (positive goodwill) appears. While IAS 22 and/or national standards required the amortization of recognized goodwill over a period not exceeding 40 years, the current IFRS 3 stipulates in paragraph 54 that goodwill acquired in a business combination should be measured at cost less any accumulated impairment losses. Therefore, instead of amortization, IFRS 3 proposes testing goodwill for impairment at least annually, or more frequently if events or changes in circumstances indicate that it may be impaired. Any impairment loss is recognized in the income statement as an expense for the impairment of intangible assets (Mitić, 2018).

According to the provisions of IFRS 3, there is no possibility for the occurrence of negative goodwill. In all situations where the acquirer's interest in the net fair value of the acquired assets, liabilities, and contingent liabilities exceeds the cost of the business combination (consideration transferred), the acquirer should, in accordance with paragraphs 34–36 of this standard: reassess the identification and measurement of the acquired company's identifiable assets, liabilities, and contingent liabilities, and the measurement of the consideration transferred or the cost of the business combination recognize any additional assets or liabilities identified in this reassessment immediately recognize in the income statement any excess remaining after the reassessment.

- Finally, the revised IFRS 3 reinstates, in paragraph 19, two methods for measuring "non-controlling interests in the acquired entity at either fair value or as a proportionate share of the non-controlling interest in the net identifiable assets of the acquired entity" (IFRS 3, 2009). It is important to note that participants in the business combination, specifically the entity identified as the acquirer, have the option to choose between these two methods for each business combination. For example, the entity may use fair value for one business combination and the proportionate share in the net identifiable assets of the acquired company for another business combination (Đorđević & Mitić, 2015).

It is important to note that IFRS 3 is an accounting standard that was not unanimously adopted by the Board. Specifically, some of its members, such as Whittington and Yamada, expressed concerns about the elimination of the pooling of interests method without offering an alternative solution. This was particularly relevant for transactions where determining the acquirer was challenging—specifically, those in which neither participant gains control. For such transactions, these board members considered the "fresh start method" (also known as the "new entity method") as an acceptable alternative. This method treats the combined entity as a new entity, with all assets and liabilities recognized at fair value. They suggested that the application of this method should be reconsidered in future periods.

However, the primary objective of the first phase of the Business Combinations project was to achieve international convergence of accounting methods for business combinations. As a result, the Board decided not to include the fresh start method to encompass certain transactions, since it is not applied in any legal system for accounting for business combinations." (Đorđević, 2007).

The convergence process of accounting standards began with the signing of the Norwalk Agreement in Norwalk, Connecticut, USA, on September 18, 2002, between FASB and IASB. Its purpose was to develop 'high-quality, compatible accounting standards (not limited to business combinations alone – the author's note) that could be used for both domestic and cross-border financial reporting" (Anić-Antić & Konsuo, 2015, 360-1), This agreement laid the foundation for what is referred to as the second phase of the Business Combinations project.. The initiation of this phase coincides with the signing of the Memorandum of Understanding in 2005, when joint projects of the two most significant accounting authorities (FASB and IASB) were agreed upon. The current IFRS 3 was adopted in January 2008 and was later partially amended by amendments in 2010, 2013, and 2017.

Although IFRS 3 issued in 2008 succeeded to a significant extent in aligning with the U.S. standard, some substantial differences remain—primarily due to discrepancies in related standards that were not part of the convergence project. These differences can be seen in the following areas:

- Different definition of control – The IASB defines control as the power to govern an entity's financial and operating policies to obtain benefits from its activities. In contrast, the U.S. Financial Accounting Standards Board (FASB) typically defines control as holding an absolute majority of voting rights or as being the primary beneficiary of a Variable Interest Entity;
- Different definitions of fair value;
- Different recognition of potential liabilities – potential liabilities assumed in a business combination are reported in financial statements if there is a present obligation arising from past events and their fair value can be reliably measured (International Accounting Standards Board), whereas U.S. GAAP does not mention the reliable measurement of fair value as a criterion for recognizing potential liabilities;
- Different treatment of employee arrangements in the acquired company – recognized and measured in accordance with the provisions of relevant IFRS and GAAP. Given the differences in the provisions of respective standards, it is logical that the amounts at which these arrangements will be recognized and measured will differ;
- Different treatment of non-controlling interests – as we have already noted, the current IFRS 3 allows for a choice between two alternative accounting treatments for non-controlling interests in each individual transaction, while the Financial Accounting Standards Board proposes measuring that interest exclusively at fair value.

Despite these differences, the convergence efforts had a meaningful impact: the U.S. Securities and Exchange Commission (SEC) eliminated the requirement for non-U.S. companies using IFRS 3 to reconcile their financial statements to U.S. GAAP when listed on U.S. exchanges.

Finally, the adoption of the revised Conceptual Framework on March 29, 2018, by the IASB, which was supposed to be the result of the joint work of the two mentioned accounting authorities, could complicate the situation regarding the processes of standardization, harmonization, and convergence of accounting regulations. The rift that arose between the IASB and FASB in 2014 did not prevent the IASB from continuing with the revision and adoption of the Conceptual Framework, which, in turn, could result in some already harmonized accounting standards being in conflict with the Conceptual Framework. This could lead to the need "for harmonizing or revising some of the already adopted or harmonized standards. There is also the issue of aligning the IASB's Conceptual Framework with a document that FASB might prepare independently (or in cooperation with other associations – author's note) under a similar or identical title" (Đorđević, Mitić, 2022). For this reason, it seems justified to express the concern raised by Professor Whittington in 2008, which has partially already materialized, that the process of harmonization and/or convergence could ultimately lead to a rift between the most significant participants in the creation of internationally acceptable accounting regulations (Whittington, 2008).

Conclusion

The work on harmonizing the rules and procedures that we could collectively refer to as international accounting regulation has been ongoing for a relatively long time (over 50 years), and recent events indicate that it will not be concluded anytime soon. Acknowledging the arguments that many circumstances have changed in the business operations of companies compared to the period when the processes of standardization, harmonization, and/or convergence began, it seems likely that they will continue for a considerable time. Whether and when they will be completed is a question to which it is impossible to provide a concrete and precise answer under the current conditions.

The issues in aligning and approaching accounting standards concerning business combinations represent, alongside the mentioned Conceptual Framework, relatively poor examples of "cooperation" between the two most significant accounting authorities. The lack of sufficient tolerance and the right to a different opinion, promoted by supporters of Anglo-Saxon accounting practice from both boards (IASB and FASB) in these processes, suggests that, at least in the foreseeable future, the aspiration for universally acceptable accounting regulation will not be realized. Of course, work on defining the rules and procedures that will aid in understanding, accepting, and adopting new ways of analyzing and encompassing accounting transactions should continue. This is supported by the position of our national association (the Union of Accountants and Auditors of Serbia), which states that high-quality financial reporting implies the alignment of the financial reporting system in our country with global (International Accounting Standards – IAS and International Financial Reporting Standards – IFRS) and regional rules (EU Directives) (Malinić et al., 2016).

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