ISSN 2560-421X

UDK 33+502/504

ECONOMICS

of Sustainable Development

2

Vol. VI

Niš, 2022

ECONOMICS OF SUSTAINABLE DEVELOPMENT
ЕКОНОМИКА ОДРЖИВОГ РАЗВОЈА

ДРУШТВО ЕКОНОМИСТА “ЕКОНОМИКА” НИШ
SOCIETY OF ECONOMISTS “EKONOMIKA”, NIS

The Journal is issued two times a year. Year VI, VII-XII 2022, Vol. 2

ECONOMICS
OF SUSTAINABLE DEVELOPMENT

PUBLISHER: Society of Economists "Ekonomika", Nis

EDITORIAL BOARD

Lector
NIKOLA TATAR

Prepress & Cover:
MILAN D. RANDJELOVIĆ

Address:
“EKONOMIKA”, Society of Economists
18000 Nis, Maksima Gorkog 5/36

Phone: +381 (0)18 4245 763; 211 443
e-mail: zoki@medianis.net; ekonomika@sbb.rs
WEB: http://www.ekonomika.org.rs

Bank Account: 160-19452-17

Printed by:
“MEDIVEST”
18000 Niš
Copies: 200

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ECONOMICS OF SUSTAINABLE DEVELOPMENT

Vol. 6, july-december 2022, № 2
UDK 33+502/504
ISSN 2560-421X

Marija Jovanović[1]
Bojan Krstić[2]
Faculty of Economics,
University of Niš

Ljiljana Berezjev[3]
Fakultet za projektni i inovacioni menadžment,
University Edukons, Belgrade

P. 1-15
ORIGINAL SCIENTIFIC PAPER
10.5937/ESD2202001J
Received: July 29, 2022
Accepted: August 29, 2022

GREEN PATENTS AS A DETERMINANT OF SUSTAINABLE ECONOMIC GROWTH

Abstract

In order to establish sustainable economic growth, governments around the world are increasingly introducing programs to support the environmental aspects of companies' business as part of their policies. In order to meet the demands of the market, and at the same time contribute to the realization of the principle of sustainability, companies increasingly invest in research and development and eco-innovation. The number of green patents is often used as a parameter of the intensity of eco-innovation. The question is how the possession of green patents affects the performance of companies and the economic growth of the national economies in which they operate. The subject of this paper is to consider the impact of green patents on the economic growth of national economies that are leading in the number of applied green patents. The aim of this paper is to determine the relationship between the selected indicators of green patents and the gross domestic product of these national economies.

Keywords: *green patents, environmental-related patents, sustainability, economic growth, green growth*

JEL classification: O34, O44, Q01

ЗЕЛЕНИ ПАТЕНТИ КАО ДЕТЕРМИНАНТА ОДРЖИВОГ ЕКОНОМСКОГ РАСТА

Апстракт

У циљу успостављања одрживог економског раста, владе широм света све више у оквиру својих политика уводе програме подршке еколошком аспекту пословања компанија. Како би одговориле захтевима тржишта, а истовремено допринеле остварењу принципа одрживости, компаније улажу у активности истраживања и развоја и еко-иновације. Као параметар интензивности еко-иновација често се користи број зелених патената. Поставља се питање

[1] marijamptrakic@gmail.com, ORCID ID 0000-0001-5997-0501

[2] bojan.krstic@eknfak.ni.ac.rs, ORCID ID 0000-0003-4597-6819

[3] ljiljana.berezljev@pmc.edu.rs, ORCID ID 0000-0002-4519-2742

како се поседовање зелених патената одражава на перформансе компанија и на економски раст националних економија у којима оне послују. Предмет истраживања овог рада јесте сагледавање утицаја зелених патената на економски раст националних економија које су водеће по броју пријављених зелених патената. Циљ рада је да се утврди јачина и карактер везе између изабраних показатеља зелених патената и бруто домаћег производа ових националних економија.

Кључне речи: *зелени патенти, патенти везани за животну средину, одрживост, економски раст, зелени раст*

Introduction

In order to establish sustainable economic growth, governments around the world are increasingly introducing programs to support the environmental aspects of companies' business as part of their policies. The environmental aspect of the company's business has been particularly emphasized since 1992 when the United Nations meeting was held in Rio de Janeiro, on which the issue of climate change was highlighted. Since then, companies have been considered an important factor in reducing the impact of human activity on the environment. Incentives from governments to base their business on environmental principles are increasingly having an impact on companies' operations, the setting of their strategies, and the way they are operationalized. In order to meet the demands of the market, and at the same time contribute to the realization of the principle of sustainability, companies increasingly invest in research and development and eco-innovation. It is necessary for companies to achieve their financial and economic performance at the desired level while being environmentally responsible.

Companies' investments in eco-innovations related to so-called green technologies have numerous positive implications for the environment (mitigation of climate change, reduction of air and water pollution, increase of resource efficiency). The number of green patents is often used as a parameter of eco-innovation intensity. Green patents have a positive impact on the development of clean technologies (OECD, 2009). The largest increase is in the number of green patents related to innovations in technologies related to climate change mitigation and solar energy. In the period from 2007 to 2009, the number of PCT (Patent Cooperation Treaty) applications for patents related to solar energy was three times higher than their share in the period from 1997 to 1999 (OECD, 2011). On the other hand, when it comes to patent applications related to energy storage technology or material recycling, their growth is slower than the growth of the total number of patents (OECD, 2011). When it comes to innovations in the production of energy from renewable and non-fossil sources, the largest number of patent applications related to this type of innovation comes from European countries (in the late 2000s, the EU27 received 37% of all PCT applications in this area, followed by the United States and Japan, while China's share is in eighth place) (OECD, 2011).

The question is how the possession of green patents affects the performance of companies and the economic growth of the national economies in which they operate. The subject of this paper is to consider the impact of green patents on the economic growth of national economies that are among the leaders in the number of applications for green patents. The aim of this paper is to determine the strength and character of the relationship between the selected indicators of green patents and the gross domestic product (GDP) of these national economies.

1. Literature review

Numerous authors have addressed the issue of sustainable economic development. The concept of sustainable development implies economic, environmental, and social dimensions. In the conditions of accelerated economic development, it is important not to neglect the other two dimensions of the concept of sustainable development in order to realize it in practice. Therefore, in the pursuit of economic development to be monitored and viewed from the other two perspectives, innovations in the field of ecology are gaining in importance, regardless of the branch in which the companies operate. Green patents as a form of intellectual property that protects eco-innovation, have become a valuable element of the portfolio of intellectual resources of companies and a significant factor in the financial performance of companies and economic growth and development of national economies. The following are the conclusions based on the results of research by various authors who have examined the link between green growth (based on eco-innovation protected by green patents) and economic growth.

In their work, Ferreira et al. (2020) examined the role of technology transfer on the European continent, including countries inside and outside the euro area. In examining this role, emphasis is placed on environmental patents and their impact on countries' real GDP as an indicator of economic growth. The authors came to the conclusion that there is a positive impact of environmental patents on the real GDP of European countries (this impact has not been established specifically within the euro area). They also highlight technological innovation as a solution to achieve environmentally friendly conditions in the production of goods and services in the context of combining economic development and sustainable growth.

In their study, Abedi & Moeenian (2021) studied the effects of patented technological innovations compatible with climate change mitigation and the impact of environmental patents on economic growth and development in the Middle East between 2010 and 2016. The results of their research indicate that patents related to the environment, patents related to environmental management, and patented technologies related to climate change mitigation have a significant positive impact on sustainable economic development and growth rate in the studied countries. However, the positive effect of patents for water adaptation on the economic growth of the countries in this region has not been confirmed. Based on this study, the role of patents as an important factor in sustainable economic growth in three important environmental areas is highlighted, namely: environmental management, water adaptation, and climate change mitigation. It is an important guideline for innovators and policymakers in making policy decisions related to sustainable development programs from the perspective of environmentally friendly technologies.

Tolliver et al. (2021) emphasize the importance of green innovation and green finance as elements of sustainable economic growth and development. Asian countries, Japan, South Korea, and China, as the fastest growing and developing economies, face the problem of climate change and environmental impact. In order to achieve sustainable economic growth, these countries have implemented policies to promote green innovation and financing as a solution to these problems. According to research by these authors, Japan has been a global leader in green patents since the mid-1980s, while South Korea and China have seen a growing trend in green patents to reduce pollution. When it comes to green bonds, China is considered the global leader in their issuance, and there is also a growing trend in their issuance by banks and financial corporations in South Korea and Japan. Many companies in these countries, which are considered to be the highest-income companies, had revenue growth that coincided with the publication of ESG (Environmental, social, and governance) information. In this way, through the promotion of environmentally friendly growth of multifactor productivity, issuance of green bonds, registration of green patents, green foreign direct investment, and disclosure of information on the environment, society, and governance, they are moving towards achieving a paradigm of sustainable growth.

Fernandez et al. (2021) provide an answer to the dilemma that is reflected in two different points of view when it comes to the relationship between green growth on the one hand and economic growth on the other. The first view implies that it is possible to achieve sustainable growth without negatively affecting economic growth. Another view is that sustainability cannot be achieved if intensive consumption is present, which continuously stimulates economic growth. The authors analyzed the role that sustainable technology transfer and sustainable innovation play in green growth, as well as the impact of green growth on economic growth. The analysis was conducted using data from 32 countries for the period from 1990 to 2013. Environmental patents were included in the analysis as one of the indicators of green growth. The authors concluded that sustainable technology transfer and sustainable innovation encourage green growth, and that green growth has a positive impact on economic growth.

Hasna et al. (2021) conducted a study entitled “Greenovate for a better environment and economy” under the auspices of KPMG. For their analysis, the authors used data on patent applications for the period from 1990 to 2018 for 43 countries (OECD and BRICS). In the last three decades, these countries accounted for 89% of the world’s real GDP and 97% of total and green patent applications. The 24 million patent applications were analyzed, which are divided into green and non-green (having in mind the designation Cooperative Patent Classification, which refers to technologies for climate change mitigation). In their report, they state that the doubling of green patent applications will lead to an increase in real GDP growth of 4.8%. They compare that to real GDP growth of 3.4%, provided that non-green patent applications are doubled. They point out that green innovations have a wider contribution than the impact on the environment, they also have a positive effect on economic growth.

In their research, Lee et al. (2021) addressed the impact of green innovation and institutional constraints on China’s high-quality economic development at the national and regional levels from 2014 to 2018. The analysis includes companies that have green patents. Based on the results of their research, the growth of a comprehensive index and levels of high-quality economic development in all regions of China is noticeable. There is a significant positive impact of green innovations and institutional constraints, i.e. their mitigation by the green revolution, on high-quality economic development at the national level. On the other hand, when looking at the regional level, the impact on the economic quality of eastern China is more positive than that of central China. The positive impact of green innovations and institutional constraints on the high-quality economic development of the central and western regions was absent because their presence in these regions is weaker. Also, the authors suggest that it is necessary to increase the "green" production line and capacity for research and development of green innovations, then that the government should improve the market system, and that all regions should increase financial investment in green innovation.

In their study, Hoang et al. (2020) determined the impact between environmental performance and financial performance of American companies (they used a sample of 361 companies; observed period: from 2007 to 2016). The companies that were in the sample were selected according to the criterion of owning green patents. Based on the results of the research, they found that transparent presentation of the environmental aspect of business has a positive impact on financial and market performance. However, there is a negative impact on the return on invested capital. They also observed different effects of lower pollution emissions on companies' financial performance depending on the time frame observed. Specifically, lower pollution emissions tend to improve current return on assets but have a negative impact on the efficiency of long-term capital employment. They then examined the impact of the global economic crisis (2007-2010) on the environmental performance of companies. They found that the global economic crisis has increased the environmental transparency of companies with green patents, and adversely affected their P/E ratio. Having in mind all the findings, the authors conclude that the environmental transparency of companies and greenhouse gas emissions are environmental variables that have the greatest significance and impact on the financial performance of companies with green patents. Finally, they note that this impact is particularly pronounced after the period of global crisis, due to the greater evaluation of their importance in the market.

Exploring the link between green patents and company performance, Zhang et al. (2019) point to their positive relationship. They found that on a sample of manufacturing companies in China for the period from 2000 to 2010. What is specific is that this conclusion applies only to public companies, not to private ones. Public companies have a close relationship with the government, whose influence in this area is significant. This is further confirmed by the fact that the positive relationship between green patents and company performance has been noticeable since 2006 when the government began to directly formally support the green industry. The authors' recommendation is that the government should focus on stimulating private companies in this area because they are an important factor that can contribute to green growth, and thus sustainable economic growth.

In their work, Scarpellini et al. (2019) aimed to point out the impact of eco-innovation on the financial performance of companies operating in Spain. To establish this, they used the number of green patents and the intensity of research and development activities as a measure of eco-innovation. For their analysis, they used a sample of 2,218 companies characterized by a proactive approach to eco-innovation, of which 249 are companies with green patents. A positive link has been established between eco-innovation activities on the one hand and the intensity of research and development and overall innovation activities on the other. Also, the impact of eco-innovation activities on the financial performance of foreign companies is positive.

Corrocher and Ozman (2020) investigated how communication and information technology companies innovate in the field of green technologies and whether this has an impact on their performance. They analyzed data related to European companies operating in the field of information and communication technology. They noted that the dispersion of technologies is desirable in the context of encouraging the development of green technologies, but not to a great extent. Also, the authors conclude that companies in the field of communication and information technology that have green patents have better performance compared to companies in the same field that do not have green patents.

Based on the literature review, it is noted that most authors point to a positive link between green patents and green growth, i.e. that green growth based on eco-innovations protected by green patents has a positive impact on economic growth and ensures sustainability. With this in mind, the authors decided to examine the impact of green patents on the economic growth of national economies, which are among those with the most number of green patents, namely (Urbaniec et al., 2021): Germany, Japan, South Korea, United States, China.

2. Methodology

In order to see the impact of green patents on the economic growth of national economies (Germany, Japan, South Korea, the United States, and China), the following parameters related to green patents were selected: the proportion of environment-related patents (ERP) over overall patent applications, the number of environment-related patents (ERP) per million residents, the number of environment-related patents (ERP) per USD 100 billion (Urbaniec et al., 2021). Economic growth is represented by the value of GDP in billions of US dollars.

Data were collected from the following sources: Urbaniec et al., 2021; World Bank (a) (2022); World Bank (b) (2022); World Bank (c) (2022); World Bank (d) (2022); World Bank (e) (2022). For the selected parameters, data were collected for the period from 2000 to 2017. Data were processed via SPSS software using Pearson's coefficient r or Spearman's ρ correlation coefficient. Preliminary analyzes determined that the assumptions of linearity and homoskedasticity were met. Depending on the normality of the data distribution, Pearson's coefficient r was used when the data distribution is normal, and Spearman's coefficient ρ was used when it is absent. With the help of these coefficients, the strength and direction of the linear relation between two variables is determined. The coefficients can take values from -1 to +1. The sign indicates whether the correlation is positive or negative, while the absolute value of the coefficient indicates the strength of the correlation (correlation does not exist: $r/\rho = 0$; small: r/ρ = from 0.10 to 0.29; medium: r/ρ = from 0.30 to 0.49; large: r/ρ = 0.50 to 1.0) (Pallant, 2011, p. 137). Then, the standard multiple regression analysis was applied, which evaluates the power of variables to predict a certain outcome (Pallant, 2011, p. 151). Preliminary analyzes have shown that the assumptions of normality, linearity, multicollinearity, and homogeneity of variance were not violated.

The research is based on the following hypothesis:

Hypothesis: There is a positive relationship between the parameters of green patents and the GDP of the selected countries (Germany, Japan, South Korea, United States, and China) in the period from 2000 to 2017.

3. Research results

The following results were obtained by processing data via SPSS software using appropriate coefficients.

Table 1: Spearman's ρ correlation coefficient, Germany

Correlations		GDP
ERP patent applications over overall patent applications	Correlation Coefficient	.608**
	Sig. (2-tailed)	.007
	N	18
ERP per million residents	Correlation Coefficient	.668**
	Sig. (2-tailed)	.002
	N	18
ERP per USD 100 billion	Correlation Coefficient	.620**
	Sig. (2-tailed)	.006
	N	18

Source: Authors

A review of Table 1 shows a strong positive correlation (Correlation Coefficient> 0.5) between the indicators of the proportion of environment-related patents over overall patent applications, the number of environment-related patents per million residents, the number of environment-related patents per USD 100 billion, and GDP when it comes to Germany for the period from 2000 to 2017.

Table 2: Pearson's r correlation coefficient, Japan

Correlations		GDP
ERP patent applications over overall patent applications	Pearson Correlation	.741**
	Sig. (2-tailed)	.000
	N	18
ERP per million residents	Pearson Correlation	.802**
	Sig. (2-tailed)	.000
	N	18
ERP per USD 100 billion	Pearson Correlation	.816**
	Sig. (2-tailed)	.000
	N	18

Source: Authors

Based on Table 2, a strong positive correlation (Correlation Coefficient> 0.5) can be observed between the indicators of the proportion of environment-related patents over overall patent applications, the number of environment-related patents per million residents, the number of environment-related patents per USD 100 billion and the GDP in the case of Japan, for the period from 2000 to 2017.

Table 3: Spearman's ρ correlation coefficient, South Korea

Correlations		GDP
ERP patent applications over overall patent applications	Correlation Coefficient	.443
	Sig. (2-tailed)	.065
	N	18
ERP per million residents	Correlation Coefficient	.847**
	Sig. (2-tailed)	.000
	N	18
ERP per USD 100 billion	Correlation Coefficient	.769**
	Sig. (2-tailed)	.000
	N	18

Source: Authors

Based on Table 3, a strong positive correlation (Correlation Coefficient> 0.5) can be observed between the indicators of the number of environment-related patents per million residents, the number of environment-related patents per USD 100 billion, and the GDP in the case of South Korea for the period from 2000 to 2017. Also, there is a positive relationship of medium strength (0.3 <Correlation Coefficient <0.5) between the indicators of participation of the proportion of environment-related patents over overall patent applications and the GDP.

Table 4: Pearson r correlation coefficient, USA

Correlations		GDP
	N	18
ERP patent applications over overall patent applications	Pearson Correlation	.310
	Sig. (2-tailed)	.210
	N	18
ERP per million residents	Pearson Correlation	.451
	Sig. (2-tailed)	.060
	N	18
ERP per USD 100 billion	Pearson Correlation	.334
	Sig. (2-tailed)	.176
	N	18

Source: Authors

A review of Table 4 shows a positive relationship of medium strength (0.3 <Correlation Coefficient <0.5) between the indicators of the proportion of environment-related patents over overall patent applications, the number of environment-related patents (ERP) per million residents, the number of environment-related patents per USD 100 billion and the GDP in the case of the United States for the period from 2000 to 2017.

Table 5: Spearman's ρ correlation coefficient, People's Republic of China

Correlations		GDP
ERP per million residents	Correlation Coefficient	.992**
	Sig. (2-tailed)	.000
	N	18

ERP per USD 100 billion	Correlation Coefficient	.938**
	Sig. (2-tailed)	.000
	N	18
ERP patent applications over overall patent applications	Correlation Coefficient	-.153
	Sig. (2-tailed)	.545
	N	18

Source: Authors

A review of Table 5 shows a strong positive relationship (Correlation Coefficient> 0.5) between the parameters of the number of environment-related patents per million residents, the number of environment-related patents per USD 100 billion and the GDP, as well as a weak negative correlation (0> Correlation Coefficient> -0.29) between the indicators of the proportion of environment-related patents over overall patent applications and the GDP when it comes to China, for the period from 2000 to 2017.

This means that the hypothesis on which the research is based has been confirmed. A positive relation was established between the parameters of green patents and the GDP of the observed national economies (Germany, Japan, South Korea, USA, China), except for the parameters of the proportion of environment-related patents over overall patent applications and the GDP in the case of China.

Based on the correlation analysis for each country, the parameter of green patents was singled out, which has the strongest connection with the GDP and as such was used in the regression analysis as an independent variable, while the GDP was used as a dependent variable. Standard regression analysis was used to assess the ability of the selected parameter of green patents to predict the value of GDP. The following is a summary of the results of the standard regression analysis for each country.

The Adjusted R Square presented in Table 6 indicates that the model explains 48.7% of Germany's GDP. In Table 7 the value of Sig. = 0.001, i.e., $p < 0.05$ which means that the model reaches statistical significance. The value of the non-standardized Beta coefficient in Table 8 of the independent variable ERP per million residents is 63.649 and shows its contribution to explaining the dependent variable in the model. Sig. value = 0.001, or $p < 0.05$, means that the variable makes a significant unique contribution to the prediction of the dependent variable.

Table 6: Regression analysis - Model Summary, Germany

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.719[a]	.517	.487	461.70489
a. Predictors: (Constant), ERP per million residents				
b. Dependent Variable: GDP				

Source: Authors

Table 7: Regression analysis - ANOVA, Germany

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3658057.835	1	3658057.835	17.160	.001[b]
	Residual	3410742.442	16	213171.403		
	Total	7068800.278	17			
a. Dependent Variable: GDP						
b. Predictors: (Constant), ERP per million residents						

Source: Authors

Table 8: Regression analysis - Coefficients, Germany

Model		Unstandardized Coefficients		Sig.
		B	Std. Error	
1	(Constant)	1676.407	368.629	.000
	ERP per million residents	63.649	15.365	.001

Source: Authors

The value of Adjusted R Square presented in Table 9 indicates that the model explains 64.5% of Japan's GDP, while the results presented in Table 10 (the value of Sig. = 0.000, i.e., $p < 0.05$) indicate that the model is statistically significant. The value of the non-standardized Beta coefficient in Table 11 of the independent variable ERP per USD 100 billion is 14.239 and shows its contribution to the explanation of the dependent variable in the model. Sig. value = 0.000, i.e., $p < 0.05$, means that the variable makes a significant unique contribution to the prediction of the dependent variable.

Table 9: Regression analysis - Model Summary, Japan

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.816[a]	.666	.645	349.03068
a. Predictors: (Constant), ERP per USD 100 billion				
b. Dependent Variable: GDP				

Source: Authors

Table 10: Regression analysis - ANOVA, Japan

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3892305.621	1	3892305.621	31.951	.000[b]
	Residual	1949158.657	16	121822.416		
	Total	5841464.278	17			
a. Dependent Variable: GDP						
b. Predictors: (Constant), ERP per USD 100 billion						

Source: Authors

Table 11: Regression analysis - Coefficients, Japan

Model		Unstandardized Coefficients		Sig.
		B	Std. Error	
1	(Constant)	4141.482	173.606	.000
	ERP_per_USD_100_billion	14.239	2.519	.000

Source: Authors

The value of Adjusted R Square presented in Table 12 indicates that the model explains 64% of South Korea's GDP, while the results presented in Table 13 (the value of Sig. = 0.000, i.e., $p < 0.05$) indicate that the model reaches statistical significance. The value of the non-standardized Beta coefficient in Table 14 of the independent variable ERP per million residents is 30827.059 and shows its contribution to the explanation of the dependent variable in the model. Sig. value = 0.000, i.e., $p < 0.05$, means that the variable makes a significant unique contribution to the prediction of the dependent variable.

Table 12: Regression Analysis - Model Summary, South Korea

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.813[a]	.661	.640	203625.00645
a. Predictors: (Constant), ERP per million residents				
b. Dependent Variable: GDP				

Source: Authors

Table 13: Regression analysis - ANOVA, South Korea

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1295556929253.002	1	1295556929253.002	31.246	.000[b]
	Residual	663410292040.610	16	41463143252.538		
	Total	1958967221293.611	17			
a. Dependent Variable: GDP						
b. Predictors: (Constant), ERP per million residents						

Source: Authors

Table 14: Regression Analysis - Coefficients, South Korea

Model		Unstandardized Coefficients		Sig.
		B	Std. Error	
1	(Constant)	657081.435	90260.252	0.000
	ERP per million residents	30827.059	5514.866	0.000

Source: Authors

The Adjusted R Square presented in Table 15 indicates that the model explains 15.4% of Germany's GDP, while the results in Table 13 (the value of Sig. = 0.060, i.e., $p < 0.1$) indicate that the model reaches statistical significance. The value of the non-standardized Beta coefficient in Table 17 of the independent variable ERP per million residents is 397.089 and shows its contribution to the explanation of the dependent variable in the model. Sig. value = 0.06, i.e., $p < 0.01$, means that the variable gives a significant unique contribution to the prediction of the dependent variable.

Table 15: Regression analysis - Model Summary, USA

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.451[a]	.203	.154	2629.78432
a. Predictors: (Constant), ERP per million residents				
b. Dependent Variable: GDP				

Source: Authors

Table 16: Regression analysis - ANOVA, USA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	28262558.472	1	28262558.472	4.087	.060[b]
	Residual	110652249.528	16	6915765.596		
	Total	138914808.000	17			
a. Dependent Variable: GDP						
b. Predictors: (Constant), ERP per million residents						

Source: Authors

Table 17: Regression analysis - Coefficients, USA

Model		Unstandardized Coefficients		Sig.
		B	Std. Error	
1	(Constant)	10388.810	2191.272	0.000
	ERP per million residents	397.089	196.428	0.06

Source: Authors

Table 18 presents the value of Adjusted R Square indicating that the model explains 95.3% of China's GDP, while the results in Table 19 (the value of Sig. = 0.000, i.e., $p < 0.05$) indicate that the model reaches statistical significance. The value of the non-standardized Beta coefficient in Table 20 of the independent variable ERP per million residents is 8531006.989 and shows its contribution to the explanation of the dependent variable in the model. Sig. value = 0.000, i.e., $p < 0.05$, means that the variable makes a significant unique contribution to the prediction of the dependent variable.

Table 18: Regression analysis - Model Summary, China

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.978[a]	.956	.953	858568.38440
a. Predictors: (Constant), ERP per million residents				
b. Dependent Variable: GDP				

Source: Authors

Table 19: Regression analysis - ANOVA, China

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	254561551769059.750	1	254561551769059.750	345.337	.000[b]
	Residual	11794234730940.242	16	737139670683.765		
	Total	266355786500000.000	17			
a. Dependent Variable: GDP						
b. Predictors: (Constant), ERP per million residents						

Source: Authors

Table 20: Regression analysis - Coefficients, China

Model		Unstandardized Coefficients		Sig.
		B	Std. Error	
1	(Constant)	1347874.206	309848.543	0.000
	ERP per million residents	8531006.989	459069.865	0.000

Source: Authors

Conclusion

In the conditions of accelerated economic growth of the most developed economies in the world, the question of sustainability of economic development and its impact on the environment arises. The problems that the world is facing today in the field of ecology are becoming more complex, more visible, more serious, and are becoming a priority to be solved, due to more and more intensive economic activity. That is why hard work is being done to find the optimal solution, having in mind both the environmental and economic responsibility of companies. Companies invest in eco-innovation and protect their inventions with green patents. Green patents are viewed as a parameter of the eco-innovation intensity of companies. Numerous studies indicate their positive impact on the financial performance of the companies that own them. Can we then assume and confirm the positive impact of green patents on the economic growth of national economies?

Based on the results of the research, it can be concluded that the hypothesis on which the research is based has been confirmed. A positive relation was established between the parameters of environmental patents and the GDP of the observed national economies (Germany, Japan, South Korea, USA, China), except for the parameters of the proportion of environment-related patents over overall patent applications and the GDP in the case of China. This means that as the value of selected parameters of green patents increases, the value of GDP increases, too. Given this fact, it is necessary for state governments to stimulate companies to focus their research and development activities on eco-innovation and thus provide environmental benefits, as well as economic benefits, which are reflected in their financial performance and their contribution to the economic growth of the national economies in which they operate. In this way, green growth and economic growth become complementary and fulfill the postulate of sustainability.

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ЭЄ
ECONOMICS OF SUSTAINABLE DEVELOPMENT

Vol. 6, july-december 2022, № 2
UDK 33+502/504
ISSN 2560-421X

Miloš Ilić[1]
University of Niš,
Faculty of Economics

Panagiota Digkoglou[2]
University of Macedonia,
Thessaloniki, Central Macedonia, Greece

P. 17-30
ORIGINAL SCIENTIFIC PAPER
10.5937/ESD2202017I
Received: August 18, 2022
Accepted: September 10, 2022

THE VOLATILITY OF STOCK MARKET RETURNS: APPLICATION OF MONTE CARLO SIMULATION

Abstract

Stock exchange is the ”mirror” of the economy and helps industry (and commerce) to accelerate the development of the country. The prices on the stock exchanges increase or decrease over the particular period and that rate represents stock market volatility. Higher stock price volatility is often associated with higher risk and indicates future fluctuations to investors in order to evaluate them. Predicting future stock price volatility can provide important information to market participants and enable them to make adequate decisions. The aim of this paper is to evaluate the stock price volatility of the Apple Company using the Monte Carlo simulation.

Key words: *Monte Carlo Simulation, Forecast, Volatility, Stock Exchange.*

JEL classification: *C15, G17*

ВОЛАТИЛНОСТ ПРИНОСА НА БЕРЗИ: ПРИМЕНА МОНТЕ КАРЛО СИМУЛАЦИЈЕ

Апстракт

Берза је “огледало” економије сваке земље и омогућава развој привреде и трговине. Цене на берзама расту или опадају током одређеног периода а та стопа представља волатилност тржишта акција. Већа волатилност цена акција често значи већи ризик и помаже инвеститору да процени флуктуације које се могу десити у будућности. Предвиђање будуће волатилности цена акција може пружити важне информације учесницима на тржишту и омогућити им да донесу адекватне одлуке. Циљ овог рада је да се процени волатилност цене акција компаније Аппле коришћењем Монте Карло симулације.

Кључне речи: *Монте Карло симулација, предвиђање, волатилност, берза*

[1] ilke.ilic@hotmail.com, ORCID ID: 0000-0002-6548-2069

[2] gdigkoglou@uom.edu.gr, ORCID ID: 0000-0001-7101-5136

Introduction

The set of sellers and buyers of securities, which represent the owner's receivables, makes up the stock exchange. These include shares that are traded only privately, such as shares of private companies that are sold to investors through group capital financing platforms, as well as securities listed on a public stock exchange. Shares are categorized according to the country in which the company is headquartered. For example, part of the Swiss stock market includes Nestle and Novastist, based in Switzerland, which are traded on the SIX Swiss Stock Exchange. Some securities can be traded in other countries. Thus we get certain time series, which dictate different trading prices over a certain period of time. Stock volatility is the degree of variation of series, and is usually measured by the standard deviation of ligorithmic yields. Volatility during crisis situations, such as the oil crisis or the pandemic and the Great Depression, is very important.

The volatility of the stock exchange is very important and that is why it is necessary to perform an analysis in emergency situations. Especially since the emergency is something that is not common in the financial world, its consequences can be long-term, and we have a pandemic as a new phenomenon in the world, which will affect the world's largest stock exchange - the New York Stock Exchange (Analytical Steps, 2021).

When it comes to the topic of volatility, it is very important to distinguish between real and implied volatility. More precisely, real volatility represents the actual current volatility of a financial instrument for a given period on the basis of historical prices. It can take more than four months to process all the analyses, and that could be one example. An option's expiration date may represent actual future volatility, as it is the volatility of a financial instrument during a given period that starts at the current time and ends in the future (on a certain date). The real historical volatility is the volatility of the past with the last observation on the date in the past and has one synonymous term - realized volatility. The volatility observed from the current prices of a financial instrument is current, future and historical implied volatility. Historical volatility, which takes historical prices, is most often used for common options.

In some periods, prices can hardly move (Investopedia 2022), and there are periods where they can fall or rise very quickly, these are periods of high and low volatility. Thus, in some foreign exchange markets are seasonally heteroskedastic with periods of one day and one week (Müller et al., 1990; Petrov et al 2019). This phenomenon is called autoregressive conditional heteroskedasticity (ARCH), because it is caused by extreme movements larger than usual. ARCH statistical model is a model of innovation as a function of real size of the term error in pre-period periods, which often refers to the squares of previous innovations (Engle, 1982), and also describes variance of increasing volatility that does not always show a further increase, but can return again. Given the extreme movements, it is difficult to say whether these large movements have the same direction or not. Volatility does not depend only on the period when measured and when the effect is observed, from the chosen time resolution, because the flow of information between short-term and long-term traders is asymmetric. High-resolution variability and vice versa is based on information that is not covered by low-resolution variability (Müller et al., 1997). For example, if we observe the period from 1974 to 2014 for risk-weighted parity variability of three assets - gold, treasury bonds and NASDAQ - which acts as an intermediary for the market portfolio, there is a 4% low point after 8 times upwards in this period.

It is suspected that implied volatility and realized volatility are measures that look forward and backward and do not maintain current volatility. As a solution to this problem, the idea of collective measures of volatility is given. Some authors consider the regular sequence of changes of direction as a proxy for current volatility (Petrov et al., 2019), while others define measures as a standard deviation of ensemble yield instead of time series of yield (Sarkissian, 2016), SVI and gSVI (Damghani & Kos, 2013).

When it comes to the sophisticated composition of the model of predicting maximum variability, critics believe that their predictive power is alike to that of ordinary measures, such as simple variable volatility (Cumby et al., 1993; Jorion, 1995), especially out-of-sample, where different data are used to evaluate models and test them (Brooks & Persand, 2003). However, there are other authors (Andersen & Bollerslev, 1998) who agreed with this, but also believe that the previous ones failed to properly implement more complicated models, while some portfolio managers and practitioners ignore or dismiss predictive models. Thus, Emanuel Derman pointed out his disappointing opinion about the large number of empirical models that are not accompanied by adequate theory and believes that "theories are attempts to discover hidden principles that support the world around us, as Albert Einstein did with his theory of relativity", and say to remember that "models of metaphors - analogies that describe one thing in relation to another" (Derman, 2011). Daniel Goldstein and Nassim Taleb stated, in relation to portfolio management: "We don't know exactly what we are talking about when we talk about volatility" (Goldstein & Taleb, 2007).

Many studies predicting and modelling the volatility of financial returns have a great impact even today, as from JPMorgan Chase in 2019, where the influence of Donald Trump was determined, tweets and called the Volfefe index that combines cofefememe and volatility. It is difficult to talk about the first papers on this topic, but we can take into account Roll's research which shows that volatility is influenced by market microstructure (Roll, 1984) or Gloucester and Milgrom's work which demonstrates that at least one source of volatility can be clarified by the provisioning process liquidity. This means that when market makers conclude the possibility of unfavourable selection, they adjust their trading volumes, which increases the range of price oscillations (Glosten & Milgrom, 1985). Today, investors can worry about volatility, more than before, because they can trade it directly by using derivative securities - options and variations. This work is especially important for several reasons concerning investors, such as: the higher the price changes in the price of the investment, the harder it is not to worry; when it is dictated for a certain date by a certain cash flow during the sale of securities, thus the chances of a deficit are higher due to higher volatility; higher volatility of returns after retirement gives withdrawals a greater lasting impact on portfolio value; the size of the portfolio position is affected by the volatility of returns after retirement; the size of the portfolio position is defined by the price volatility of the trading instrument; higher volatility of return with retirement savings results in a wider distribution of possible final portfolio values; the complex annual growth rate (CAGR) portfolio is negatively affected by its volatility; for cheap property purchase and sale when it is overestimated, price volatility plays a big role; volatility affects option prices, which is a parameter of the Black-Scholes model.

The primary aim of this paper is to determine the possible movement of market prices of shares on an adequate sample from stock exchange using Monte Carlo simulation. Thus, we can determine how the pandemic could have affected prices. It will be important for a later conclusion, if the current situation in the world with the virus worsens or if a similar one appears in the future. In the second part we provide a review of the literature on market variability and application of the Monte Carlo method, while in the third part, the research methodology applied in the paper is discussed. The fourth part presents the research methodology applied in the paper and gives the results and the discussion. Finally, the fifth part includes concluding remarks.

Literature review

This topic has become especially intensified in recent years due to the COVID-19 pandemic and uncertainty that it caused. As a result, numerous researches (Boettke & Powell, 2021; Açikgöz & Günay, 2020) on this topic can be found in the modern literature. Several researchers have examined the adequacy of responses to market instability to make appropriate recommendations to policy makers (Schwert, 1990; Adam et al., 2016). In addition, there are papers that deal with the observation of macroeconomic phenomena together with variability, which is of great importance, because the COVID-19 pandemic has affected the entire economy. Some authors analysed connection between macroeconomics fundamentals and asset return volatility in approximately forty countries (Diebold & Yilmaz, 2008), one group of authors investigated relation between stock market volatility and macroeconomics activity using a new class of component models that differentiate short-run from long-run movements (Engle et al., 2013). Macroeconomics of a country can also be related to volatility by presenting a theory of excess stock market volatility, in which market movements are due to trades by very large institutional investors in relatively illiquid markets (Gabaix et al. al., 2006). This is how we can recognize and locate variability in the observed pandemic. We can only try to predict how the pandemic could have affected the stock market.

In relation to forecasting in the literature, we notice a lot of applications of Monte Carlo methods in finance, for valuation and hedging of securities, risk management, portfolio optimization and model calibration (Staum, 2009), then for valuation of derivatives (Joy et al., 1996) or for theoretical research (Creal, 2011) and calculations (Asmussen, 2018). There is also the combination of the Monte Carlo method with other methods, for example with the Malivian calculus - an attempt was made to combine these two methods (Fournie et al., 1999; Fournie et al., 2001).

The conclusion is that the Monte Carlo method can be used to determine the price of financial derivatives (Rebentrost et al., 2018) as well as for stock market valuation (Siddiqui, Patil, 2018) and for forecasting (Estember and Maraña, 2016). One of the best examples of predicting research, estimating and comparing the predictive power of the Monte Carlo simulation technique in predicting randomly selected 10 listed shares on the SET50 stock exchange of Thailand (Parungrojat & Kidsom, 2019). We also have examples of evaluating predictive performance of a selection of value-at-risk (VaR) models for Japanese stock market data, where, among others, are also considered Monte Carlo method (Lee, Saltoglu, 2002), as well as examples of yield forecasting on the Amman Stock Exchange (Alrabadi & Aljarayesh, 2015).

Such concrete examples that show the correlation between COVID-19 pandemic and shares, where COVID-19 had caused a negative shock to the global stock markets, which specifically refers to emerging markets and small firms (Harjoto et al., 2020), as well as the possibility of applying the method on the stock exchange, we can observe with the investment crisis from 2008 in relation to efficiency of the stock exchange (Anagnostidis et al., 2016). Before further investigations, we can see that COVID-19 have mostly negative effect on firms` stock returns (Nguyen et al., 2021) and investors decisions about buying and selling stocks of some companies (Ramelli & Wagner, 2020). We can further investigate this by observing only the fractal effect of COVID-19 pandemic on stock exchanges in 32 affected economies in different periods (Okorie & Lin, 2020) or by analysing the time before COVID-19 and during the stock exchange pandemics in Bursa Malaysia and Singapore Stock Exchange (Yong et al., 2021). However, some researchers are more interested in stock returns and associate COVID-19 with an increasing number of infected (Anh & Gan, 2020) or confirmed cases, due to the pandemic (Khanthavit, 2021). However, all these researches have some contact with volatility, and at the same time, they can provide a basis for further research.

This paper uses a method that has been applied to other securities, such as options (Boyle, 1977; Mehrdoust & Fallah, 2015), but there are those who question its variability (Zhang et al., 2018; Ferson, 2008), and this certainly opens up new topics for discussion.

The main objective of this paper is to investigate stock market volatility using the Monte Carlo simulation to provide insight into stock price movements, as there was a significant stock market collapse in 2020 caused by the COVID-19 pandemic and increased uncertainty, and to forecast potential returns for next period.

In 2020, there was a collapse of the market that occurred after a decade of global economic progress and constant growth, after the recovery from the 2007-2008 financial crisis. On the other hand, the quality of life has improved all over the world. At the beginning of 2020, the COVID-19 pandemic begins, which is more influential than the Spanish flu, and which decimates the economy (WBUR, 2021). The market has been exacerbated by panic disruptions in purchase and supply, leading to a global economic halt. The market was already vulnerable (Time, 2021; Capital, 2021), as indicated by the International Monetary Fund as well as other mitigating factors seen before the pandemic.

Since the 2007-08 financial crisis, a corporate debt bubble has emerged, increasing from 84% of world gross domestic product in 2009 to 92% in 2019, or about $ 72 trillion (The Economist, 2021). China, the United States, Japan, Britain, France, Spain, Italy and Germany, which are the eighth largest economies, have a total debt of $ 51 trillion in 2019 (for example $ 34 trillion in 2009). The biggest risks are developing markets such as China, India and Brazil, where 25-30% of bonds were issued by risky companies (McKinesey, 2021), warns in 2018 McKinsey Global Institute.

Getting back to crisis in 2020, we can say that sales increased during the first half and until mid-March same year, although the decline began on February 20, 2020. During the fall, there are multiple daily declines in the stock market on a global level. The biggest drop was on March 16, 2020, called "Black Monday II", by 12-13% in most global markets (CNBC, 2021). We have two more significant dates of the stock market crash - March 9, 2020 known as "Black Monday I" (BBC, 2021) and March 12, 2020 with the nickname "Black Thursday" (CNBC, 2021). Banks around the world are cutting cash flow rates and interest rates - in order to solve panic, and offer support to investors and markets (Reuters, 2021).

Methodology

Monte Carlo simulation is usually used in corporate and finance to evaluate and analyse portfolios and investments by simulating various factors of uncertainty that affect their value, and then determine the distribution of their value in the range of resulting outcomes. This is most often done on a stochastic means models basis. David B. Hertz introduced this method in finance in 1964 and published in his article in Harvard Business Review (2021). He highlighted its application in corporate finance. Boyle is considered a pioneer of application because he used it in 1977 to evaluate derivatives (Boyle, 2013, p. 323-338). Compared to other growth techniques, as the sources of uncertainty - sources of the problem increase (Palisade, 2021), the Monte Carlo method has an advantage.

This method includes any statistical sampling technique used to approximate solutions to quantitative problems. The Monte Carlo method actually solves the problem by simulating the basic process and then determining the average result. Monte Carlo simulation is a technique for simulating the probability of an outcome based on probability distribution, which achieves more accurate coverage of uncertainty. The essence of this simulation is in the random generation of data based on probability distribution, with the aim of simulating the sampling process from the actual population (Bakar & Rosbi, 2019).

The Monte Carlo method is used in finance to calculate the representative value of instruments in relation to all possible values of the underlying investment, as well as to simulate various sources (factors) of uncertainty affecting the value of the instrument, portfolio or investment which are the subject of analysis. In essence, this is the application of a neutral risk assessment in terms of financial theory. In addition, this method can be used for personal finance planning. An example is the calculation of plan 401 (k), which determines the possibility of retirement based on target income. By increasing the amount of money allocated for savings, we can determine the need to take on more risk.

The use of Monte Carlo simulations is not always appropriate, despite the fact that they provide flexibility and can deal with complex sources of uncertainty. However, these simulation methods are certainly more desirable than others only if there are several variable states. Due to a specific nature of American style derivatives, it is important to emphasize that these techniques are limited in valuation of that type of derivatives. Namely, it will be presented one of the techniques on the example of the New York Stock Exchange.

The vicious pandemic that has swept the world as well as the fall of the stock market in 2020 is making Monte Carlo simulations more significant than before. Data taken from Yahoo Finance for each of the trading days for five years as well as simulations were done using the R programming language, all in order to assess stock price volatility.

Results and discussion

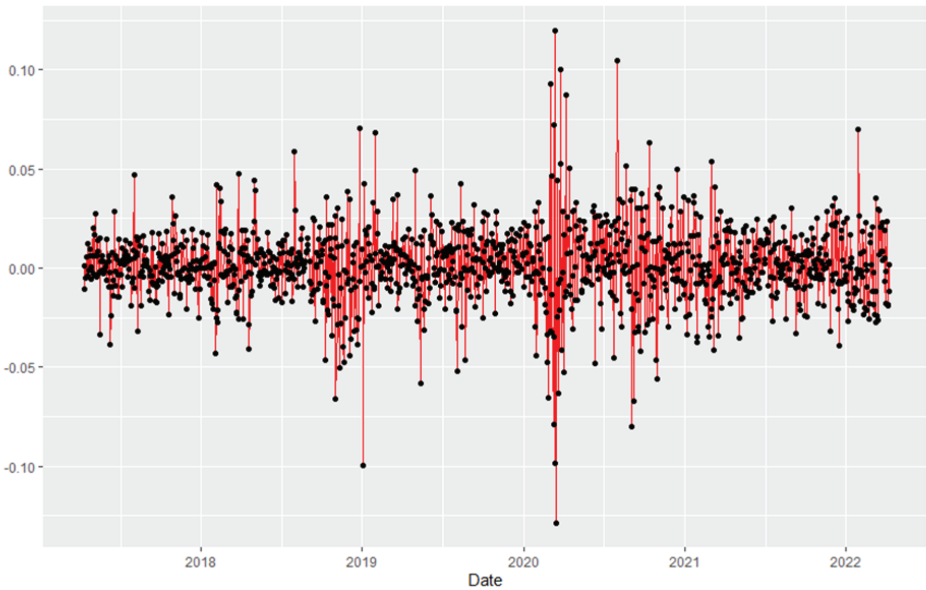
Based on data on stock price movements, Apple's average daily returns over six years were calculated using the formula:

$$Rt=(Pt-P\_(t-1))/P\_(t-1)$$

where: Rt represents the return rate at the period t, Pt stock price at the period t, and P_(t-1) stock price at the period t-1.

The movement of daily returns during the observed period recorded significant volatility, where it can be noticed that the highest volatility of returns was recorded during 2021, especially in the first half of 2020, which coincides with the period of the outbreak of the COVID-19 pandemic (Figure 1).

Figure 1. Daily return rates of AAPL stocks



Source: Authors' calculations

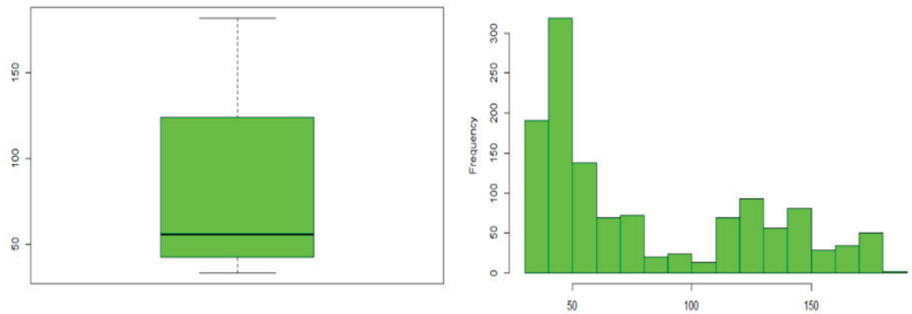
When it comes to adjusted closing prices, it can be noticed that after a short downward trend during the second half of 2018 and during the first half of 2020, there was an increase in prices that continued during 2021 and 2022, with increase in prices having moderate volatile movements (Figure 2).

Figure 2. Trend of adjusted closing price

Source: Authors' calculations

However, during most of the observed period, adjusted closing prices were less than the average values of the series, which can be seen on the basis of box plot and histogram (Figure 3).

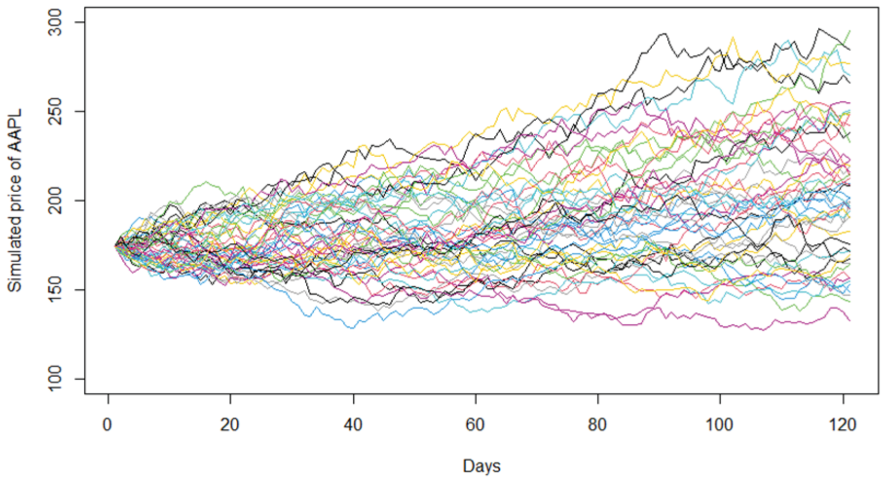
Figure 3. Box plot and histogram of the adjusted closing price



Source: Authors' calculations

The price simulation was performed for a period of 120 days, during which 1000 simulations were created (Figure 4).

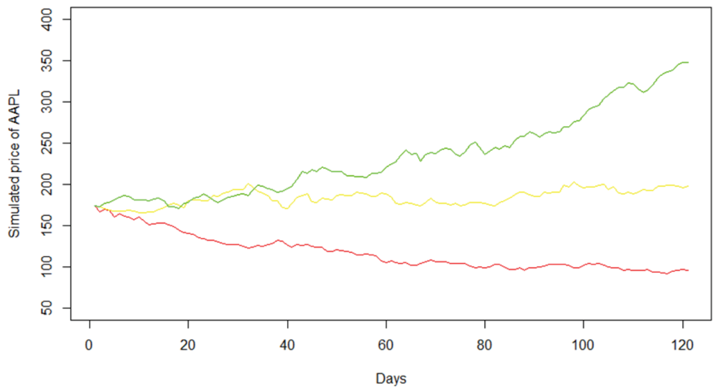
Figure 4. Simulated values of Apple adjusted closing prices



Source: Authors' calculations

Figure 5 shows the projected highest adjusted closing prices, the lowest adjusted closing prices and the mean value of projected adjusted closing prices.

Figure 5. Highest and lowest adjusted closing prices



Source: Authors' calculations

The prediction of future return was made on the basis of probability distribution, and it was determined that the probability of making more than 10% of return is 55.64436 %, while the probability of losing more than 10% is 12.68731 % during the next 120 days. Furthermore, the probability of making more than 50% of return is 6.293706 %

while the probability of losing more than 30% is 0.5994006 % and the probability of losing more than 50% is 0 %. These probabilities indicate a good investment potential of Apple's shares in the next 120 days, since the probability of creating return is higher than probability of losing.

Conclusion

Modern business is characterized by a distinct dynamism resulting from rapidly changing business conditions. Stock price movements are characterized by pronounced volatility, which leads to investors' exposure to potential losses. In order to avoid the negative consequences of stock price volatility, the information obtained by applying the Monte Carlo simulation can be extremely important. Monte Carlo method represents a methodological tool used for studying analytical intractable problems and for forecasting, and its usefulness has been more pronounced lately.

With the aim of pointing out to the possibilities and advantages of applying Monte Carlo simulations when analysing the volatility of the stock market, the paper analysed the data of the Apple Company which is listed on New York Stock Exchange. The purpose of the analysis was to examine the volatility of stock market returns. For the purpose of this research, the data were obtained for the six-year period, from 2017 up to 2022. The analysed period includes the period of the COVID-19 pandemic outbreak which affected the world and world economy leading to one of the biggest markets fall since The Great Depression in 20th century.

The results of the research indicate the expected trends of the stock prices returns in the next 120 days, which allows investors to make informed decisions. Further research in this area can be directed towards analysing the particular stock portfolio and identifying the optimal structure of the portfolio.

With the development of unexpected crisis situations, like the newest situation in Ukraine, methods that enable predictions are gaining in importance for investors and researches.

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ECONOMICS OF SUSTAINABLE DEVELOPMENT

Vol. 6, july-december 2022, № 2
UDK 33+502/504
ISSN 2560-421X

Aleksandra Aleksić[1]
Faculty of Economics,
University of Niš

Tamara Rađenović[2]
Faculty of Occupational Safety,
University of Niš

Zoran Simonović[3]
Institut of Agriculture Economics, Belgrade

P. 31-42
SCIENTIFIC REVIEW PAPER
10.5937/ESD2202031A
Received: September 01, 2022
Accepted: September 30,2022

RESOURCE MANAGEMENT AND PERFORMANCE MEASUREMENT INDICATORS IN THE CIRCULAR ECONOMY

Abstract

The concept of circular economy involves the use of indicators that help measure performance by looking at the key elements of this concept. Efficient use of resources and responsible behavior towards waste through reuse of materials and recycling of raw materials are one of the basic activities and tasks of the circular economy. It is important to prevent and reduce the production of waste materials and to ensure that resources are used in several production cycles. The aim of this paper is to point out the basic aspects of efficient use of resources, to get acquainted with the basic operational principles of circularity, but also to get acquainted with the indicators that can be used for reporting. The main goal is, therefore, to understand how organizations can choose a group of indicators that will help them measure the performance of the circular economy and its activities, but also to point out the principles that are important for the application of this concept.

Keywords: *circular economy, principles of circular economy, performance indicators, waste management, efficient use of resources*

JEL classification: *Q56, Q57, M21*

УПРАВЉАЊЕ РЕСУРСИМА И ИНДИКАТОРИ МЕРЕЊА ПЕРФОРМАНСИ У ЦИРКУЛАРНОЈ ЕКОНОМИЈИ

Апстракт

Концепт циркуларне економије подразумева употребу индикатора који помажу мерењу перформанси кроз сагледавање кључних елемената овог концепта. Ефикасна употреба ресурса и одговорно понашање према отпаду кроз поновну употребу материјала и рециклирање сировина једни су од

[1] aleksandra.saska.aleksic@gmail.com, ORCID ID 0000-0003-0025-7642

[2] tamara.radjenovic@znrfak.ni.ac.rs, ORCID ID 0000-0003-1632-7772

[3] zoki@medianis.net, ORCID ID 0000-0002-2769-686

основних активности и задатака циркуларне економије. Важно је остварити превенцију и смањење производње отпадних материја и обезбедити да се ресурси користе у више производних циклуса. Циљ рада је указивање на основне аспекте ефикасне употребе ресурса, упознавање са основним оперативним принципима циркуларности, али и упознавање са индикаторима који се могу користити за извештавање. Основни циљ је, дакле, разумевање начина на који организације могу изабрати групу индикатора који ће им бити од помоћи при мерењу перформанси циркуларне економије и њених активности, али и указивање на принципе који су од значаја за примену овог концепта.

Кључне речи: *циркуларна економија, принципи циркуларне економије, индикатори перформнаси, управљање отпадом, ефикасна употреба ресурса*

Introduction

The circular economy is a recent concept that has emerged in response to the growing environmental and economic problems in the world. The economy uses resources from nature, consumes energy and returns waste materials, whether they are toxic or non-degradable. It is an unsustainable system, which can burst at any moment, because the hoops in the form of climate change, pollution and the effects of the greenhouse are increasingly gathering and tightening the economy, but also nature itself, which can no longer accumulate all these negative phenomena. Therefore, the importance of applying the concept of circular economy, which implies the circulation of matter and raw materials through the system, is increasingly emphasized. All resources and materials used must be from renewable sources and strive to achieve zero waste at the end of the reproduction cycle. It is important to ensure good waste prevention, use recyclable materials and components from the beginning, then strive to reuse the product after the end of its service life, with servicing, replacement of parts and redesign. Waste is managed responsibly and, in addition to recycling, the part that represents waste material is disposed of in a way that does not harm the environment.

The benefits of applying the concept of circular economy are visible at the micro and macro level. Companies have numerous savings from the use of used resources, money is now being invested in recycling, the use of new and advanced technology. At the level of the environment and the economy, the ecosystem, nature, non-renewable energy sources and resources are protected. All this contributes to increasing the competitiveness of the company, but also of the entire business environment. Efficient resource and waste management are underlined as two basic, equally important, goals of the circular economy. It can be concluded that resources are the basis of this concept because attention is focused on their protection, rational exploitation and maximum utilization - renewable and recyclable sources of raw materials. It is important to note that the circular economy is a closed system that connects procurement with the waste management phase. This achieves a compact business unit that operates effectively and efficiently based on the principles of circular economy. The value of resources is retained within that system by applying the principle of maintaining the value of materials through product reuse or recycling of raw materials.

The way in which the circular economy and its system function is explained by operational principles. According to one of the classifications, they are divided into basic, target and transversal. Principles are the basis of the existence and understanding of the concept, the basis that serves to share knowledge about the circularity in society and economic organizations.

In a circular economy, performance indicators are used. Their number varies depending on the views of the authors, but what is suggested is certainly the use of not too many, but enough relevant indicators that will provide a good information basis for making a performance assessment. Most indicators are directly or indirectly related to measuring the performance of the use of resources, which are one of the main management topics of the circular economy. All of the above should be helpful in understanding the basic facts about resource use and waste management, as well as the ability to measure performance in a circular economy. The number of indicators in use depends on the characteristics of the business system, organization and characteristics of the production itself. The most important thing is that by choosing a set of indicators, management achieves the goals of adequate and accurate measurement of the performance of the circular economy.

Resource and waste management in the circular economy

The linear business model has become almost unsustainable for many economies around the world due to the numerous negative externalities that fast-growing industries and the activities they bring with them. The effects of the greenhouse, climate change, environmental pollution and the lack of an adequate solution for waste materials have prompted the world to think about potential solutions to the accumulated problems. There was a need for man to change his attitude towards nature and the material world because his existence was disturbed. In addition, the increasing use of energy and resources from nature with the increase in production contribute to the reduction of available raw materials or change their quality. These are just some of the reasons why the world economy is starting to pay attention to the concept of circular economy and to look for a solution in its principles and application.

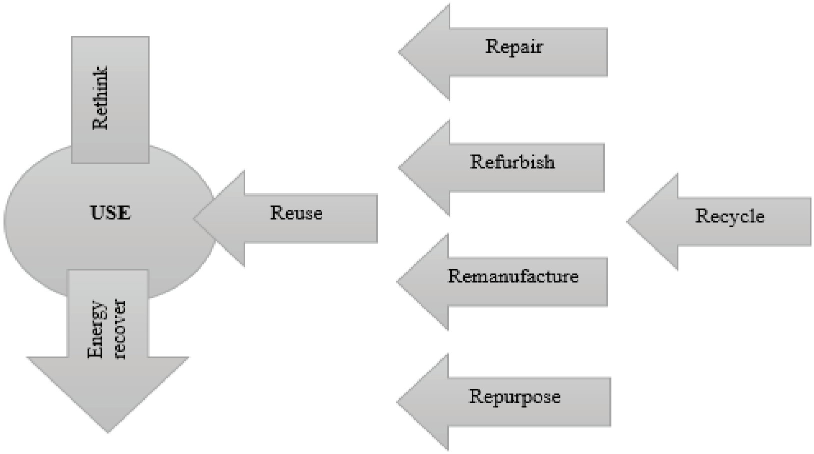
The circular economy has its roots in the field of industrial ecology, and on the other hand, in the field of ecological economics, which emphasizes recycling and efficient use of waste, but also through specific areas such as industrial ecosystem, eco-efficiency, emission reduction (Sanchez-Ortiz et al., 2020). From the aspect of theory, circular economy is a concept that combines the principles of several schools of thought - the school of regenerative design, performance economy, green growth, industrial ecology (Pauliuk, 2018). It is an approach that promotes sustainable development and is one of the frameworks applied for the implementation of sustainable development strategies and the achievement of economic goals, while respecting environmental requirements and the need for rational and responsible use of natural resources.

The concept of the circular economy, as an emerging framework for waste and resource management, aims to offer an alternative to linear production thinking through the use of reuse, recycling and remanufacturing strategies (Blomsma, 2017). Analyzing the circular economy as the so-called "an umbrella concept" that seeks to examine the knowledge gap in the field of circular economy, with the aim of connecting the scientific and practical segment of the circular way of doing business, and until the appearance of the umbrella concept, they exist independently of each other (Hirsh & Levin, 1999). Numerous economies and companies, starting with Germany, which was among the first countries to support the concept of circularity, noticing the benefits of doing business according to the principles of circular economy, advocate abandoning the linear system and switching to a new model. Linear economy, with profit orientation as the main driver of all processes, uses natural resources from the environment, with insufficient respect for environmental principles and insufficient care for technical and technological waste that harms both humanity and nature itself. Although the linear model of the economy is dominant in the world, the world public, faced with increasingly difficult forms of environmental problems and poverty problems, notices that this model is becoming unsustainable in the long run (Čarapina & Mihajlov, 2015). That is why the world is turning to the application of the circular economy model and respect for the principles associated with it. On the other hand, the circular model of the economy strives to create a system with zero waste, maximum utilization of each substance and raw material that has already suffered the process of production and use. The benefits of doing business in the circular economy are reflected in the protection of resources and the environment through compliance with sustainable development guidelines, then in the increased use of renewable energy sources while reducing non-renewable, reducing losses that companies consciously or unconsciously make, increasing the competitiveness and reputation of companies in the eyes of consumers who recognize that someone cares about them and their environment and, therefore, choose recyclable and environmentally friendly products.

With the growing environmental and climate problems in the world, more and more attention is being paid to sustainable development and the circular economy. The circular economy is seen as an instrument for achieving sustainable development goals through the pursuit of efficient and rational use of resources and respect for environmental and zero waste principles, all through a system that allows product reuse or recycling of components after the end of product life. It is necessary to use circular economy strategies that require as little use of natural resources as possible and offer maximum utilization of waste materials and raw materials that have already gone through the production process.

Figure 1 shows the strategies applied in the circular economy system - strategies further away from the center requiring less investment and less use of natural resources. At the same time, the materials and raw materials in use are made from recycled raw materials and components of products that were in use, reducing the overload of the natural environment from which less resources and energy are now extracted, and reducing or completely neutralizing waste that pollutes nature.

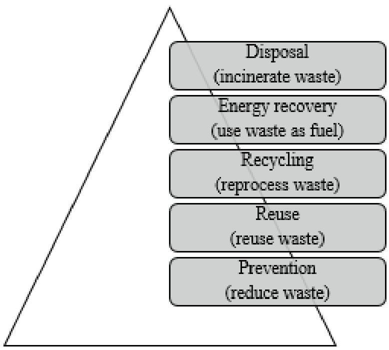
Figure 1: Strategies for the use of resources and materials in the circular economy



Source: Adapted to Potting & Hanemaaijer (2018)

Doing business in a circular economy, along with improving the management of waste and materials, helps to address issues related to their impact on the environment. The return of materials from waste streams to the process of recycling or reuse contributes to longer use of goods and increasing the intensity of use, which is the aspiration of the circular economy - maximizing the value of materials circulating within the economy, minimizing material consumption and paying special attention to primary materials and waste streams. All this maintains the value of resources within the system for a longer period of time (OECDiLibrary, 2021).

Figure 2: Waste management hierarchy



Source: Adapted to OECDiLibrary (2021)

The main goal of efficient management of resources and waste is waste prevention, general reduction of waste, especially hazardous substances. In addition, the reuse of products at the end of their useful life or the preparation and treatment of waste components for reuse is something that is also considered a priority. Looking at Figure 2, recycling, energy recovery through the use of waste as fuel and waste disposal through landfilling and incineration of what cannot be used as fuel for energy production, are direct waste management. Essentially, to use absolutely everything from raw materials - to return nothing to nature, can set it back and damage it because it needs time to regenerate and recover.

Operational principles of circular economy

The term "operating principle in the circular economy" describes and explains how the circular system works, how the parts of the system and the strategy are interconnected. One of the classifications divides the operational principles according to the main goal of each implementation strategy (Suarez Eiroa et al., 2019). In that sense, we are talking about target principles, basic and transversal operational principles.

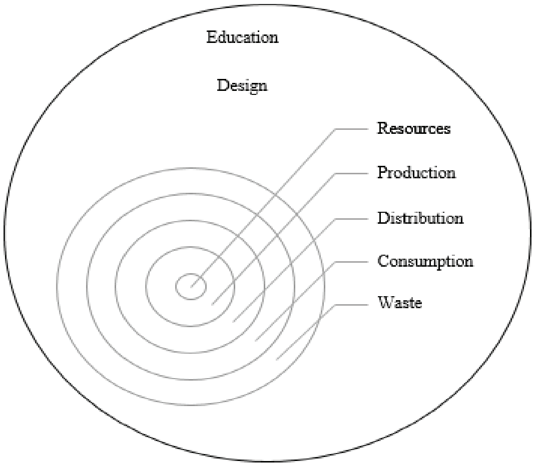
The target principles are a direct link between theoretical goals and practical strategies in the circular economy. The first operational principle of this category - adjustment of inputs (inputs to the system with regeneration rate) is the principle that first divides resources and inputs into renewable and non-renewable. The essential aspiration of this principle is to eliminate the use of non-renewable resources. This is one of the main goals of the circular economy because its postulate is precisely the promotion of renewable energy sources and the use of renewable resources, as well as the reuse of the same materials and raw materials after use. Renewable energy management must respect two rules of sustainable development: first, that the utilization rate is equal to the regeneration rate and, second, that the waste emission rate is equal to the natural assimilation capacity of the environment in which the waste is emitted (Daly, 1990). The second principle - adjusting inputs to the rate of absorption is a principle that considers strategies that eliminate technological waste, and adjust the emission of biological waste to acceptable limits for the ecosystem. All circular economy strategies have this ecological dimension and attitude towards the environment that is socially responsible and sustainable.

Basic operational principles are crucial to achieving theoretical goals and they are able to channel strategies that indirectly adjust the use of inputs with a regenerative rate and waste out of the system to the rate of absorption. One of such principles of circular economy is the principle of closing the system, which aims to connect the phase of waste management with the procurement of resources. It integrates the 3R philosophy of waste management prevention, preparation for reuse, recycling, where the reuse and recycling phase is especially important, which is the focus of this principle (Usapein & Chavalparit, 2014). Certain products or their components can be reused after the end of their useful life, or they can be decomposed into components that can be recycled and reused in the reproduction process. Such a system of work saves energy, resources and leads to increased efficiency in the use of resources and raw materials, which simultaneously protects the ecology and the environment. The principle of maintaining the value of resources within the system by improving the durability of the product or connecting the intermediate phases of the product life cycle through reuse, repair, renovation, overhaul, etc. The principle of reducing the size of the system means reducing the total resources circulating within the system, which is realized by strategies to reduce the total amount of products needed to meet the needs and through the production of sustainable and environmentally friendly products (Heshmati, 2015).

Transversal principles participate in promoting other principles in any circular economy strategy. Within this group, the principle of designing is identified. The importance of this principle is reflected in the fact that a well-designed product can be easily repaired or recycled, and only the promotion of eco-design contributes to the overall success of the company. Another principle from the group of transversals is the principle of education in the field of circular economy, which is necessary for people to understand the importance of economical and rational use of resources, as well as the importance of circular behavior from the consumer's point of view.

The circular economy model, in a rounded way, looks at nine important business elements based on its principles: inputs, outputs, resources, production, distribution and services, consumption, waste management, design and education. In addition, this conceptual solution for presenting the essence of the circular economy is based on two models - 1) the circular economy model, proposed by the European Commission, and 2) the Ellen Mac Arthur Foundation model, which introduces the concepts of technical and biological output. The use of non-renewable resources and the existence of technical waste must be reduced to a minimum (Suarez Eiroa et al., 2019).

Figure 3: Conceptual framework of circular economy



Source: Adapted to Suárez-Eiroa et al. (2019)

The operational principles that support a sustainable and circular economy are derived in a way that enables the adjustment of the flows of the social and economic system to the values that promote sustainable development (Suarez Eiroa et al., 2021). For the construction of a sustainable and resilient socio-ecological system, it is important to apply the principles of sustainability, elasticity and circularity, because all of them lead to the achievement of the desired goals through synergistic action. Sustainability refers to the analysis of production and consumption through the use of inputs and the analysis of the output of the reproduction process, while circularity is related to the retention of resources and materials within the production sustainable process over a long period of time. The resilience of a system is its ability to change and adapt to changes in the environment.

Performance measurement indicators in the circular economy

The subject of expert debate is the question of what should be measured in the circular economy, because different indicators can lead to different conclusions (Moraga et al., 2019). The methodologies and indicators used and considered independently are not able to track all aspects of the circular economy. There is a need for a comprehensive and holistic approach that encompasses the environmental, economic and social dimensions (Jovanović, 2017).

Numerous studies show variation in the number of indicators proposed as relevant for analysis - from one indicator up to 189, while most studies advocate the use of a smaller number of indicators that should not exceed a dozen indicators, relevant to the analysis of performance efficiency in circular economy (Negri et al., 2021). The framework for measuring the performance of the circular economy must be clearly defined to support the business of the organization in all phases of its transition from linear to circular business, and in all phases of development of resources, competencies and levels of awareness and knowledge of the concept of circular economy. Therefore, it is necessary to determine the priority indicators and focus on their use, and over time, with the increase of knowledge and needs, to expand the list.

The performance monitoring framework should contain relevant indicators that can be grouped into four phases of the circular economy: production and consumption, waste management, secondary raw materials, and competitiveness and innovation (Sanchez Ortiz et al., 2020). In addition, the system of indicators is developed according to the level for which it is intended - micro and macro level. At the micro level, companies choose indicators in accordance with the characteristics of the company and the conditions in which it operates. These are usually indicators based on the 3R principle. The macro level involves the selection of indicators that help design and monitor policy at the state level.

According to Pauliuk (2018), the measurement of performance in the circular economy is based on the use of indicators within the control panel, with the help of the BS 8001: 2017 standard. It is a standard that is not certified, but is written in the form of recommendations for the implementation of circular economy (Niero & Rivera, 2018), and implies respect for six principles: 1) systemic thinking, 2) innovation, 3) management, 4) transparency, 5) value optimization and 6) cooperation. Pauliuk (2018) points out the existence of sets of circular economy performance indicators, but is also of the opinion that most indicators are actually a measure of resource efficiency. Based on the available information, the main performance measurement indicators or, in another case, their auxiliary indicators can be used (Sanchez Ortiz et al., 2020): direct use of materials or raw materials, the extent of material loss in key production cycles, share of secondary raw materials in material consumption, share of ecologically certified materials in the use of total materials, time required to dismantle the product, share of recycled materials in new products, total waste in the production process, quality of recycled material compared to the original material, environmental effects and analysis of total costs and benefits of waste management.

Indeed, most indicators relate to the efficiency of resource management because they and their use are the most important aspect of management in a circular economy. From exploitation, through reproduction to waste management, resources are the focus of all important processes because the circular economy has the basic mission of protecting natural resources and energy, in the processes of exploitation and production, while preserving ecosystems and sustainable development.

An important moment of the circular economy is the retention of resources within the system, when the products can no longer be used, but their components and materials are used for recycling and reuse as inputs. With knowledge of the market value of a resource, circularity can be viewed as part of the value of a resource in the form of a percentage that returns after the end of the life of the product. The methodology for measuring resource efficiency depends on the characteristics of resources, ie their use and the impact they have on the environment (Di Maio et al., 2017). The four key categories of resource use include: material use, energy use and climate change, water use, and land use. For these categories of resource use, there are indicators related to the use of resources and their impact on the environment, viewed at the level of domestic demand, but also globally. Economic value is a key parameter for measuring resource efficiency because it reflects both the quantity and quality of resources themselves, so value-based indicators are more efficient in decision-making and policy implementation. In this sense, the professional literature recognizes 16 relevant indicators shown in Table 1 (Behrens et al., 2016).

The indicators from the table with a clear focus on the use of resources look at the use of raw materials, land and water at the level of the domestic economy, but also on a global scale, in order to protect excessive exploitation and use. On the other hand, indicators attach equal importance to environmental protection and measuring the impact on its safety and sustainability during the process of using materials and energy. It is important to follow the data at the level of one economy, but also at the level of the world economy.

Table 1: Indicators for measuring resource efficiency

	Orientation to the use of resources		**Orientation to the impact on the environment**	
	Resources for domestic production and consumption	*Domestic resources in the global context of use*	*Impacts on the environment by the use of resources in the domestic conditions*	*Impacts on the environment in the global context*
Use of materials	Domestic consumption of materials	Consumption of raw materials	Indicator of life cycle of resources in a certain territory - ecologically weighted consumption of materials	Indicator of life cycle of resources - ecologically weighted consumption of materials
Energy use and climate change	Gross domestic energy consumption	Energy footprint	GHG emissions in the domestic territory	Global GHG emissions
Water use	Water consumption	Water footprint	Water exploitation index	Global water exploitation index
Land use	Domestic land demand	Current land demand	Domestic primary production intensity	eHANPP, LEAX and other ecosystem quality indicators

Source: Behrens et al. (2015)

One of the indicators that can be used for this purpose is VRE (Value of Resource Efficiency) indicator. It is a resource efficiency indicator that is harmonized with environmental, social and economic policies. It indicates whether a particular branch or the entire economy is using resources efficiently (Di Maio et al., 2017). It is calculated as follows:

$$VRE = \frac{Y}{\sum i \, WiXi}$$

where Y is the output value, Xi are the resources, and Wi is the environmental impact value. To measure resource efficiency, Wi represents the impact of resource use on the living environment as well as the social implications of resource use Xi. This indicator uses market prices as a known quantity that directly show the demand for resources, which indicates their scarcity or value for the economy. The focus is on non-renewable sources of resources, and the inputs that are in the analysis are energy, raw materials and labor.

Resource management efficiency indicators are of great importance to management as a creator of business strategies because they enable the identification of important parts of the strategy, assessment, monitoring and measurement of resource management. Of course, not all indicators can be used, for practical reasons, but also for the impossibility of perceiving the results of their measurements, as well as monitoring and creating a good information base for all of them.

Due to the existence of a wide range of resources, the difference between them and the fact that they are renewable, non-renewable, toxic or non-toxic to the environment, assessing the efficiency of their use and the use of indicators themselves is a complex task. It is important to identify a couple of indicators that can help assess the performance of the circular economy, especially in the initial stages of development and application of this concept.

Conclusion

The undoubted importance of the circular economy is reflected in the adoption of a new business framework, as well as in the adoption of new principles and rules of conduct that are acceptable to society and nature. The question arises: what would have happened to our society and the world economy if circularity had been known much earlier, if there had been a desire and intention to respect the principles of sustainable development and the principles of circularity? Life would probably be much better, we would breathe cleaner air, have adequate climatic conditions and clean rivers. But, it is good if the world still understands that only with a change in thinking and way of doing business can the existing living and business standard be maintained, albeit disturbed, but with radical changes sustainable in the long run. The most important thing is to understand that waste is actually a resource, a cheap resource that brings both profit for the company and society as a whole.

The circular economy implies responsible management of natural resources and energy sources, respect for the principles of sustainable development, good attitude towards the environment and maximum utilization of the resources that are in use. The benefits of applying this concept are clear - at the micro and macro level and, most importantly, future generations will also benefit from it. The model successfully integrates all basic and important elements of business: inputs, outputs, resources, production, distribution and services, consumption, waste management, design and education. For the four key categories of resource use - material use, energy use and climate change, water use and land use, it is important to have a framework with indicators to measure the performance of these categories at the domestic economy level, but to know indicators showing the global picture of use. Retaining value within the system is a feature of the circular economy, the value passes from one form to another, through a closed system that connects procurement with waste management.

In order to manage something, a way must be found to measure the results of activities, which is why it is important to measure the performance of the circular economy, above all the efficient use of resources and adequate waste management. More efficient business and a positive outcome of measuring indicators that are adapted to the characteristics of the production process and the products themselves, but also the characteristics and types of resources used, allow to conclude whether the application of the circular business concept has positive effects and to what extent it affects society and environment. The indicators that will be in use depend on the activity of the company, the type of resources used, the products that are made from those resources. Therefore, the professional literature suggests the selection of adequate indicators in no more than a dozen, in order to properly respond to the need to report and control the results of performance measurements. Measuring the performance of the circular economy is important to know how society applies this concept, whether and how quickly it changes its old business habits and how socially responsible it is. Companies must start from the micro level of application of the principles and performance measurement, so that in the end, the macro level of analysis itself makes sense and positive changes.

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ЭЕ
ECONOMICS OF SUSTAINABLE DEVELOPMENT

Vol. 6, july-december 2022, № 2
UDK 33+502/504
ISSN 2560-421X

Milica Jovanović Vujatović[1]
Innovation Center,
University of Niš

Jasmina Ognjanović[2]
Faculty of Hotel Management and Tourism in Vrnjačka Banja,
University of Kragujevac

Slavica Popović[3]
University Union Nikola Tesla Belgrade,
Faculty of Applied Sciences Niš

P. 43-51
SCIENTIFIC REVIEW PAPER
10.5937/ESD2202043J
Received: June 30, 2022
Accepted: August 15, 2022

THE ROLE OF ECO-INNOVATION IN SUSTAINABLE INTELLECTUAL CAPITAL OF THE COMPANY

Abstract

Due to the growing concern for the environment and the impact of new technologies on it, companies are asking how to make a profit while respecting the problems of the environment. In this sense, they develop eco-innovations that do not reduce economic performance, but ultimately affect the strengthening of sustainable intellectual capital, sustainable competitiveness of enterprises and greater business efficiency. The goal of this paper is to point out the importance of the development of sustainable intellectual capital in modern business conditions and the role of eco-innovation within this intangible asset of the company.

Keywords: *eco-innovation, sustainable intellectual capital, environmental capital, green intellectual capital, sustainability*

JEL classification: *M21, O31, O34*

УЛОГА ЕКО-ИНОВАЦИЈА У ОДРЖИВОМ ИНТЕЛЕКТУАЛНОМ КАПИТАЛУ ПРЕДУЗЕЋА

Апстракт

Због све веће забринутости за животну средину и утицаја нових технологија на њу, предузећа постављају питање како остварити профит уз уважавање проблема животног окружења. У том смислу развијају еко-иновације које не смањују економске перформансе, већ у крајњем утичу на јачање одрживог интелектуалног капитала, оџиву конкурентност предузећа и већу ефикасност пословања. Циљ рада је да укаже на важност равоја одрживог интелектуалног капитала у савременим условима пословања и на улогу еко-

[1] jovanovicmilicaa90@gmail.com, ORCID ID 0000-0002-6410-0938

[2] jasmina.lukic@kg.ac.rs, ORCID ID 0000-0002-6036-5269

[3] popovic.slavica@hotmail.com, ORCID ID 0000-0003-4985-929X

иновација у овој нематеријалној имовини предузећа.

Кључне речи: *еко-иновације, одрживи интелектуални капитал, зелени интелектуални капитал, еколошки капитал, одрживост*

Introduction

Eco-innovations include new business and management methods, new production processes and new products or services that will contribute to environmental protection. In recent decades, with increasing environmental risks and declining natural resources, there has been growing public concern. Companies are required to become more environmentally conscious. What companies could do in this regard is to ensure a minimal impact of their products on the environment, through a change in the inputs and outputs used, especially product design.

In today's business environment, sustainable business and growth is becoming a key issue. In all of this, the development of sustainable intellectual capital and the development of eco-innovation as components of sustainable structural capital play an important role. Namely, the key aim is to achieve reduction in environmental harm. In order to make progress from environmentally responsible to sustainable development, the previously left out factor - the cost of environmental impact, must be integrated. Taking this cost into account when determining the price of a business activity/project would make many of the activities/projects undertaken today irresponsible.

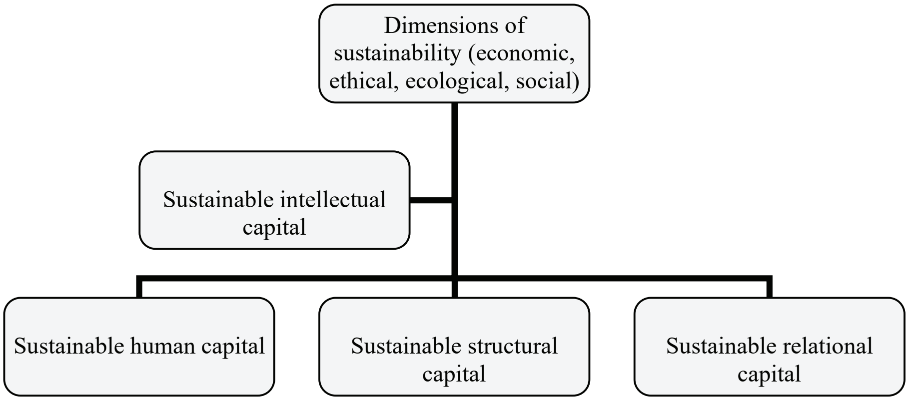
Many companies act as if human capital is still scarce and nature abundant, as was the case during the first industrial revolution. The rapid mechanization of the textile industry at the time caused explosive economic growth that led to a shortage of labor in the factories. However, the pattern of scarcity is changing. Today, labor is "not scarce", but nature is. This is primarily manifested in industries that directly depend on the quality of the environment, given that, unlike traditional factors of industrial production - capital and labor - biologically limiting factors cannot be replaced. Companies addresses these problems by reintegrating environmental and economic goals. The ones that are the first to take a step towards solving these problems will gain a competitive advantage.

The main determinants of sustainable intellectual capital of the company

Different authors (Claver-Cortés et al., 2007; Chen, 2008; Lungu et al., 2013) use different terms to denote the intellectual capital of a company that is focused on solving environmental problems and environmental protection – sustainable intellectual capital, "green" intellectual capital, environmental capital.

Sustainable or green intellectual capital, in the knowledge economy, is becoming a key prerequisite of sustainable growth and development of modern enterprises. This is a consequential precondition for achieving a sustainable competitive advantage of an innovative company. The term is related to intellectual asset that includes knowledge resources aimed at satisfaction of environmental issues (Jovanović et al., 2021).

Figure 1: Integrating the sustainability dimension into intellectual capital



Source: Lungu et al. (2013)

Taking into account the concept of sustainable intellectual capital according to Lungu et al. (2013) - shown in Figure 1, it can be concluded that this is a comprehensive concept. Namely, it includes all dimensions of sustainability - economic, ethical, ecological and social. Sustainable human capital refers to the training of employees and the activities of employees in terms of solving sustainability problems. Sustainable structural capital includes culture, strategy, management process and R&D investment in sustainable business. Finally, sustainable relational capital refers to the company's image/reputation as socially responsible, and its environmental relations.

According to Chen (2008), the concept of green intellectual capital consists of three elements: green human capital, green structural capital and green relational capital. First, green human capital is focused on knowledge, skills, expertise, capabilities, experience, moral values, attitude, creativities of employees and organizational commitment about environmental management. Green structural capital includes organizational capabilities and competencies, knowledge management systems, IT systems, databases, processes, culture, company image and intellectual property related to green innovation. In addition, green relational capital highlights interactive relationships with customers, partners, suppliers and public about environmental protection and green innovation of the company.

Claver-Cortés et al. (2007) points out that environmental capital is a component of intellectual capital of the company and is based on the following elements:

1) Employees – environmental knowledge, skills and experience related to environmental policy and procedures in order to produce minimum impact on the environment,
2) Culture – reputation and image of a responsible and ecological company; environmental commitment of organization and individuals,
3) R&D – innovation capacity for environmental ideas; development of ecological products and cleaner technologies; intellectual property related to environmental issues; investments in ecological processes,

4) Production – products and processes in accordance with environmental regulations; alternative materials and adequate design; cost savings based on waste reduction, material and energy reduction; using clean materials and technology; recycling and reuse,
5) Marketing – possession of the knowledge and capabilities for creating "green consumer behavior".

It can be concluded that the last concept explained is narrower than the previous two.

Eco-innovation in the structure of sustainable intellectual capital of the company

There are various terms used in the literature to describe innovations that have a reduced negative or positive impact on the environment: "green", "eco", "ecological" and "sustainable". The Brundtland report, initiated by the United Nations, used the term "sustainable innovation" for the first time, defining it as satisfying the needs of the present generations, without compromising the opportunity of future generations to meet their own needs. Namely, the concept of sustainable development implies not absolute limitations, but restrictions that impose the modern state of technology and social organization on environment, as well as the capacities of the biosphere to to deal with the effects of human activity (Brundtland, 1987).

Eco-innovation can be defined as the production, assimilation or exploitation of a product, production process, service, management method or business method that is new to the organization and whose outcome is an mitigation in environmental risk, pollution and other negative impacts of resource use compared to relevant alternatives (Kemp & Pearson, 2007). It is any innovation that discourages the use of natural resources and the utilization of harmful substances throughout the life cycle. The growing number of eco-innovative services and products is proof of society's turn towards a circular economy, and the key indicators that monitor progress are: eco-innovation index, investment in research and development, eco-labels and environmental management systems. It is a concept of creating value by spending fewer resources because resources are retained in the value system by producing more durable products, concepts of sharing (instead of owning), reusing. At the end of the product life cycle, materials are not disposed of but enter the recycling process and returned to the production cycle. This concept largely corresponds to the concept of sustainable production and for the purposes of its implementation, eco-innovations are necessary (Matešić, 2020).

The classification of eco-innovation is presented in Table 1 and indicates the structure of green innovations, in order to understand the relationship of these elements with the elements of sustainable intellectual capital of the company.

Table 1: Eco-innovation classification

Environmental technologies	- Technologies for pollution control; - Cleaner technologies (innovative processes aimed at less polluting); - Waste management technologies; - Monitoring of environmental issues; - Technologies for green energy ; - Water supply; - Control of noise.
Organizational innovation	- Pollution prevention systems (substitution of inputs, efficient processes, changes in production plants); - Environmental management systems; - Environmental auditing systems; - Chain management (coordination between organizations to reduce environmental damage across the value chain).
Product/service innovation	- Environmentally friendly material products; - Green financial products; - Environmental services (water management, environmental consulting/testing/engineering); - Services focused on less pollution and resource usage.
Innovations of green system	- Systems of production and consumption that are more environmentally friendly.

Source: Kemp & Pearson (2007)

Bearing in mind that sustainable human capital refers to the knowledge, skills and attitudes of employees considering environmental safety and proper management of environmental problems, the quality and number of green innovations in the company largely depend on the quality of this segment of sustainable intellectual capital. If a company invests in sustainable human capital, employees will be aware and will have enough knowledge/skills and to deal with environmental problems. One of the main factors influencing green human capital is the quality of employees' knowledge of the green economy. This means that skilled human capital will increase the organization's willingness to reap business benefits because a more conscious human resources will have more pronounced skills to deal with environmental issues and, thus, maintain economic performances (Pellegrini et al., 2018). A company with better quality sustainable human capital will have a better chance of success of green innovations (Singh et al., 2020). In addition, human resources are a dominant driver for eco-innovation (Paraschiv et al., 2012).

The connection between eco-innovation and sustainable structural capital can be observed through eco-design or "green" design, which is a type of eco-innovation but is also a segment of sustainable intellectual capital (structural capital) of the company. According to Lewis et al. (2001), designers should have knowledge of the materials characteristics, given that: they can decide on the number of various materials, that they can influence the number of components, that they are included in system design. They identified some main environmental issues that designers should consider when making decisions: problem of global warming; reduction of biodiversity; spending of resources;

water and air pollution; degradation of land; waste issues; the problem of acidification. To create eco-design, designers must strive to minimize material and energy consumption, extend the life cycle of as many products as possible, and provide conditions for the product to be recycled at the end of its useful life.

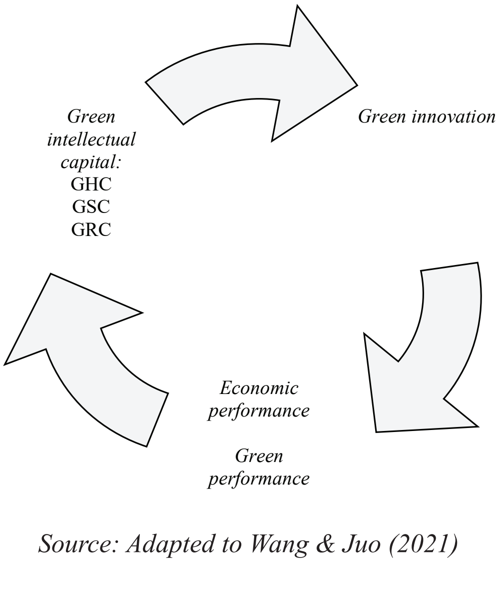
Dickel et al. (2018) consider that sustainable relational capital has a particularly important role in creating green innovations because it allows companies to enter different networks for the exchange of “green” ideas. However, on the other hand, the development of green innovations improves the company’s reputation and creates better relations between companies and their stakeholders - consumers, suppliers, partners, the state, public. This indicates the reciprocal impact of green innovation on the sustainable relational intellectual capital of enterprises.

Eco-innovation in the function of company sustainability

The key drivers of eco-innovation in the company are: financial assets, human capital, R&D costs for the new technologies, current environmental policy, environmental management issues, market demand, competition situation, innovation cooperation, pressure of stakeholders, high-skilled human capital (Kemp & Pearson, 2007).

Figure 2 suggests that the elements of green intellectual capital – green human capital (GHC), green structural capital (GSC) and green relational capital (GRC) affect and create green innovations. On the other hand, green innovations have an influence on economic and green performances of a company. All this positively affects the overall green (sustainable) intellectual capital of the company. This indicates that eco-innovations not only affect the green business of the company - sustainable business in the long run, but also the financial goals of the company.

Figure 2: Green intellectual capital and performance of the company

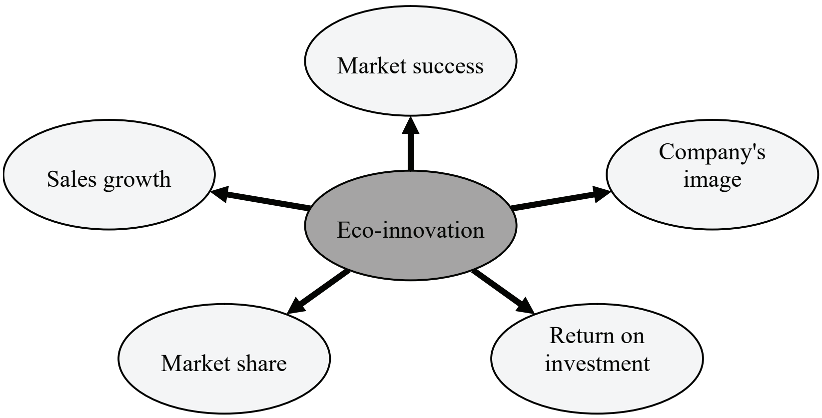


Source: Adapted to Wang & Juo (2021)

It can be concluded that eco-innovation enables innovation processes towards sustainable enterprise development, bearing in mind that it affect the most important areas/problems from the aspect of sustainable development - greenhouse effect, toxic effect on ecosystems, toxic influence on humans, loss of biodiversity, usage of soil, land, resource utilization (Rennings, 2000). It is related to any form of innovation aimed at making significant and visible progress towards the goal of sustainable development, through the reduction of environmental impact or the achievement of more efficient and responsible use of natural resources, including energy (European Commission, 2007).

Various studies (Lewis et al., 2001; Tseng et al., 2013; Bossle et al., 2016) indicate that the application of eco-innovation has a positive effect on certain business performance indicators, as shown in Figure 3.

Figure 3: Eco-innovation and business performance



Source: Adapted to Lewis et al. (2001); Tseng et al. (2013); Bossle et al. (2016)

Lewis et al. (2001) conclude that companies are investing in mitigating their environmental negative impact in order to achieve following sustainable performances:

1) to present themselves as market leaders, corporate responsible and innovators;
2) to avoid surprises in the future - they want to predict a change in the regulatory context and market environment, instead of reacting to changes when they happen;
3) take into account the existence of a new business paradigm and new areas of competition;
4) to have impact on the regulations and laws - in cooperation with governments, they want to ensure their investments;
5) to strengthen the current technical competence and conquer the new fileds of technical competence;
6) to create the positive company’s image in the market.

Conclusion

Businesses today face a number of challenges related to environmental degradation, climate change, rising raw material prices and legal constraints. Therefore, it can be said that, environmental protection is an integral component of the business of modern companies, and the increasingly rigorous requirements regarding the way of doing business are a consequence of the fact that business activities negatively affect the quality of the environment.

The reasons for the introduction of environmental innovations in the company can be divided into internal and external factors. Internal factors refer to specific characteristics of the company - size of the company, the type of the industry, organizational culture, environmental policy of the company, environmental awareness and aspirations of managers. External factors, on the other hand, include environmental policy of the government, constantly rising prices of raw materials and energy, the growth of social awareness, institutional support, relationships with customers and other stakeholders.

Eco-innovations are widely accepted as a method of improving the environmental performance of companies, product improvements and progress towards a more sustainable business model, so their introduction into the company brings many benefits. First, eco-innovation discourages the use of natural resources and harmful substances throughout the product life cycle. They make the best use of all types of waste generated in industry, conserve energy and contribute to the preservation of biodiversity. Also, eco-innovations lead to the creation of products that are suitable for similar products offered on the market, but their production requires the consumption of a smaller amount of natural resources and energy. As such, eco-innovation is an integral part of a successful transition to a green economy.

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Vol. 6, july-december 2022, № 2
UDK 33+502/504
ISSN 2560-421X

Milica Vuković[1]
Faculty for hotel management and tourism–Vrnjci spa,
University of Kragujevac

P. 53-62
SCIENTIFIC REVIEW PAPER
10.5937/ESD2202053V
Received: June 30, 2022
Accepted: August 15, 2022

THE APPLICATION OF GIS IN SUSTAINABLE TOURISM MANAGEMENT

Abstract

The direction of future development of tourism destinations has been determined by market trends, including a need to preserve natural and anthropogenic resources. Considering previously mentioned, this research paper presents Geographic Information Systems (GIS) as an innovative approach of managing sustainable tourism. In this regard, the subject of the paper is to determine if GIS has positive impacts on sustainable tourism management. The paper is based on academic publications from different scientific disciplines: tourism, sustainable management and information technology (IT). Research outcome validated the primary hypothesis, which indicated that GIS application could be beneficial for decision-making process in sustainable tourism. The importance of the research results is reflected as a contribution to theoretical foundation for sustainable tourism, as well as a determination of its' innovative perspectives as a smart sustainable tourism.

Key words: geographic information systems (GIS), sustainable tourism, innovation, technology

JEL classification: Z32

ПРИМЕНА ГИС-А У МЕНАЏМЕНТУ ОДРЖИВОГ ТУРИЗМА

Апстракт

Правац будућег развоја туристичких дестинација обликован је прилагођавањем трендова на тржишту, уз потребу очувања природних и антропогених атракција. Имајући у виду наведено, истраживачким радом је представљен иновативан приступ коришћења географских информационих система (ГИС) за управљање одрживим развојем туризма. Циљ овог рада је утврдити да ли употреба ГИС-а има позитиван утицај на менаџмент одрживим туризмом. У изради рада доминирају секундарни подаци из академских публикација у области туризма, менаџмента одрживог развоја и информационих технологија (ИТ). Резултати рада потврдили су почетне хипотезе, при чему је установљено да постоје користи од коришћења ГИС-а у процесу доношења одлука за потребе одрживог развоја туризма. Допринос овог рада огледа

[1] milicapopovic.hit@gmail.com, ORCID ID **0000-0002-5157-902X**

се у проширивању теоријског оквира одрживог туризма, као и утврђивању иновативних перспектива његовог развоја.

***Кључне речи**: географски информациони системи (ГИС), одрживи туризам, иновације, технологија*

Introduction

Research on sustainable tourism has been done over the last 30 years extensively (Hunter, 1995; Hardy et al., 2002; Ritchie & Crouch, 2003; Liu, 2003; Pigram & Wahab, 2005; Lu & Nepal, 2009; Miller et al., 2010; Harris et al., 2012; Higgins-Desbiolles, 2018; Streimikien et al., 2021). Studies have also made a connection between sustainable tourism and information technologies (Hjalager, 1997; Yaw, 2005; Ali & Frew, 2010; Alie & Frew, 2014; Gossling, 2020; Fernell, 2021), although Liu (2003) points out that "sustainable tourism debate is patchy, disjointed and often flawed with false assumptions and arguments" (pp. 459). Nowadays, the emergence of the smart tourist destinations has given rise to new prospects for achieving the necessary tourism sustainability. This resulted in interchange of traditional concepts of tourism and sustainability, which now include long-term planning, innovation and cooperation (Ribe & Baidal, 2018).

Increased development of tourism destinations and growing number of tourists have caused numerous negative effects, which Jordan et al. (2019) ranged from increased traffic and crowding to increased cost of living or environmental degradation. Su et al. (2018) pointed out that negative environmental impacts might result in diminished sense of residents' wellbeing and security. These concerns have led to development of numerous methods (Lu & Nepal, 2009; Molina-Azorin & Font, 2016) for their prevention, including technology use. If effectively implemented, IT could affect tourists' attitudes and following intentions toward environmental preservation (Tan & Law, 2016).

In order to have a successful spatial modeling and analysis for sustainable tourism purposes, it is necessary to make use of location-based systems such as GIS, which are known as as the most efficient technology for this tourism management approach (Longley et al. 2015; Omardadeh et al., 2021). Some destination management organisations have already used GIS, but primarily for charting tourist movements and routes during their stay in the tourism destination (Ali & Frew, 2013). Considering the facts above, developing GIS model for sustainable management could be benefitial for preservation of tourism resources and tourists' loyalty, which will result in long-term sustainability and profitability.

With regards to the facts mentioned above, this research paper is based on two hypotheses:

Hypothesis 1: GIS application by Destination Management Organizations has positive impacts on sustainable tourism development.

Hypothesis 2: GIS application by Destination Management Organizations has positive impacts decision-making process in sustainable tourism.

Methods

Relating to the subject and the main goal of the research, the paper is based on secondary data research of academic publications in subsequent scientific disciplines: tourism, sustainability management and ICT.

Based on the information collected, the results of the research were presented in detail in two steps:

1. GIS usage for development of sustainable tourism: Literature review
2. GIS based sustainable tourism development: Case studies

Gis usage for development of sustainable tourism: literature review

Emerging tourist market trends are conditioning destinations to change and adapt, accepting sustainability as one of the main developmental focuses. According to Amerta et al. (2018) sustainable tourism development can be achieved if the usage degree of different resources does not exceed beyond their regeneration capacity. Besides, the quality of decision regarding sustainable tourism depends on the accessibility and the reliability of the information about the resources being managed. The flow of information between stakeholders is essential if the primary goal is to manage resources in a sustainable manner (Latu, 2009). Thus, sustainable tourism development must be based on combining GIS and spatial decision-making tools that can serve as decision support systems (Jokar et al. 2020). In other words, sustainable tourism has to be developed in a organized approach where GIS is thought about as a suitable framework for land suitability (Jokar et al., 2021) and decision-making for future land-use planning (Malczewski and Rinner, 2015).

Bahaire & Elliot-White (1999) were one of the first researchers to point out a role of GIS in investigation of environmental conditions, assessment of site suitability for planned development and identification of conflicting interests. Besides them, few authors have studied GIS and its application in sustainable planning process. Aminu et al. (2013) have proposed an integrated use of GIS, ANP and Water Quality Index (WQI) for sustainable tourism planning. Patwal (2013) have suggested GIS-supported sustainable tourism infrastructure planning approach (STIP), which is focused on creating a sustainability dimensions' package (i.e., corresponding to development goals, favorable tourists' experiences etc.) in GIS based tourism planning.

Considering these different approaches of GIS usage in sustainable tourism development, it could be concluded that the role of GIS is crucial in this process. GIS can be used for analysis, planning and monitoring of indicators, conflicts leading to the identification of optimum locations for tourism development (Kyrıakou et al., 2017). Further, many authors have presented capabilities of GIS related to tourism sector, namely tourism resources inventories, identifying optimal locations for development, measuring tourism effects on natural resources, analysing relationships associated with resources use, and evaluating potential positive or negative results of tourism development (Bahaire & Elliott-White, 1999; Farsari & Prastacos, 2004; Miller, 2008; Albuquerque, 2018). In addition, Cvetković & Jovanović (2016) pointed out the significance of GIS usage for the analysis for master planning in sustainable tourism, which is used worldwide to prepare regions for development and growth. GIS-driven master plans can track the environmental impacts of tourism and will most likely be increasingly crucial for destinations experiencing rapidly growing tourism demands.

Besides the fact that sustainable tourism includes environmental protection, it also incorporates social and economic aspects of the surrounding living conditions and tourist areas (Janusz & Bajdor, 2013), which means that GIS could be used for improved waste management, energy monitoring, information comparison and integration and fostering better decision–making (Ali & Frew, 2014). This complex process of making decisions in order to solve key issues for sustainable tourism could be facilitated by enabling easily available and concise information. With this information attainable to them, destination managers could focus on practising sustainable tourism management. Using technology for sustainable tourism will enhance communication between tourists and tourism organizations by building platforms where every stakeholder could exchange information on sustainable tourism questions (Ali & Frew, 2013).

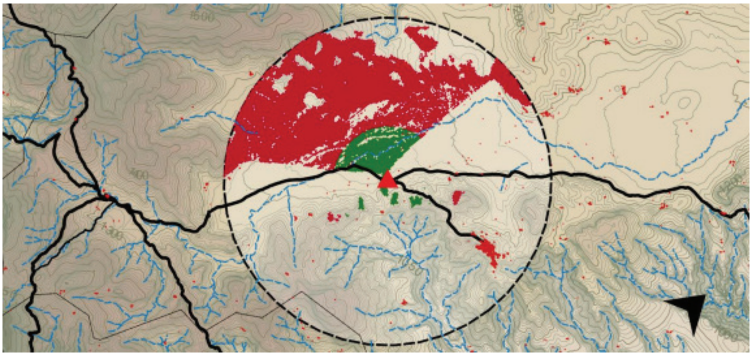
Having this in mind, it is essential to respond to the requirements of those interested groups in order to successfully plan and implement tourism strategies (Hall, 2008; Rasoolimanesh et al., 2020). Sustainable tourism needs to address several issues, including: environmental protection and financial health, guest satisfaction and promotion of community well-being (Hardy & Pearson, 2018; Amerta et al., 2018; He et al., 2018; Chan et al., 2020). Thus, it is of great importance for these stakeholder groups to accept and implement GIS, as a tool for accomplishing sustainable tourism goals.

Gis based sustainable tourism development: case studies

The research of GIS apllication in sustainable tourism development, although not detailed enough, has been done during the last decade. Several examples of GIS usage in sustainable tourism are given in this chapter of the review paper. In addition, the examples emphasise the need of further research in this area, as it could be valuable for sustainable development of tourism in the future.

García-Esparza and Altaba used GIS to analyze Vistabella del Maestrazgo, Spain and identified landscape areas of tourism value (presented in green) and surroundings (presented in red). In addition, they fragmented these areas considering their historical, cultural, etnographic and intangible values. The fragmented areas are located in the green area, as shown in the Picture 1.

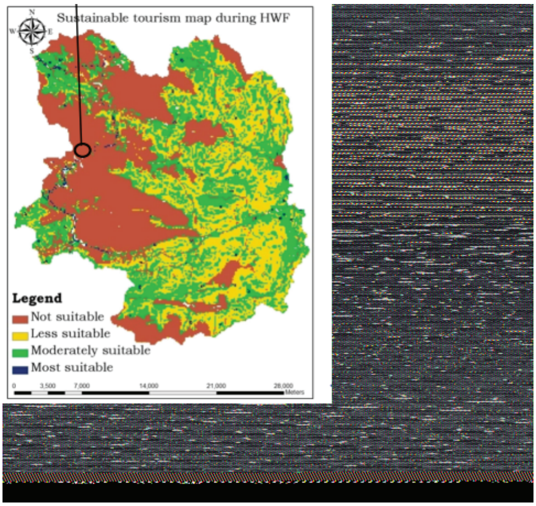
Picture 1: GIS presentation of tourism valuable areas in Vistabella del Maestrazgo, Spain



Resource: García-Esparza & Altaba (2018)

Ghorbanzadeh et al. (2019) used fifteen geographical factors grouped in four clusters: water attractions, forest attractions, mountain attractions and scenic spots in Iran. These four layers, presented in GIS, were used for identification of the most visited tourism sites (presented in red) and areas with no tourism value (presented with dark blue). This research could be used for further identification of sustainable tourism sites and their categorization by the level of sustainable significance (economic, social and environmental).

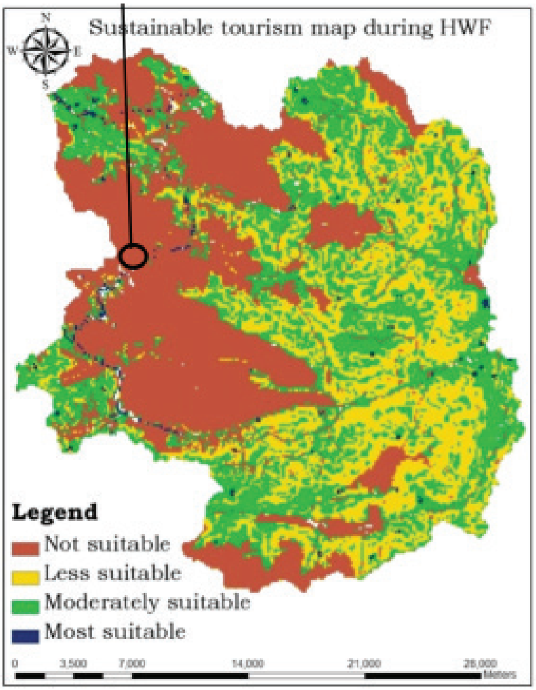
Picture 2: Mapping potential nature-based tourism areas by applying GIS-decision making systems in East Azerbaijan Province



Resource: Ghorbanzadeh et al., (2019)

Aminu et al. (2017) identified areas in Cameron Highlands (Malaysia) for sustainable tourism development, which are mostly areas that are less sensitive to human interference - that occupy only 0.57% (presented in blue). They have also distinguished constraint areas, which are areas that would be conserved from tourism and related sustainable development (presented in red).

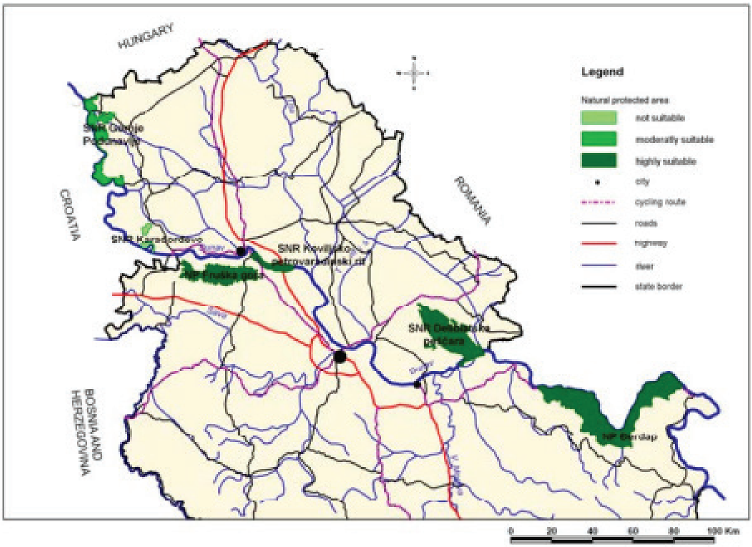
Picture 3: Analytic network process (ANP)-based spatial decision support system (SDSS) for sustainable tourism planning in Cameron Highlands



Resource: Aminu et al., (2017)

GIS analysis of sustainable tourism locations in Serbian Danube region has been done by Stojković et al. (2015). The research showed the most suitable protected natural areas for sustainable development: Fruška Gora National Park and Đerdap National Park, as well as the Koviljsko-Petrovaradinski Rit Special Nature Reserve and Deliblatska Peščara Special Nature Reserve, moderately suitable location - Gornje Podunavlje Special Nature Reserve, and the only unsuitable location - Karađorđevo Special Nature Reserve.

Picture 4: Application of multi-criteria analysis and GIS in ecotourism development



Resource: Stojković et al., (2015)

Conclusion

With increasing tourist arrivals and their negative impacts on tourism resources (both natural and anthropogenic), it has become crucial to sustainably develop tourism. Although the area of sustainable tourism has been researched, there are still unexplored areas and approaches. In order to broaden strategic knowledge of tourism sustainability, it is necessary that the stakeholders implement GIS in sustainable tourism management.

Four case studies (García-Esparza & Altaba Tena, 2018; Ghorbanzadeh et al., 2019; Aminu et al., 2017; Stojković et al., 2015) have been presented in the research in order to determine different solutions of GIS usage in sustainable tourism. These approaches are based on analyzing developed or undeveloped tourism destinations in order to determine suitable and unsuitable areas for tourism development.

The research showed that GIS could be used for identifying the most suitable locations for sustainable tourism development and those locations that are unsuitable for this type of tourism. GIS could be also used for measuring tourism impacts on natural and anthropogenic resources and analysing relationships associated with resources use. Authors have also suggested using GIS for master planning of sustainable tourism and, improving waste management and energy monitoring. These facts confirmed confirmed primary hypotheses that GIS application has positive impacts on decision-making process in sustainable tourism and overall – on its' development.

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ECONOMICS of Sustainable Development =
Економика одрживог развоја / editor-in-chief
Zoran Simonović. - Vol. 5, br. 1 (2021)- . - Niš :
Society of Economists "Ekonomika", 2020 - (Niš :
"Medivest"). 68 стр. - 24 cm

Dva puta godišnje.
ISSN 2560-421X = Economics of Sustainable
Development