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Sustainable development progress and challenges - Modelling SDG's based on the income level in European countries

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Abstract: Sustainable Development Goals (SDGs) present a global framework for balancing the economy, society and environment. These are management tools for national, regional and global sustainable development planning and programming until 2030. The efforts to improve sustainable development data should be aimed at fostering innovation in SDG monitoring and modelling. Identifying inter-relationships between the 17 SDGs is crucial to managing them effectively and achieving sustainability. This study aims to explore the structure and interlinkages between the SDGs and determine the SDGs that significantly differ between groups of European countries depending on their income level. The dataset was created based on the European Sustainable Development Reports from 2017 – 2022 and World Bank open data. It was processed using the principal component analysis/factor analysis (PCA/FA) and discriminant analysis (DA). PCA of the data sets yielded five Principal Components with Eigenvalues > 1 , accounting for 81,57% of the total variance. Results indicate that specific social and economic indicators mostly determine the success of European countries in implementing sustainable development concepts. Also, there are notable synergies between SDGs, especially when it comes to the socio-economic dimensions. Conversely, important potential trade-offs with environmental-related SDGs are identified. The findings revealed that a higher level of economic development leads to greater success in implementing the general concept of sustainability. Lower-income countries are more advanced regarding the SDGs that fall under the environmental dimension – responsible consumption and climate change. The discrimination goals of responsible consumption and partnership for goals indicate clear differences between two groups of countries and can undermine progress toward sustainable development in high-income countries. It implies that socio-economic goals are prioritised over environmental ones when achieving sustainable development.

Keywords: Sustainable Development Goals, Income level, European countries, Principal Component Analysis, Discriminant analysis

1 Introduction

Sustainable development is a fundamental concept of the contemporary world. This concept has a central place in considering the long-term perspective of the survival and progress of humanity. Sustainability, or sustainable development, is an essential prerequisite and the ultimate goal of human activities on Earth. The Brundtland Commission Report defines it as "*the development that allows meeting the needs of current generations without compromising the ability of future generations to meet their needs*" [1]. Sustainable development means striking the perfect balance between economic growth, social progress, and environmental protection. It can be seen as the intersection of three dimensions: social, economic and ecological. In the past few decades, socio-economic and environmental challenges have posed significant obstacles to the discourse on sustainable development. Climate change, environmental degradation, rapid economic development, growing human population, and the global pandemic of COVID-19 are the phenomena that have hindered the successful implementation of the concept of sustainability to the greatest extent [2-5]. As a result, sustainable development has become a burning issue among scientists, global institutions and the wider community.

To improve the understanding and management of the entire concept, in September 2015, the UN General Assembly adopted the resolution titled "Transforming our World: the 2030 Agenda for Sustainable Development", known as "Agenda 2030". This report specified the modern approach that provides a comprehensive and multidimensional view of development through the Sustainable Development Goals (SDGs) (Table 1). The topics of these goals cover five critical areas (the so-called 5 P's) - People, Planet, Prosperity, Peace, and Partnership [6]. SDGs are multilevel indicators directly linked to the components of sustainable development that should be pursued until 2030. The series of 17 goals is determined by 169 targets and aimed at supporting nations to achieve economic, social and environmental balance [7-11]. By addressing all dimensions, the goals built a universal, holistic framework for helping set humanity on a sustainable development course.

SDGs, targets, and indicators serve as a management tool to direct governments in creating implementation strategies and allocating resources. These monitor progress toward sustainable development at local, national, regional, and global levels. Successful policy-making and implementation require a series of efforts rather than individually focused SD paradigm initiatives, e.g. environment, society, or economy [12]. Given the multidimensionality of sustainable development goals, policymakers should be able to integrate economic, social and environmental components into a long-term strategy. Therefore, observing and analysing the SDGs as a group, not separately, is necessary. To reach the SDGs, governments and civil society need to set action priorities, detect significant implementation issues, analyse progress, enforce accountability, and identify gaps that must be filled. Therefore, a greater understanding of this issue is needed [13].



Figure 1
Sustainable Development Goals (Source: www.un.org/)

The SDGs defined within the Agenda represent a broad multinational attempt to redirect the world towards more sustainable and resilient directions while satisfying the needs of developing countries [14]. Achieving the SDGs requires implementing fundamental changes in each country and investing significant efforts in monitoring and measuring progress [15]. Agenda 2030 highlighted a need for urgent global action and cooperation between developed and developing countries.

The subject of this paper is modelling sustainable development goals to create guidelines for effective strategies and managing the concept of sustainable development at the European level. The aim is to recognize the problems in achieving sustainable development goals in European countries. Specific goals are: i) to define the most important SDG challenges in European countries depending on their development level; ii) to define the pattern of SDG structure in Europe that drive the overall SDG score; iii) to define SDGs that differentiate European countries according to their development level. These goals are pursued in the following sections. Section 2 consists of the literature review in the field of SDGs and their interlinkages, as well as the types of modelling techniques that are most frequently used. In Section 3, the study area and the methodological approach are presented. In Section 4, the obtained results of the proposed model were displayed and discussed in Section 5. Finally, Section 6 highlights the main conclusions of the research and the limitations and directions for future studies in this field.

2 Literature review

A bibliometric analysis of scientific papers on the SDGs reveals that most studies (31%) are conducted by authors from the USA, China, and the UK and concentrated in developed countries [16,17]. Research databases related to SDGs indicate that

natural and engineering sciences were more prominent than social sciences [16]. Studies focused on SDGs are mostly dealing with the specific SDGs rather than the SDGs as a unified and interrelated framework outlined in the UN resolution [18-24]. At the same time, most studies deal with SDG 3 - Good health and well-being, while SDG 7 - Affordable and Clean Energy is the second [25]. However, system thinking is essential in studies on sustainable development and the SDGs [16].

Interdependencies, conflicts, and links between the SDGs require systemic thinking that incorporates the spatial and temporal interconnection of the SDGs, demanding multidisciplinary skills [13]. A significant positive correlation between SDG indicators is classified as a synergy, while a significant negative correlation is classified as a trade-off [26]. Spreading knowledge about synergies in sustainable development is important for enabling progress toward the SDGs and saving substantial resources [27]. Through various studies, researchers have investigated the relationships between the SDGs but have come to different conclusions [28]. In a study by Lusseau and Mancini (2019), they referred to the networks of SDG interactions as sustainomes [29]. Their study aimed to identify the obstacles and opportunities for achieving the SDGs through their interactions. They found that limiting climate change, reducing inequalities, and responsible consumption are significant hurdles to achieving the 2030 goals. However, focusing on poverty alleviation and reducing inequalities can accelerate the achievement of all SDGs. Dawes (2022) developed mathematical models to quantify the level of interlinkage networks that predict higher progress on particular SDGs than others [30]. The results showed that the impacts of other SDGs on goals 1-3 are more frequent than influences on later goals, and goals 6 and 7 are more dominant than the others. Scharlemann et al. (2020) concluded that environmental and environmental-human relations cause most interactions between SDGs [28].

The literature is still in the evolutionary stage in identifying the importance of social, economic and environmental sustainability indicators for more effective achievement of the SDGs [12]. However, in most of the previous studies, the fact that the interactions between the SDGs depend on the socio-economic characteristics of the countries has yet to be taken into account. A potential limitation of the SDGs is the need for more distinction between developed and developing countries [31]. For this reason, determining the spatial patterns of sustainable development and defining the factors that influence the success of establishing a balance between economic, social and environmental conditions are priority tasks by which the pursuit of maintaining development can be harmonised with the environmental conditions. In the work of the author Koehler (2016), it was pointed out that the SDGs can improve gender and climate justice [32]. According to some studies, performance in different SDG areas shows dependence on the income and geographical location of individual countries [29, 33-35]. Also, the SDGs can be used as a measure of sustainable well-being that can motivate and guide the process of global social change [36]. The availability of renewable energy

sources to the population in rural areas significantly contributes to achieving the SDGs in developing countries [37,38].

The efforts to improve sustainable development data should be aimed at fostering innovation in SDG monitoring and modelling. Attempts to clarify SDG relationships using different methodologies are not negligible. However, policy-relevant modelling of sustainable development remains a challenge [39]. Authors Nilsson et al. (2016) developed a methodology for determining the interactions between the SDGs applicable at all levels – between goals and targets and global and national policies [40]. They rated seven possible types of SDG interactions from the most positive (scoring +3) to the most negative (scoring -3). Still, there is a lack of distinct modelling methodologies and model types that satisfy all the analytical requirements imposed by the new SDGs [39]. Many approaches remain complicated, time-consuming, and unintegrated [41]. Jayaraman et al. (2015) used a multi-criteria decision-making model to achieve SDGs by efficiently allocating resources [42]. Allen et al. (2016) defined contemporary modelling tools' positive and negative features and identified gaps in national sustainable development planning [39]. They found that scenario analysis and quantitative modelling are important analytical tools and have multiple benefits in developing national strategies towards achieving SDGs. Asadikia et al. (2022) applied the Gradient Boosting Machine algorithm to identify the top five SDGs that drive the overall SDG score [35]. Grochová Ladislava & Litzman (2021) used the non-parametric method of Data Envelopment Analysis to assess the level of the achievement of SDGs and evaluate the countries' progress [33]. Jabbari et al. (2020) attempted to develop a model based on the SDG index to cluster and differentiate the countries of different SD levels using non-hierarchical clustering, known as the K-means method [31]. Authors Cao et al. (2023) modelled SDGs to evaluate the causality and strength among them [43]. They constructed 1302 connections using the spatio-temporal geographically weighted regression method.

Studying the possibility of applying statistical methods in monitoring and managing sustainable development is increasingly intensive. However, further research is needed to evaluate the benefits and drawbacks of various modelling techniques [39]. To overcome this gap, the author of this study will examine the effectiveness of selected multivariate statistical techniques for modelling sustainable development goals. Multivariate statistical techniques such as Principal Component Analysis (PCA), Factor analysis (FA) and Cluster analysis (CA) have multiple benefits. The method of multivariate analysis used to reduce the data set dimensionality while keeping the maximum possible variability is called the method of principal components (PCA -Principal Component Analysis). Of all factor analyses, PCA is the most commonly used. The method of principal components was developed by Hotelling in 1933 [44]. In addition to reducing dataset dimensionality, the method of principal components is a tool of analysis by which hypotheses about the studied phenomenon are generated. PCA efficiently deals with multi-collinearity in the data as a non-parametric approach by generating factor variables [12]. This technique

converts extensive interrelated variables into independent (orthogonal) variables. In this way, the number of variables is reduced, and with a slight loss of information, it represents the same amount of variance. PCA/FA usefulness proven in the modelling of sustainable development indicators in manufacturing [45], energy [46], water management [47], international food trade [48], air quality [49], etc. According to Kwatra et al. (2020), these analyses can determine the relationships between variables, the existence of a balance between different dimensions of sustainability, classify voluminous information into data sets that can be managed and share information about composite indicators with the possibility of simultaneous monitoring of individual ones [50].

The novelty of this research consists of the multivariate analysis of the interlinkages across the SDGs in European countries and the recognition of the SDGs that significantly differ between countries depending on income level. For this purpose, principal component analysis/factor analysis (PCA/FA) and discriminant analysis (DA) were used. Based on the results, it will be possible to identify fields that require additional engagement and create guidelines to accelerate SD progress.

3 Experimental

3.1 Data set

In July 2016, The Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN) jointly, founded the initial SDG Index and Dashboards with data from 149 of 193 UN member states. Annual SDG reporting is based on high-quality data from all countries and presents a quantitative assessment of the level of SDG achievement. The Report includes the SDG Indices for each goal individually and overall SDG Index. The scores are presented on a scale of 0 to 100, with zero denoting the worst performance and hundred describing the best performance in SDGs achievement. The total SDG Index has been listed among the ten composite indices useful for policymaking by the European Parliamentary Research Service. The data set used for the defined research objectives was created using the database published in the European Sustainable Development Reports from 2017 - 2022 [51]. The statistical packages SPSS v.21 and Statistica v.13 were used in their processing.

3.2 Study area

Regional monitoring and accountability ensure regional collaboration and coherence in SDG-related policies. The European Union is recognised as a global leader in improving sustainable development given that European Commission requires its members to adhere to several legal measures that uphold the principle of sustainability.

Given the assumption that the performance in the SD depends on the individual countries' income, the European countries are separated into two groups using the World Bank classification according to the income level – upper middle income (GNI3) and high income (GNI4) countries (Table 2). The GNI per capita is the dollar value of a country's annual income divided by population [52]. It should reflect the average pre-tax income of a country's population. GNI is a useful indicator of the country's economic strengths and the general standard of living experienced by the citizens. The GNI per capita correlates with many other indices that measure the country's and its people's social, economic, and environmental well-being. Based on the insight into the division according to GNI, it can be seen that the countries of the GNI3 group, except for Bulgaria, are not EU members, while the GNI4 group consists only of EU member countries.

Upper middle income countries – GNI3	High income countries – GNI4	
Albania	Austria	Italy
Armenia	Belgium	Latvia
Azerbaijan	Croatia	Lithuania
Belarus	Cyprus	Malta
Bosnia and Herzegovina	Czech Republic	Netherlands
Bulgaria	Denmark	Norway
Georgia	Estonia	Poland
Montenegro	Finland	Romania
Moldova	France	Slovak
N. Macedonia	Germany	Slovenia
Serbia	Greece	Spain
Turkey	Hungary	Sweden
Ukraine	Iceland	Switzerland
	Ireland	United Kingdom

Table 2.
Analysed countries and their grouping according to the GNI

3.3 Methodology

3.3.1 Principal Component Analysis/Factor Analysis

Principal component analysis (PCA) is mathematically derived from the covariance matrix, which explains the dispersion of multiple measured parameters by adding eigenvalues and vectors. The covariance matrix (K_s) is calculated by taking the mean values of each column from each variable and scaling the columns. The resulting output is the extraction of new orthogonal variables called principal components (PC's). They represent a linear combination of the original variables and provide maximum variance. In order to obtain the simplest and most effective

presentation of the principal factors, it is recommended to perform the rotation of the axis of the principal components, which leads to the creation of new groups of variables called varifactors (VFs). This procedure is commonly known as factor analysis (FA). In an attempt to explain the correlation between observations of underlying factors that are not directly observable, FA is used in addition to PCA analysis. The most important difference between PC and VF is reflected in the fact that PC represents a linear combination of observed variables, while VF can take into account latent, hypothetical variables.

3.3.2 Discriminant analysis

Discriminant analysis (DA) is a multivariate technique applied to classify observed variables into one or two alternative groups based on a specific set of measurements. This analysis can also be used to determine the variables that contribute to the classification. One of its tasks is to graphically or algebraically describe the differential features between observations of different sets. Therefore, DA can have predictive and descriptive roles. Stepwise discriminant analysis is used when the researcher has no reason for assigning some predictors higher priority than others. In this research, a linear "stepwise" method, characterised by Mahalanobis's distance measure, was applied. The result of training data classification is summarised by comparing the obtained and predicted grouping. The effectiveness of the discrimination functions can be confirmed using the cross-validation method, which determines the degree of predictability of the observed sample from which the model was created. Also, the effectiveness can be confirmed with a new data set that is used together with the cross-validation model to evaluate the performance of the set functions.

4 Results

The initial step in this study was to conduct the descriptive statistics by country groups GNI3 and GNI4. Mean values of indicators of progress towards sustainable development goals are presented in Table 3.

	Group of country			
	GNI3		GNI4	
	Mean	Std.dev.	Mean	Std.dev.
SDG1 (No poverty)	96.91	4.789	99.37	.565
SDG2 (Zero hunger)	62.10	6.801	66.57	5.326
SDG3 (Good health and well-being)	78.40	3.660	91.62	4.334
SDG4 (Quality education)	84.27	11.307	96.37	3.926
SDG5 (Gender equality)	59.70	9.598	78.08	9.111
SDG6 (Clean water and sanitation)	72.25	5.707	83.30	10.480
SDG7 (Affordable and clean energy)	73.78	4.999	80.26	8.501
SDG8 (Decent work and economic growth)	71.77	6.161	82.48	4.367
SDG9 (Industry, innovation and infrastructure)	52.30	10.364	84.80	9.467
SDG10 (Reduced inequalities)	77.02	16.952	89.49	9.312
SDG11 (Sustainable cities and communities)	77.96	5.374	88.88	5.185
SDG12 (Responsible consumption and production)	80.44	5.627	56.59	10.744
SDG13 (Climate action)	86.61	6.159	65.88	13.829
SDG14 (Life below water)	62.22	12.784	70.06	10.840
SDG15 (Life on land)	72.79	13.818	82.11	10.115
SDG16 (Peace, justice and strong institutions)	69.60	5.512	82.35	7.608
SDG17 (Partnerships for the goals)	72.00	8.691	62.63	12.529
Total SDG Index	73.81	2.469	80.14	3.019

Table 3.

Descriptive statistics of SDGs indicators for groups of countries for the period 2017-2022

The results of descriptive statistics indicate that the mean value of the total SDG score for the monitoring period is lower in the GNI3 group of European countries (73.81) compared to the GNI4 group (80.14).

4.1 Data structure and the identification of the dominant SDGs

To examine the reliability of the data set for the PCA/FA, Bartlett's sphericity and the Kaiser-Mayer-Olkin (KMO) tests were conducted. The high value (close to 1) of the KMO measure of adequacy indicates that the PCA/FA is useful. In this study, the KMO value is 0,747 (Table 4). This confirms the validity of the obtained PCA/FA analysis. Bartlett's sphericity test with a significant level of 0 in this case (<0.05) indicated that there are significant relationships among the variables (Table 4).

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.747
Bartlett's Test of Sphericity	Approx. Chi-Square	2902.180
	df	136
	Sig.	.000

Table 4.

Bartlett's Test and Kaiser-Mayer-Olkin coefficients

After testing the validity of the data set, principal component analysis and factor analysis (PCA/FA) were performed. In doing so, normalised values of the entire data set were used simultaneously for all analysed countries. The PCA of the data sets yielded five PCs. The Principal Components with Eigenvalues >1 account for 81,57% of the total variance. Liu et al. (2003) classified the factor loadings as "strong", "moderate", and "weak", corresponding to the absolute loading values of >0.75, 0.75–0.50 and 0.50–0.30, respectively [53]. The variable loadings and the explained variance of SDGs are presented in Table 5. Also, the strong and moderate loadings are highlighted in the following table. The PCA/FA analysis extracted a satisfactory number of the parameters with the moderate and high loadings of every varifactor. This confirms that it is feasible to identify the SDGs that correlate to each other and the groups of SDGs that mostly determine the progress towards sustainable development.

	VF1	VF2	VF3	VF4	VF5
SDG_1	.250	.125	.153	-.048	-.826
SDG_2	.013	.273	.846	-.144	-.247
SDG_3	.859	-.149	.329	.016	-.167
SDG_4	.752	-.111	.113	-.293	.429
SDG_5	.887	.052	.244	.141	.061
SDG_6	.281	.316	<u>.608</u>	.205	.406
SDG_7	.493	.113	-.217	<u>.600</u>	.238
SDG_8	<u>.599</u>	.486	.433	-.081	-.113
SDG_9	.814	-.046	.493	.085	-.108
SDG_10	<u>.705</u>	.183	-.025	.123	-.079
SDG_11	.785	.269	.181	-.041	.195
SDG_12	-.901	-.029	.101	.005	.318
SDG_13	-.823	-.087	.067	-.143	.247
SDG_14	.054	.902	.153	.095	-.026
SDG_15	.103	.767	.182	-.384	-.104
SDG_16	.863	.225	-.028	.251	.057
SDG_17	.051	-.170	.063	.909	-.047
Eigenvalue	6.860	2.075	1.877	1.628	1.427
% Total variance	40.352	12.208	11.040	9.577	8.397
Cumulative % variance	40.352	52.560	63.600	73.177	81.573

*Bold and underlined values indicate strong and moderate mean values, respectively

Table 5.

The factor loadings value and explained variance of SDGs

The sustainable development in Europe is mostly determined by five varifactors (VF). The VF1 explains 40.35% of the total variance. This VF is characterised by the strong positive loadings of SDG3 (0.859), SDG4 (0.752), SDG5 (0.887), SDG9 (0.814), SDG11 (0.785) and SDG16 (0.863) and strong negative loadings of SDG12 (-0.901) and SDG13 (-0.823). The moderate positive loadings are present in the case of SDG8 (0.599) and SDG10 (0.705). These results indicate the predominant social-related sustainable development goals in Europe. VF2 accounts for 12.21% of the total variance, whereas the strongest positive loadings are on SDG14 (0.902) and SDG15 (0.767), which reflects environmental-related goals. In the VF3, the strong positive loading is assigned to SDG2 (0.846), whereas the moderate positive loading is on SDG6 (0.608). Both of these SDGs are linked with the social aspect of sustainable development. The fourth VF consists of SDG17 (0.909) and SDG7(0.6), whereby SDG7, as environmentally related, dominates. Finally, VF5 consists of a strong positive loading of SDG1 (0.826) and reflects the social dimension.

4.2 Identification of discriminant SDGs between European upper-middle and high-income countries

In further research, the possibility of defining the SDGs that differentiate upper-middle and high-income European countries was examined. In Table 6 are given key measures of stepwise discriminant function analysis that indicate its' effectiveness in this research. The validity of every discriminant function was examined by Wilk's Lambda (λ) Test. Its value ranges from 0 to 1.0. The smaller λ , the more it contributes to the discriminant function. In this study, λ values are near zero (.08672, .08686, .09540) for standard, forward and backward stepwise mode, respectively, which proves high discrimination between groups. The F -ratio determines whether the variances in two independent samples are equal. In this case, the F -ratio indicates high variability between the two groups.

	Wilks' Lambda	Approx. F	Sig.
Standard stepwise	.08672	F (17,228) = 141.24	p<0.00
Forward stepwise	.08686	F (15,230) = 161.20	p<0.00
Backward stepwise	.09540	F (7,238) = 322.38	p<0.00

Table 6.

Stepwise discriminant function analysis - measures of effectiveness

SDG	Standard stepwise mode		Forward stepwise mode		Backward stepwise mode	
	GNI3	GNI4	GNI3	GNI4	GNI3	GNI4
SDG1	-0.252	0.124				
SDG2	1.885	-0.925	1.855	-0.911		
SDG3	-0.832	0.408	-0.788	0.387		
SDG4	-1.044	0.513	-0.982	0.482		
SDG5	3.28	-1.61	3.226	-1.584	2.611	-1.282
SDG6	-0.885	0.434	-0.885	0.435		
SDG7	-0.972	0.477	-0.943	0.463	-1.505	0.739
SDG8	-1.885	0.925	-1.883	0.924		
SDG9	-12.273	6.025	-12.359	6.067	-11.636	5.712
SDG10	-3.608	1.771	-3.671	1.802	-3.136	1.539
SDG11	1.395	-0.685	1.422	-0.698		
SDG12	2.137	-1.049	2.504	-1.229	1.819	-0.893
SDG13	0.166	-0.082				
SDG14	-0.822	0.404	-0.896	0.44		
SDG15	-1.320	0.648	-1.306	0.641	-1.839	0.903
SDG16	0.932	-0.458	1.146	-0.563		
SDG17	4.858	-2.385	4.818	-2.365	4.495	-2.207
Constant	-11.75	-2.963	-11.731	-2.959	-10.69	-2.708

Table 7.

Classification functions and their coefficients for DA

In Tables 7 and 8, the discriminant functions (DFs) and the classification matrices (CMs) obtained as a result of the standard, forward and backward stepwise modes of the DA are presented. The variable that provided the greatest univariate discrimination is selected, and the criterion is re-evaluated for all remaining variables. Only variables which subsequently meet this criterion value are entered into the model.

Group of countries	% Correct	Number of cases assigned by DA	
		GNI3	GNI4
GNI3	96.3	78	3
GNI4	100	0	165
Total	98.8	78	168

Table 8.

Discriminant matrix

The standard mode on the 17 analysed SDGs' constructed the discriminant functions – DFs, with approximately 98.78% correct assignment. In the forward stepwise mode, the variables were included step by step, beginning with more

significant ones, whereas no significant changes were obtained. The forward stepwise mode of the DA gave the CMs with 98.8% correct assignments using 15 discriminant parameters. The backward stepwise DA mode rendered the corresponding CMs, correctly assigning 98.8% of cases, yielding seven discriminant parameters (SDG5, SDG7, SDG9, SDG10, SDG12, SDG15, SDG17).

5 Discussion

The results of descriptive statistics showed that low-income countries (GNI 3) lag behind more developed countries in meeting almost all sustainable development goals, considering the overall SDG score. Based on this, it can be concluded that the country's higher level of economic development leads to greater success in implementing the general concept of sustainability, which is confirmed by the previous studies [31,34,35].

Conversely, higher values in GNI3 countries are recorded in the cases of SDG 12 (Responsible consumption and production), SDG13 (Climate action), and SDG17 (Global partnership for sustainable development). It is confirmed by Lusseau and Mancini's (2019) study, which points out that, in contrast with low-income countries, for high-income countries, SDG13 (climate actions) and SDG12 (responsible consumption) are obstacles to other goals [29]. To combat climate change, nations must switch to renewable energy sources, halt deforestation, and modify production and consumption patterns [33].

Given that the first two goals are related to the environmental dimension of sustainability, the results of this study confirm that lower-income countries are more advanced in terms of the SDGs that fall under the environmental dimension [54,55], even though the environmental aspect is an urgent problem and a subject of discussion during the implementation of various projects all over Europe [16]. One of the explanations is that high-income countries leave a higher environmental footprint than low-income countries [56]. Global material consumption and the amount of material waste per person have increased dramatically, endangering the attainment of SDG 12. The footprint per capita of developed countries is at least double that of underdeveloped countries for every type of material, especially because of a more than four times higher material footprint for fossil fuels. According to Jabbari et al. (2020), Goal 17, which emphasises the need for global partnership, is an overarching goal providing the means of implementing all other SDGs [31]. Based on that, developing countries are on the right course in achieving sustainable development in the future, while partnerships among developed countries stagnate.

By applying PCA/FA, all SDGs are grouped into five VFs, confirming the conditions for a significant reduction in the initial data set. SDGs that belong to the same varifactor are mutually conditioned. In this manner, the first VF consists of 9

SDGs, and we can characterise it as socio-economic because it is dominated by SDGs of social (SDG3, SDG4, SDG5, SDG11, SDG16) and economic (SDG9, SDG10) nature. They are positively conditioned; that is, progress in achieving one affects progress in achieving other goals. In this VF, only SDG12 (Responsible consumption and production) and SDG13 (Climate action) are exceptions because they relate to environmental issues. Also, with the same SDGs, negative factor loadings are noticeable, which indicates that the fulfilment of other SDGs from this group causes negative consequences for climate change and responsible consumption. The second VF can be characterised as ecological because it comprises only two SDGs - Life below water and Life on land, which act synergistically.

VF3 is also made up of two SDGs, which are considered to be mutually conditioned. In this case, both are social - Zero hunger and Clean water and sanitation and represent prerequisites for satisfying basic human needs. Socio-economic SDGs are intertwined in VF4, where we simultaneously have Affordable and clean energy and Partnerships for goals. This component implies that strengthening multilateralism and global partnerships is the prerequisite for ensuring affordable, sustainable, and modern energy for all. The last VF is reflected only in SDG1 - No poverty and it is reflected as a social dimension. It can be concluded that this SDG does not interact with others because the level of poverty in the territory of Europe is very low, and its impact on others is in this area unrecognizable. It can be concluded that the success of European countries in the implementation of sustainable development concepts is mostly determined by specific social and economic indicators. Also, there are notable synergies between SDGs, especially when it comes to the socio-economic dimensions. Conversely, important potential trade-offs with environmental-related SDGs are identified and solutions for overcoming these should be considered.

In this study, a stepwise discriminant analysis was used to determine those variables (SDGs) which were best suited to differentiate between the two groups of countries – upper-middle (GNI3) and high (GNI4) income levels. The low values of this coefficient for the mentioned modes prove that the DA in this study was valid and effective. When a stepwise procedure was run, seven (SDG5, SDG7, SDG9, SDG10, SDG12, SDG15, SDG17) of the seventeen original variables remained. By analysing the SDGs that were extracted as discriminatory, it can be recognized that these are predominantly socio-economic (SDG5 – Gender equality, SDG7 – Affordable and clean energy, SDG9 - Industry, innovation and infrastructure, SDG10 - Reduced inequalities, SDG17 - Partnership for goals), while two of them are environmental related (SDG12 - Responsible consumption and production and SDG15 - Life on land).

Even though the SDGs related to the environmental dimension are more fulfilled in GNI3, it is concluded that the differences between these two groups of countries are mainly reflected in their socio-economic conditions. Through comparative analysis with the results of descriptive statistics, it was observed that the success in achieving

the socio-economic SDGs is far greater in the case of high-income countries, which indicates that the goals of sustainable development aimed at the socio-economic dimensions represent a dominant factor that contributes to the greater success of GNI4 countries in reaching the concept of sustainability. The significant advantage of the GNI4 countries is reflected in a gender equality, a higher degree of industrial development and innovation, better access to affordable and modern energy for all, equal opportunities and rights for all people without discrimination and peaceful, inclusive societies with effective and accountable institutions at all levels. At the same time, it indicates a significant backlog of GNI3 countries in those areas and the necessity of strengthening measures and policies to improve these goals. On the other hand, the discrimination goals of responsible consumption and partnership for goals indicate clear differences between GNI3 and GNI4, where, unlike the previous one, countries with a low-income level are more successful in their implementation. The result, which is reflected in significantly better environmental-related SDG12 in lower-income countries, does not necessarily mean that those countries are more committed to ecology and environmental protection, but only that they do not have the prerequisites for leaving higher environmental footprint. Strong international cooperation is needed now more than ever to ensure that countries have the means to achieve the SDGs especially after the COVID19 pandemics. During the pandemic period which is covered by this research, countries began to close and all international cooperation and contacts stopped. Accordingly, this could be the reason for the poor results in the field of SDG17 (Partnership for goals).

Conclusions

In this paper, multivariate statistical techniques such as PCA/FA and discriminant analysis were conducted to determine the dominant SDG structure in Europe and whether SD priorities vary by income level. Climate action and responsible consumption and production can undermine or inhibit progress toward a range of development goals. We must reverse current trends and shift our consumption and production patterns to a more sustainable course. Multilateralism and global partnerships are more important than ever if we are to solve the problems of high-income countries. The results indicate that some countries that fall behind in social and economic sustainability (mostly developing countries in Europe) get relatively better scores in environmental goals. However, this advantage should be taken with a grain of salt because any future economic progress of these countries could slow down the achievement of environmental SDGs.

Given the broad scope of the SDGs, policymakers will need to easily assess the economic, social and environmental implications of their strategies in an integrated way over the long term. The results of this study should provide insight and direction for future efforts to promote sustainable development. The conducted analysis proved that there are common features and differences between European states depending on income level. Therefore, various and specific measures are needed to support the improvement of sustainable development. High-income

countries should prioritize environmental sustainability through resource efficiency, waste reduction, sustainable management of chemicals and wastes, and the implementation of environmentally sound practices. Conversely, middle-income countries' policymakers must take action to ensure economic competitiveness and social growth, which, according to the results of PCA/FA, drive the overall SDG score and form the basis of progress in implementing the concept of sustainable development.

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References

- [1] Brundtland, Gro Harlem, (1987). Report of the World Commission on Environment and Development: Our Common Future. United Nations General Assembly document A/42/427.
- [2] Nerini Francesco Fuso, Sovacool Benjamin, Hughes Nick, et al., (2019) Connecting climate action with other sustainable development goals. *Nature Sustainability*, 2(8), pp. 674–680.
- [3] Aravindaraj, K, Rajan P. Chinna, (2022) A systematic literature review of integration of industry 4.0 and warehouse management to achieve Sustainable Development Goals (SDGs). *Cleaner Logistics and Supply Chain*, 5, 100072.
- [4] Guo Huadong, Liang Dong, Sun Zhongchang, et al., (2022) Measuring and evaluating SDG indicators with big earth data. *Science Bulletin*, 67(17), pp. 1792–1801.
- [5] Zhao Wenwu, Yin Caichun, Hua Ting et al., (2022) Achieving the Sustainable Development Goals in the post-pandemic era. *Humanities and Social Science Communications*, 9, 258.
- [6] United Nations. *Transforming our World: The 2030 Agenda for Sustainable Development*. 2015.
- [7] Rodríguez-Antón J. M., Rubio-Andrada L., Celemín-Pedroche M. S., Alonso-Almeida M. M., (2019) Analysis of the relations between circular economy and sustainable development goals. *International Journal of Sustainable Development & World Ecology*, 26(8), pp. 708–720.
- [8] Coscieme Luca, Mortensen F. Lars, Anderson Sharolyn, Ward James, Donohue Ian, Sutton C. Paul, (2020) Going beyond Gross Domestic Product

as an indicator to bring coherence to the Sustainable Development Goals. *Journal of Cleaner Production*, 248, 119232.

- [9] Carlsen Lars, Bruggemann Rainer, (2022) The 17 United Nations' sustainable development goals: a status by 2020. *International Journal of Sustainable Development & World Ecology*, 29(3), pp. 219–229.
- [10] Pondel Hannah, (2021) An attempt to evaluate the level of sustainable development in European Union countries. *Economics and Law*, 20(2), pp. 383– 399.
- [11] Grzebyk Mariola, Stec Malgorzata, Hejdukova Pavlina, (2023) Implementation of sustainable development goal 8 in European Union countries – A measurement concept and a multivariate comparative analysis. *Sustainable Development*, 31 (4), pp. 2758-2769.
- [12] Lamichhane Shyam, Gökhan Eğilmez, Ridvan Gedik, M. Khurram S. Bhutta, Bulent Erenay, (2021) Benchmarking OECD countries' sustainable development performance: A goal-specific principal component analysis approach. *Journal of Cleaner Production*, 287, 125040.
- [13] Sianes Antonio, Vega-Muñoz Alejandro, Tirado-Valencia Pilar, Ariza-Montes Antonio, (2022) Impact of the Sustainable Development Goals on the academic research agenda. A scientometric analysis. *PLoS ONE* 17(3), e0265409.
- [14] Caiado G. G. Rodrigo, Filho L. Walter, Quelhas L. G. Osvaldo, Nascimento de Mattos L. Daniel, Avila V. Lucas, (2018) A literature-based review on potentials and constraints in the implementation of the sustainable development goals. *Journal of Cleaner Production*, 198, pp. 1276-1288.
- [15] Schmidt-Traub Guido, Kroll Christian, Teksoz Katerina, Durand-Declare David, Sachs D. Jeffrey, (2017) National baselines for the Sustainable Development Goals assessed in the SDG Index and Dashboards. *Nature Geoscience*, 10, pp. 547–555.
- [16] Yeh Shin-Cheng, Hsieh Yi-Lin, Yu Hui-Ching, Tseng Yuen-Hsien, (2022) The Trends and Content of Research Related to the Sustainable Development Goals: A Systemic Review. *Applied Sciences*, 12, 6820.
- [17] Mishra Manoranjan, Desul Sudarsan, Santos Celso Augusto Guimarães et al., (2023) A bibliometric analysis of sustainable development goals (SDGs): a review of progress, challenges, and opportunities. *Environment, Development and Sustainability*, 26, pp. 11101-11134.
- [18] Abad-Segura Emilio, Gonzalez-Zamar Mariana-Daniela, (2021) Sustainable economic development in higher education institutions: A global analysis within the SDGs framework. *Journal of Cleaner Production*, 294, 126133.

- [19] Cortés D. Julian, Guix Mireia, Carbonell B. Katerina, (2021) Innovation for sustainability in the Global South: Bibliometric findings from management & business and STEM (science, technology, engineering and mathematics) fields in developing countries. *Heliyon*, 7, e07809.
- [20] Imaz Mariana, Sheinbaum Claudia, (2017) Science and technology in the framework of the sustainable development goals. *World Journal of Science, Technology and Sustainable Development*, 14, pp. 2–17.
- [21] Zhenmin Liu, Espinosa Patricia, (2019) Tackling climate change to accelerate sustainable development. *Nature Climate Change*, 9, pp. 494–496.
- [22] Quinlivan Lauren, Chapman V. Deborah, Sullivan Timothy, (2020) Validating citizen science monitoring of ambient water quality for the United Nations sustainable development goals. *Science of the Total Environment*, 699, 134255.
- [23] Lund Crick, Brooke-Sumner Carrie, Baingana Florence, et al., (2018) Social determinants of mental disorders and the Sustainable Development Goals: A systematic review of reviews. *Lancet Psychiatry*, 5, pp. 357–369.
- [24] Rice Brian, Boccia Delia, Carter J. Daniel et al., (2022) Health and well-being needs and priorities in mining host communities in South Africa: A mixed-methods approach for identifying key SDG3 targets. *BMC Public Health*, 22, 68.
- [25] Pakkan Sheeba, Sudhakar Christopher, Tripathi Shubhamet al., (2023) A correlation study of sustainable development goal (SDG) interactions. *Quality and Quantity*, 57, pp. 1937–1956.
- [26] Pradhan Prajal, Costa Luis, Rybski Diego et al., (2017). A Systematic Study of Sustainable Development Goal (SDG) Interactions, *Earth’s Future*, 5, pp. 1169–1179.
- [27] Pedercini Matteo, Arquitt Steve, Collste David et al., (2019) Harvesting synergy from sustainable development goal interactions. *PNAS*, 116, 46, pp. 23021-23028
- [28] Scharlemann P.W. Jörn, Brock C. Rebecca, Balfour Nicholas et al., (2020) Towards understanding interactions between Sustainable Development Goals: the role of environment–human linkages. *Sustainability Science*, 15, pp. 1573–1584.
- [29] Lusseau David, Mancini Francesca, (2019) Income-based variation in Sustainable Development Goal interaction networks. *Nature Sustainability*, 2, pp. 242–247.
- [30] Dawes J.H.P. (2022). SDG interlinkage networks: Analysis, robustness, sensitivities, and hierarchies, *World Development*, 149, 105693

- [31] Jabbari Mehdi, Shafiepour M. Motlagh, Ashrafi Khosro et al. (2020) Differentiating countries based on the sustainable development proximities using the SDG indicators. *Environment, Development and Sustainability*, 22, pp. 6405–6423.
- [32] Koehler Gabriele, (2016) Tapping the Sustainable Development Goals for progressive gender equity and equality policy? *Gender and Development Journal*, 24, 53e68.
- [33] Grochová Ladislava Issever, Litzman Marek, (2021) The efficiency in meeting measurable sustainable development goals. *International Journal of Sustainable Development & World Ecology*, 28 (8), pp. 709-719.
- [34] Warchold Anne, Pradhan Prajal, Kropp P. Jürgen, (2021) Variations in sustainable development goal interactions: population, regional, and income disaggregation. *Sustainable Development*, 29, pp. 285–299.
- [35] Asadikia Atie, Rajabifard Abbas, Kalantari Mohsen, (2022) Region-income-based prioritisation of Sustainable Development Goals by Gradient Boosting Machine. *Sustainability Science*, 17, pp. 1939–1957.
- [36] Griggs David, Stafford-Smith Mark, Gaffney Owen et al., (2013) Sustainable development goals for people and planet. *Nature*, 495, pp. 305–307.
- [37] Urmee Tania, Md Anisuzzaman, (2016). Social, cultural and political dimensions of off-grid renewable energy programs in developing countries. *Renewable Energy*, 93, pp. 159-167.
- [38] Mboumboue Edouard, Njomo Donatien, (2016) Potential contribution of renewables to the improvement of living conditions of poor rural households in developing countries: Cameroon's case study. *Renewable and Sustainable Energy Reviews*, 61, 266e279.
- [39] Allen Cameron, Metternicht Graciela, Wiedmann Thomas, (2016) National pathways to the Sustainable Development Goals (SDGs): A comparative review of scenario modelling tools. *Environmental Science & Policy*, 66, pp.199-207.
- [40] Nilsson Måns, Griggs Dave, Visbeck Martin, (2016) Map the interactions between Sustainable Development Goals. *Nature*, 534, pp. 320-322.
- [41] Stevenson Samuel, Collins Alexandra, Jennings Neil et al., (2021) A hybrid approach to identifying and assessing interactions between climate action (SDG13) policies and a range of SDGs in a UK context. *Discover Sustainability*, 2, 43.
- [42] Raja Jayaraman, Cinzia Colapinto, Davide La Torre, et al., (2015) Multi-criteria model for sustainable development using goal programming applied to the United Arab Emirates. *Energy Policy*, 87, pp. 447-454

- [43] Cao Min, Chen Min, Zhang Junze et al. (2023) Spatio-temporal changes in the causal interactions among Sustainable Development Goals in China. *Humanities and Social Sciences Communications*, 10, 450.
- [44] Hotelling H., (1933) Analysis of a complex of statistical variables into principal components. *Journal of Educational Psychology*, 24(6), pp. 417–441.
- [45] Dong Xiucheng, Guo Jie, Höök Mikael et al., (2015) Sustainability assessment of the natural gas industry in China using principal component analysis. *Sustainability*, 7 (5), 6102e6118.
- [46] Khan Kamran Muhammad, Teng Jian-Zhou, Khan Imran Muhammad, (2019) Effect of energy consumption and economic growth on carbon dioxide emissions in Pakistan with dynamic ARDL simulations approach. *Environmental Science and Pollution Research*, 26(23), 23480e23490.
- [47] Voza Danijela, Vuković Milovan, (2018) The assessment and prediction of temporal variations in surface water quality—a case study. *Environmental Monitoring and Assessment*, 190, pp. 434,
- [48] Soler Rovira José, Soler Rovira Pedro, (2009) Assessment of aggregated indicators of sustainability using PCA: the case of apple trade in Spain. In: "6th International conference on Life Cycle Assessment in the Agri-food Sector. Towards a sustainable management of the food chain.", 12-14 noviembre 2008, Zurich (Switzerland). ISBN 978-3-905733-10-5.
- [49] Shihab S. Abdulmuhsin, (2022) Identification of Air Pollution Sources and Temporal Assessment of Air Quality at a Sector in Mosul City Using Principal Component Analysis. *Polish Journal of Environmental Studies*. 31(3), pp. 2223-2235.
- [50] Kwatra Swati, Archana Kumar, Prateek Sharma, (2020) A critical review of studies related to construction and computation of Sustainable Development Indices. *Ecological Indicators*, 112, 106061.
- [51] United Nations. The sustainable development goals reports 2017-2022. Available online: <https://unstats.un.org/sdgs/report/2018/>
- [52] World Bank (2004) World Development Report 2004.
- [53] Liu, W. X., Lia, X. D., Shena Z.G., et al., (2003) Multivariate statistical study of heavy metal enrichment in sediments of the Pearl River Estuary. *Environmental Pollution*, 121 (3), pp. 377–388.
- [54] Saud Shah, Chen Songsheng, Haseeb Abdul et al., (2019) The nexus between financial development, income level, and environment in Central and Eastern European Countries: a perspective on Belt and Road Initiative. *Environmental Science and Pollution Research*, 26, pp. 16053–16075.

- [55] Zhuo Jianxin, Qamruzzaman Md., (2022) Do financial development, FDI, and globalization intensify environmental degradation through the channel of energy consumption: evidence from belt and road countries. *Environmental Science and Pollution Research*, 29, pp. 2753–2772.
- [56] Chen Sheng-Tung, Chang Hui-Ting, (2016) Factors that affect the ecological footprint depending on the different income levels. *AIMS Energy*, 4(4), pp. 557-573.

Exploration and prediction of evolution of industrial revolutions

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Abstract: This paper deals with exploration and prediction of the historical periods of the industrial revolution (IR) starting in the 18th century as IR 1.0, highlighting the current one – the IR 5.0 – and forecasting the development of the IRs until 2050. Researches foresees that by the mid of this century a paradigm shift in both production and consumption will be characterized by use of clean energy resources, advanced automated production systems and robotics, the wide use of Artificial Intelligence, environmentally friendly technologies and cost-effective mass transportation systems

Each IR has different energy sources, unusual transportation and communication systems, various production systems and different education and research and developing the thought. As conclusion: every industrial revolution can generate diverse impacts on the economic, social, political, and technological realms, progressively manifesting at different magnitudes and levels. A noteworthy observation is that the primary impact of any industrial revolution is predominantly on the economic and technological domains.

1 Preface

The motto of the 22nd International Conference on Management, Enterprise and Benchmarking is „Paradigm Shift: Path to Shared Drift.” A paradigm shift refers to a fundamental change in the basic concepts and experimental practices of a specific discipline. It often occurs when new discoveries challenge existing theories and methodologies, leading to the reevaluation of beliefs and the emergence of new perspectives.

Paradigm shift is a concept that was introduced and made known to the public by the American physicist and philosopher [Thomas Kuhn](#) in 1962. Even though Kuhn restricted the use of the term to the [natural sciences](#), the concept of a paradigm shift has also been used in numerous non-scientific contexts to describe a profound change in a fundamental model or perception of events. ¹ Thomas Kuhn presented

¹ See at https://en.wikipedia.org/wiki/Paradigm_shift

his theory in his book *The Structure of Scientific Revolution*.² Kuhn proposed that science advances through a “*series of peaceful interludes punctuated by intellectually violent revolutions*” in which “one conceptual world view is replaced by another.”

Even though Kuhn restricted the use of the term to the [natural sciences](#), the concept of a paradigm shift has also been used in numerous non-scientific contexts to describe a profound change in a fundamental model or perception of events.

Kuhn used the duck-rabbit optical illusion developed by the Austrian philosopher Ludwig Josef Johan Wittgenstein to demonstrate the way in which the paradigm shift could lead to different output one to see the same information in an entirely different way.

Kuhn explains the development of paradigm shift in science in four stages:

- Normal science;
- Extraordinary research;
- Adoption of a new paradigm; and
- Aftermath of the scientific revolution.

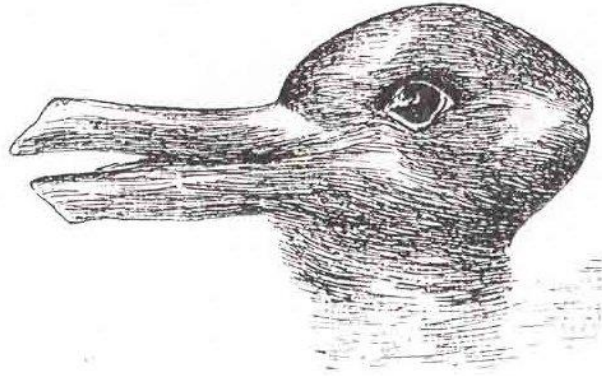
1.1 Definition of industrial revolution

According to the **Britannica**, industrial revolution is the process of change from an agrarian and handicraft economy to one dominated by industry and machine manufacturing. These technological changes introduced novel ways of working and living.

During the industrial revolution the work began to be done more and more by machines instead of hand operated processes made at home. The employment conditions in factories do not change much. However, many workers moved to the towns looking for a better life.

The history of industrial revolutions possesses distinct and defining characteristics. The basic concept and its social dimension is changing and it reaches a real paradigm shift. Each revolution stage has advantages and disadvantages, introduces new challenges and contributes to the rise of economic development in individual countries and nations.

² Thomas S. Kuhn: *The Structure of Scientific Revolution*. 1962, University Chicago Press. ISBN [9780226458113](#)



To understand the evolution, we categorize industrial revolutions into three stages:

- pre-industrial revolution;
- present industrial revolution;
- post-industrial revolution.

Each industrial revolution has six fundamental conditions:

- 1 discovering and introduction of new technologies;
- 2 introduction of innovative production systems and methods;
- 3 use of new energy sources;
- 4 modernization of communication and transportation systems;
- 5 development of research systems and institutions;
- 6 development of existing education systems and human capital,

2 Evolution and history of the industrial revolutions

First industrial revolution – ir 1.0 (from 1700s)

The Industrial revolution started in the 18th century in the United Kingdom and later spread throughout the world. The First Industrial Revolution started in the beginning of the 18th century 1782-1840. and lasted somewhere Goods started to be produced in mass quantities in factories. Products were manufactured faster and cheaper. In 1712 Thomas Newcomen invented the atmospheric engine, which was operated by condensing steam drawn into the cylinder, thereby creating a partial vacuum that allowed the atmospheric pressure to push the piston into the cylinder. Newcomen engines were used throughout [Britain](#) and [Europe](#). These engines pumped water out of [mines](#). Hundreds were constructed throughout the 18th century. At the end of the 1700s, James Watt invented the steam engine, a machine

using steam power to perform mechanical work. The [adaptation](#) of the steam engine to railways by the English engineer [George Stephenson](#) in 1825 revolutionized the whole transport system.

In the field of textiles, in 1733 an English inventor John Kay patented the flying shuttle contributing to an increase in the output of a weaver. The series of new patent and mechanization efforts contributed to high textile product output. Although mechanization dramatically decreased the cost of cotton cloth, by the mid-19th century machine-woven cloth still could not equal the quality of hand-woven Indian cloth,

This transformation changed not only the work done and the goods produced but also the relationship between people. The main features involved were technological, socioeconomic, and cultural changes. The technological changes included the use of new basic materials like iron and steel, use of new energy sources like coal, steam engines, electricity and petroleum, and division of labour, new organization of work in factories and specialization of function. Just as steam engines needed coal, steam power allowed miners to go deeper and extract more of these relatively cheap energy sources. The demand for coal would be needed to run not only the factories used to produce goods but also the railroads and steamships used for transporting them.

Second industrial revolution – ir 2.0 (started in 1870)³

Starting in the mid-18th innovation like the spinning jenny – a wooden frame with multiple spindles -, the flying shuttle, the water frame and power loom made weaving cloth and spinning yarn and thread much easier. Production cloth became faster and requested less time and far less human labor.

The Second Revolution brought about inventions in the methods and modalities of how energy was produced and used. It brought the use of internal combustion engines and electricity in industrial units. The Second Revolution also brought about a focus on steel production. Innovations in manufacturing changed the manufacturing processes, such as the establishment of a [machine tool](#) industry, the development of methods for manufacturing [interchangeable parts](#), as well as the invention of the [Bessemer process](#) and [open hearth furnace](#) to produce steel. The key industry is automobile, but also steel and electrical appliances. The US has access to resources iron, coal, and oil.

In 1876 Alexander Graham Bell invented the telephone, in 1897 Rudolf Diesel's constructed the engine, while in 1903 Ford Motor Company and Wright brother's airplane were discovered. In 1909 23% of industrial power was generated by electrical motors which number reached 77% in 1929. 6.7 million cars in the US in 1919, by 1929 it was 23 million.

³ See at <https://www.internationalschoolhistory.com/ib-history---first-and-second-industrial-revolution.html>

After 1870 the large-scale expansion of rail and telegraph lines took place which allowed unprecedented movement of people and ideas, which culminated in a new wave of [globalization](#).

Third industrial revolution – ir 3.0 (from 1970s)

The Third Industrial Revolution started in the '70s in the 20th century through partial automation using memory-programmable controls and computers. This is a period of technological advancement which continued to the present day.

Beginning in the 1950s, the third industrial revolution brought *semiconductors, mainframe computing, personal computing, and the Internet—the digital revolution*.. Since the introduction of these technologies, we are now able to automate an entire production process - without human assistance.

One consequence of the Third Industrial Revolution is that the number of blue-collar workers will continue to decline while productivity increases. ⁴ More work will be done in front of a computer screens.

Jeremy Rifkin author of the New York Times in his work on «The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy and the World», states that **the** five pillars of this Revolution are: ⁵

- The transformation of renewable energies.
- Use buildings on each continent in micro power plants to generate renewable energy.
- Expand hydrogen and other storage technologies in every building, as well as in all energy storage infrastructure.
- Use the internet to transform the global electricity grid into an energy network that acts as a connection to the internet.
- Transition from fossil fuel vehicles to plug-in and fuel cell electric vehicles that can buy and sell green electricity through a smart, continental, interactive grid system.

In the period of the Third Industrial Revolution a significant achievement was the introduction of the atomic energy in electricity generation, which fundamentally changed the global economy.

⁴ Sandvik Coromant: <https://www.sandvik.coromant.com/en-gb/defining-the-third-industrial-revolution>

⁵ Jeremy Rifkin The third industrial revolution: How lateral power is transforming energy, the economy, and the world, PALGRAVE MACMILLAN, New York. 2011

Fourth industrial revolution – ir 4.0 (starting from 2000)

The 21st century characterised by the application of **information and communication technologies to industry and it refers to the current era of connectivity, advanced analytics, automation, digital manufacturing technology. IR 4.0 offers four types of disruptive technologies as following:**

- connectivity, data and computation power: **cloud technology connectivity**, Internet, blockchain, using sensors;
- analytics and intelligence: advanced analytics, machine learning, use of **artificial intelligence**;
- human-machine interaction: **virtual reality and augmented reality, robotics automation** and autonomous guided vehicles;
- advanced engineering: **additive manufacturing**, such as 3D printing, renewable energy, such as solar energy, geothermal energy and wind energy. The key achievement is the introduction of massive electricity consumption.

The technological development generated a significant impact in individual industries. Technological adaptation has become a key factor, since the new technological achievement concluded in increase in productivity. Demographics have changed. Even the skills that brought our society to where we are today have changed. Leaders must account for these transformations or risk leaving behind their companies, their customers and their constituents. Unfortunately humans pushed into the background.

Fifth industrial revolution – ir 5.0 (started from 2020)

Regarding the content of the Fifth Industrial Revolution concept, there is no consensus. IR 5.0 encompasses the notion of harmonious human-machine collaborations, with a specific focus on the well-being of the multiple stakeholders including society, companies, employees and customers. The conceptual framework bases on the people-centeredness and employee well-beings. IR 5.0 enhances human work with machines, but do not replace the human being.

While IR 4.0 focuses on the use of automation and robotics, the IR 5.0 puts the focus on people. IR 4.0 focuses on connecting machines, IR 5.0 is dedicated to customers. IR 5.0 puts technology at the service of people.

Industry 5.0, often referred to as the Fifth Industrial Revolution, is a new development model **promoted by the European Commission** and described in the report [*Industry 5.0*](#).⁶ „Industry 5.0 attempts to capture the value of new technologies, providing prosperity beyond jobs and growth, while respecting

⁶ European Commission, Directorate-General for Research and Innovation, Breque, M., De Nul, L., Petridis, A. Industry 5.0. Towards a sustainable, human-centric and resilient European industry. Published in 2021. See at <https://op.europa.eu/en/publication-detail/-/publication/468a892a-5097-11eb-b59f-01aa75ed71a1/>

planetary boundaries, and placing the wellbeing of the industry worker at the centre of the production process.”

According to the Hungarian Ministry for Economy the concept of the IR 5.0 is still only along theoretical connection. For companies the primary priority is adapting the achievement of IR 4.0 and to increase the productivity. One of the biggest hindering factors is moving towards IR5.0 is the trust in technology and its acceptance. László Kovács, the Head of the Industry 4.0 Technology Centre at the Budapest University of Technology and Economics states, that “it is too early to talk about the Industry 5.0, because the challenge called by Industry 4.0 has not taken place in 90% of the companies.”

The Japan plan to “balance economic development and social issues through systems that integrate cyberspace (virtual space) and Physical space (real space) at a high level” as **SOCIETY 5.0** is the most advanced and leading concept. In fact, Japan for long time achieves coexistence with society and the environment and action thought new human-centred concept. Society 5.0, also known as the **Super Smart Society**, is a concept for a future society created through a new industrial revolution, introduced by the Japanese government in 2016. The plan proposes integrating various technologies, such as artificial intelligence, more effectively into society.

Japan's [National Institute of Advanced Industrial Science and Technology](#) report lists the following six topics as basic technologies for realizing Society 5.0:⁷

- Technology for enhancing human capabilities, fostering sensitivity, and enabling control within Cyber-Physical Systems (CPS).
- AI hardware technology and AI application systems.
- Self-developing security technology for AI applications.
- Highly efficient network technology along with advanced information input and output devices.
- Next-generation manufacturing system technology designed to facilitate [mass customization](#).
- New measurement technology tailored for digital manufacturing processes.

⁷ https://en.wikipedia.org/wiki/Society_5.0

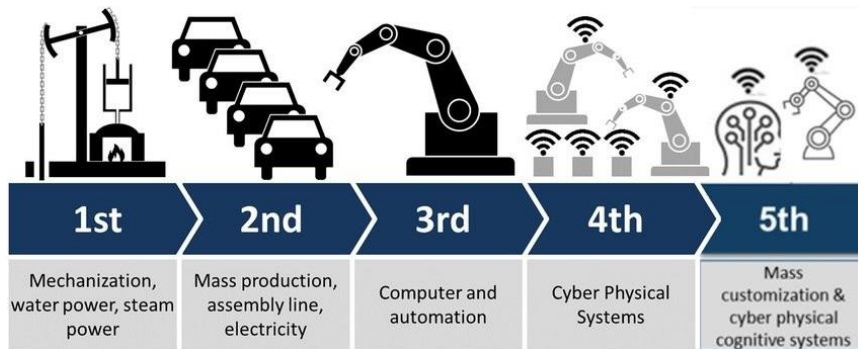


Figure 1

The steps of industrial revolutions

Source: Antonio Clim

at https://www.researchgate.net/figure/Industrial-revolutions-5_fig1_334390284

Sixth industrial revolution – ir 6.0 (probably in 2030)

Industry 6.0 incorporates advanced electricity storage systems.

IR 6.0 is characterized by using advanced technologies such as quantum computing, and nanotechnology over the pre-built Industry 5.0 architecture. These technologies will enable more efficient and effective solutions to solve complex problems, as well as the potential for new business models.

The use of Industry 6.0 technologies will also provide the potential for advanced robotics, and increased safety and security in production and manufacturing processes. Additionally, the use of blockchain technology will enable secure and reliable data-sharing and communication between connected devices, as well as the potential for new economic models. Ultimately, the use of Industry 6.0 will continue to revolutionize the way we produce, manage, and consume goods, services, and information but as with any technological advancement, Industry 6.0 may also have some potential drawbacks or negative impacts.

Seventh industrial revolution – ir 7.0 (2050-2070)

Forecast by Maio Arturo Ruiz Estrada

The IR 7.0 concentrates around Natural Organic Artificial Intelligence Systems (NOAI-Systems), involving intricate interplay of sensors, microchips, neural artificial networks, mega-computers, complex intelligent auto-sustainable software systems, and practical applications grounded in robust ...

Research carried out by the NOAI foresees that by the year 2050, a paradigm shift in production and consumption models will manifest, characterized by the adoption of clean energy sources and mechanism, advanced autonomous production systems under robotics and Artificial Intelligence (AI), environmentally friendly products

designed for easy recycling, and the implementation of cost-effective mass transportation systems.

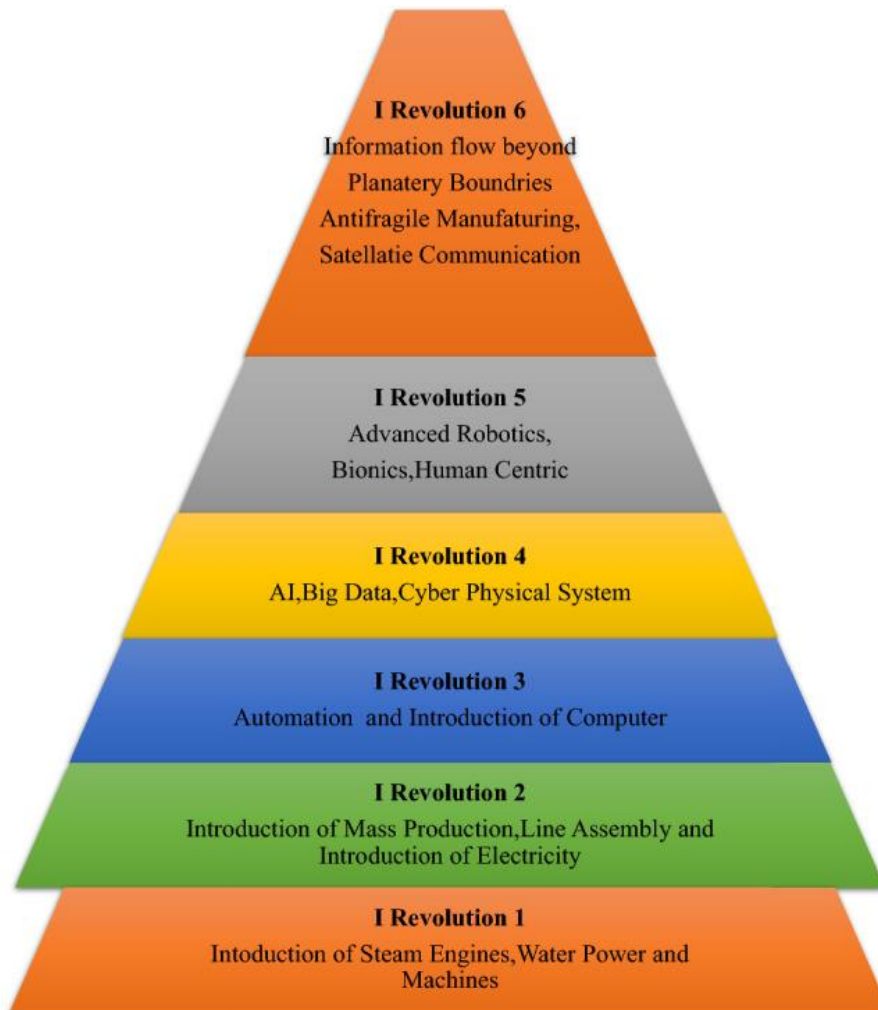


Figure 2.
The transformation journey of industrial revolution
from IR 1.0 to IR 6.0

Summary and conclusion

- We have concluded that every industrial revolution can generate diverse impacts on the economic, social, political, and technological realms, progressively manifesting at different magnitudes and levels.
- A noteworthy observation is that the primary impact of any industrial revolution is predominantly on the economic and technological domains.
- However, the key discovery underscores that the most significant impact of any industrial revolution lies in the dynamic and unforeseen changes within the labour market, leading to the emergence of new labor divisions and specializations.
- In the initial stages of any industrial revolution, a substantial increase in unemployment is anticipated, paving the way for the creation of new job niches.
- There is a rapid transformation in the actual education system.

The switch between the traditional Olympic and Paralympic Games model and the new Paris 2024 model: A research perspective

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Abstract: Rising local costs, environmental damage, negative responses from local populations, and the abandonment of candidacies have made the Olympic and Paralympic Games model no longer sustainable for mega-events. The Olympic games that are to be held in Paris in 2024 must involve rebuilding a better Olympic and Paralympic Games (OPG) model with high global and local value and low direct local costs. Like London, Paris is a city shaped by heritage and will use this sporting and cultural heritage as a central element for the OPG model to become sustainable. This case study attempts to capture the shift between the circular heritage model (use of existing heritage) proposed by Paris and the traditional model illustrated by London 2012 by presenting the SWOT matrices of the two models.

Keywords: Circular model, Heritage city, Olympic and Paralympic Games, Paris 2024

Introduction

The Olympic and Paralympic Games (OPG) are a global event that have many positive effects, including being economically beneficial for the city that hosts the games. The OPG mega-event is a specific model in which the event takes place in one city and lasts no more than one month. This model is intended to provide the host city with a long-term legacy, as encouraged by the International Olympic Committee (IOC) since the games were held in Melbourne in 1956. However, the model is on decline due to negative effects from hosting the OPG and seems no longer sustainable. Paris 2024 is proposed as a new OPG model capable of resolving the weaknesses of the traditional model by establishing a circular heritage model that uses and reuses existing cultural and sport heritage sites (Ricordel, 2023). This research paper aims to study the evolution of the OPG model with the proposal of the Paris 2024 model. To do this, we present SWOT matrices that compare London 2012 and Paris 2024. We adopt the Plan Quality Evaluation methodology (Ricordel, 2022), which consists of applying the data triangulation process of Denzin (1978) to 11 official public documents and internet sites that are published or available in

preparation for the event by official organizing institutions and stakeholders. The information linked to the SWOT matrices is therefore based on the planning established four years before the event. Only for the “threat” quarter of the SWOT matrices do we take into account post-event information from academic studies in the literature. This article is organized as follows. In the first section, we address the question of why is the OPG model changing? In the second section, we demonstrate the differences between the traditional linear model and the new circular model of Paris 2024. In the third section, we present the results of our case study, showing the SWOT matrices for the traditional OGP of London 2012 and the circular model of Paris 2024.

1 Why a new OPG model?

The OPG begins with a giant, emotional opening ceremony followed by events that can inspire an entire generation. This mega-event is a global public good, first as a philosophy inherited from the Greeks based on cardinal virtues such as friendship, respect, and excellence inscribed in the stone of an Olympic charter defending peace, inclusion, and effort. Second, it is a movement aiming for a more peaceful world built on sport and education accompanied by numerous public policies focused on promoting cultural events, education, sport and initiatives, and health. Third, it is an accessible, televised event with 4 billion viewers and over 350,000 hours of free streaming.

Regarding the host city, the OPG event is likely to bring more economic benefits and visitors to the hosting city due to the heritage that remains longer than the event itself (Gratton & Preuss, 2008). All the new tangible heritage assets produced by the OPG include sports facilities, the Olympic village, and urban regeneration. However, there is also the intangible heritage linked to the games and the attractiveness of a highly publicized city during the event. Finally, the legacy of the Olympic Games generally extends well beyond sport and involves long-term economic, tourism, social, and environmental outcomes for the host city and the ability to accelerate or initiate changes in the material/social infrastructure and culture, thereby transforming the urban order (Essex and Chalkley, 1998; Hiller, 2006). This catalytic effect, where the city, region, state, and a myriad of actors are oriented in the same direction, is an opportunity to promote public policies (Gignon, 2023) in terms of education, health, sports, and inclusion after the OPG. The creation of new heritage sites has been the pillar of the OPG's sustainability model, as stated in the IOC agenda since 1956 (Gammon & Ramshaw, 2014). This is expected to have long-term positive effects on inhabitants and largely offset the negative effects associated with a very expensive and short-lived event. Heritage is the control variable used to enhance the OPG model for the host city.

However, despite the heritage associated with the OPG, the model has suffered from increasing threats with a growing disconnect between the expected and realised economic benefits of hosting the OPG (Scandizzo & Pierleoni, 2017) and the increase in direct and indirect costs for host cities (Müller et al., 2022). Faced with the issue of mega-events (Müller, 2015) characterized by stronger local resistance and the withdrawal of several candidate cities (e.g., Boston, Budapest, Rome, Hamburg, Munich), the strengths of the OPG model seem to be counterbalanced by its weaknesses, notably the financial burden of hosting the games and the difficulties of maintaining the Olympic facilities afterwards. First, local organizational costs have been on the rise: Athens 2004 cost €9 million; Beijing 2008 cost €30 million; London 2012 cost €13 million; and Rio 2016 cost €16 million. Second, there is an increase in hidden indirect costs during the event such as security costs, traffic disruptions, congestion costs, and market disruption. Third, there is a rising risk of “white elephants”, those sport structures that put strains on a city and become largely unused after the event.



Figure 1
White elephant from Athens 2004
Source: The author

Fourth, disruption due to the OPG leads to a growing gap between the diffused global benefit and the concentrated local costs in congestion and security for the event—the so-called mega-event syndrome (Müller, 2015). Fifth, there was visible organised resistance from non-stakeholders and passive resistance from the population who “voted with their feet” during the event, with a measured loss of buy-in from the local population. Sixth, the withdrawals of several other candidate cities (e.g., Boston, Budapest, Rome, Hamburg, Munich) precipitated the end of the model, leaving Paris as the only candidate for 2024.

The urgent need to improve was affirmed in the IOC Agenda 2020, where sustainability became a key goal (Zembri & Engrand-Linder, 2023) with a focus on reinforcing more heritage, paying more attention to environmental considerations,

and lowering costs. In the difficult context of converging economic and environmental crises, Paris 2024 took up the challenge of rebuilding a new OPG model that preserved the magic of the event while placing it on a sustainable path by significantly reducing costs, eradicating the risk of the white elephant, and guaranteeing a neutral environmental impact on the local city. To meet this challenge, Paris 2024 articulated the concept of a circular economy by emphasising the use of existing cultural and sports-related heritage sites (Ricordel 2023). This model is opposed to the traditional OPG model, which is linear and has a high potential for waste. The next section aims to highlight the shift that differentiates the Paris 2024 OPG model from older models. To do this, we refer to the London 2012 and Paris 2024 as case studies. Our analysis of qualification and consequences is based on the study of 11 documents made public by the organisers and the main official actors of Paris 2024 and London 2012 by triangulating the data and sources (Denzin, 1978) to understand the main characteristics and identify the strengths, weaknesses, and opportunities in the SWOT matrix of Section 3.

2 What is the shift in the Paris 2024 OPG model?

To capture the evolution towards the new regenerated OPG model of Paris 2024, we describe the main characteristics of the two OPG models, the traditional OPG exemplified by London 2012 and the circular heritage OPG Paris 2024.

• The traditional OPG model is linear

The traditional OPG model is based on the creation of a new physical sports heritage site and ambitious urban regeneration projects (Boukas et al., 2015). It is designed as a linear model whereby new infrastructures are built and added to existing but ageing infrastructures. London 2012 showed great promise in terms of local heritage with the regeneration of the Thames Gateway and the many new facilities created in the Stratford area as a part of urban regeneration. The main features are as follows:

- 1 – Regenerate a disadvantaged area
- 2 – Most venues are new construction
- 3 – Concentrating on a large territory

London 2012 OPG created 11 new venues: the Olympic Stadium, Olympic Village, Media Complex, Aquatic Centre, Water Polo Arena, Riverbank Arena, Lee Valley White Water Centre, Olympic Stadium Park BMX, basketball arena, the Copper Box Velodrome, and the Lee Valley Velo Park. Ten new venues (including the Olympic Village and Media Complex) were concentrated in the Stratford area to form the Queen Elizabeth Olympic Park, a 2.5 km² area aimed at regenerating the

Thames Gate to the east of London. This Olympic Park for London 2012 exemplified the traditional linear model with a large investment in new sports and hospitality infrastructure. This park, coupled with a new shopping centre (Westfield Centre) aimed at regenerating the Stratford area, represented the main tangible legacy of the games. The London 2012 Olympic bid was based in part on the vision of creating a lasting legacy for London and the United Kingdom. The legacy objective of the London Organising Committee of the Olympic and Paralympic Games (LOCOG) has been clearly expressed in the Legacy Action Plan priority: to make the Olympic Park a model of sustainable living through the creation of one of Europe's largest urban parks (250 ha), demonstrating that the UK is a great place to live, work, and do business, and establish the UK as a leading nation in sports. Accordingly, the Thames Gateway, which has been given top priority, is almost eight times the size of the Paris 2024 urban regeneration zone.

- **The Paris 2024 OPG is a circular heritage model**

Paris 2024 calls for a new circular heritage model for future OPGs and has the following characteristics:

- 1 – Reuse of prestigious sports heritage sites
- 2 – Use of prestigious cultural heritage sites as sports venues
- 3 –Decentralisation of sports sites

A circular economy is the opposite of a linear economy, which uses resources and disposes of them as waste (London 2012 did not reuse the London 1948 Olympic Stadium at Wembley). A circular economy is a system in which the continuous use of resources minimises all forms of waste (Lacy et al., 2020). Implementing the concept of circular heritage implies that each system has the potential to become circular (Levoso et al., 2020). In the case of Paris 2024, this involves the adaptive reuse of cultural sites (Foster, 2020; Foster et al., 2021; Rudan, 2023) and sports sites (Wergeland & Hognestad, 2021) as antidotes for excessive spending and accumulation of waste in buildings (Mercader-Moyano, 2017; Charter, 2018).

In other words, the Paris 2024 model is built upon reusing existing cultural and sports heritage facilities. The Seine River will be temporarily used for the opening ceremony, and a number of temporary venues will be also set up at heritage sites such as the Eiffel Tower, Place de la Concorde, Grand Palais, Trocadéro, and Paris City Hall. Sports heritage sites, such as the Stade de France, which hosted the 1998 Football World Cup, will also be used. Overall, 95% of the OPG sites in Paris will be recycled heritage sites, while 5% will be new sites. Compared to the 11 new venues for London 2012, the new venues are limited to four permanent venues: the Olympic Village, Media Cluster, Aquatic Centre, and Arena Porte de la Chapelle. In total, 22 cultural and sporting heritage sites out of 26 sites are reused (85%), with 14 temporary sites located in prestigious heritage sites (63% of valued heritage,

54% of total sites). Regarding sporting events, 42 sports take place in reused venues, while only five take place in new venues. Finally, the regeneration legacy focuses on three areas in the north-east of Paris: the new mixed district “Pleyel-Bord de Seine”, which is 35 ha in Seine-Saint-Denis, the new 25 ha city-park district of Le Bourget (Seine-Saint-Denis), and the regeneration of the Porte de la Chapelle.

Paris 2024 claims a neutral environmental impact at the forefront of its heritage and sustainable development plan: “*Our objective is to halve the emissions linked to the Games, while offsetting even more CO2 emissions than we will generate.*” Paris 2024 placed drastic cost reduction and environmental responsibility as its main objectives, paying close attention to climate and environmental considerations with 100% renewable energy, a circular economy without waste, sustainable food, responsibility digital technology, the development of clean mobility solutions, and the protection of biodiversity and water management of the regenerated Seine ecosystem. The new city-park project in Seine-Saint-Denis is based on a 13-ha regeneration project park, and the new Pleyel-Bord-de-Seine district, a 10-ha green park with 100% bio sourced materials.

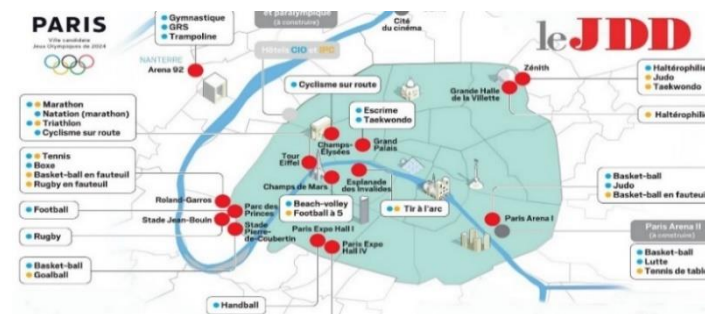


Figure 2
Circular venues in Paris 2024

3 Which consequences? The SWOT approach

The results of the study are presented in the form of SWOT matrices representing the traditional modal model and the circular model of Paris 2024.

<p style="text-align: center;">STRENGTHS</p> <p>A light spot on a city, a country, with 4 billion TV viewers</p> <p>An emotional imprint that lasts at least one generation</p> <p>Tourist and business attractiveness with an economic multiplier of growth</p>	<p style="text-align: center;">WEAKNESSES</p> <p>Rising organisational costs</p> <p>Rising indirect tangible and intangible costs: security, environment damage, local side-effects during the event</p>
<p style="text-align: center;">OPPORTUNITIES</p> <p>Creation of sport facilities for the city and country</p> <p>Catalyst effects for big projects that are otherwise politically difficult to initiate</p> <p>Urban regeneration of a disadvantaged neighbourhood</p>	<p style="text-align: center;">THREATS</p> <p>Visible and organised resistance by local non-stakeholders</p> <p>Environmentally unfriendly</p> <p>Lack of candidate cities</p>

Table 1
SWOT matrix for the traditional OPG (Source: Author)

As mentioned in parts 1 and 2, the mega-event is likely to bring numerous benefits to the host city and constitutes a real opportunity to execute otherwise politically difficult projects in the areas of social interest, transport, and inclusion. If we consider the direct negative effects associated with traditional OPG, then we see that the literature highlights the enormous organisational and environmental damage of the OPGs. Of course, indirect costs are also mentioned, but they are offset by the reality of the heritage and legacies after the OPG. Resistance and a lack of candidate cities are strongly associated with cost and environmental factors.

<p>STRENGTHS A spotlight on a city, a country, with 4 billion TV viewers</p> <p>A low-cost organisation (the cheapest in the recent history with 6.6 B€ in constant euros)</p> <p>An emotional imprint that lasts at least one generation</p> <p>An eco-friendly event</p>	<p>WEAKNESSES Limited impact in city development</p> <p>Limited heritage perspective</p> <p>Rising indirect tangible and intangible costs (lack of public support risk)</p> <p>More market regulation with short term vision and risk of corruption</p>
<p>OPPORTUNITIES Catalyst effect for big environmental projects that are otherwise politically difficult to initiate</p> <p>Spreading effects on a larger part of population with decentralisation of sport competition</p>	<p>THREATS Visible and organised resistance by local non-stakeholders.</p> <p>Waste of money with no sense decision (clean river seine project = 1 B€)</p> <p>A locked model for potential new candidates</p> <p>No legacy supervision by authority after the OPG (specific to Paris 2024)</p> <p>Eviction effect of tourists with the reuse of cultural heritage</p>

Table 2
SWOT matrix of the Paris 2024 model (Source: Author)

By comparing the two matrices, we observe similarities and differences in each quadrant. It is striking that OPG Paris 2024 response to remedy the weaknesses of the traditional model is to eliminate the high costs and adverse environmental impacts, resulting in an eco-friendly and low-cost event. The circular model reinforces the possible weaknesses of the problematic traditional OPG model while retaining the benefits and magic of the event for the city. However, the factor of tourist and commercial attractiveness disappears because the level of regeneration and new infrastructure is very limited in the circular model. Furthermore, we observe that the indirect material and intangible costs associated with the event also remain high in the circular model due to security and the congested cost of hosting multiple events in the city centre.

When we consider threats, we see the same level of resistance, our study identifies new threats that appear with the circular model. The first and specific choice of decision-makers is the waste of money with the decision to organise a swimming competition in the Seine River. This is a problematic decision since several long-term aquatic complexes could have been built in the same area for 1 billion euros. In the same vein, the decision of the Paris 2024 OCOG not to create a post-match heritage agency (unlike London 2012) will limit the benefits to be expected after the games. More importantly, two threats need to be considered in this model. First, there is an eviction effect with the crowding out of tourists hoping to visit the area due to the inability to move easily from one place to another, which can lead to the risk less visitors. In London 2012, instead of welcoming 300,000 visitors per day, the city only saw 100,000 per day. Second, since the circular heritage model uses existing cultural heritage sites to reduce direct costs, there is a serious threat of eliminating the candidacy of cities with limited cultural heritage. Therefore, there is a ‘lock-in’ risk that is not consistent with the Paris 2024 motto of “games wide open.”

Conclusion

This study analysed the evolution of the OPG mega-event with Paris 2024. The Parisian model is a circular heritage model that aims to “bring home the gold” to the OPG by reducing direct costs and guaranteeing an environmentally friendly event. The new model eliminates the main weaknesses of the traditional model. However, the sustainability of such a model is still questionable because of the eviction effect for tourists and the ‘lock-in’ effect for future OPG candidacy. When the mega-event occurs in the city centre, it risks creating a ghost city, and when the model is based on pre-existing cultural and sporting infrastructures, the number of potential candidates is reduced, making the games less open, contrary to what the committee in charge of the OPG Paris 2024 claims.

References

- [1] Olympic world library
- [2] <https://www.paris2024.org>
- [3] Rapport officiel des jeux olympiques London 2012 volume 3
- [4] London 2012 Olympics – Regeneration legacy evaluation framework – DCLG departments for Communities and Local Government
- [5] Les jeux de Londres et l’héritage olympique, sacha dallis alice duthuil ecole urbaine de science po.
- [6] Les jeux olympiques et paraolympiques de 2024, un levier pour la construction du grand paris (APUR)

- [7] The legacy and sustainability plan for the Paris 2024 Olympic and Paralympic Games / Organising Committee for the Paris 2024 Olympic and Paralympic Games. Organising Committee for the Paris 2024 Olympic and Paralympic Games - 2021
- [8] London 2012 Olympic Games : the official report / The London Organising Committee of the Olympic Games and Paralympic Games. Edited by LOCOG – 2013
- [9] Plan for the Legacy form the 2012 Olympic and Paraolympic Games. December 2010. DCMS
- [10] Site Mairie de Paris onglet JO Paris 2024 <https://www.paris.fr/jeux-olympiques-et-paralympiques-de-paris-2024>
- [11] Site CNO Paris 2024 <https://www.paris2024.org/fr/site/arena-la-chapelle/>
- [12] Boukas N, Ziakas V., Boustras G. (2013) Olympic legacy and cultural tourism: exploring the facets of Athens’ Olympic heritage. *International Journal of Heritage Studies* 19(2) pp. 203-228.
- [13] Charter, M. (ed.) (2018) *Designing for Circular Economy*. London: Routledge.
- [14] Denzin, N. K. (1978) Triangulation: A Case for Methodological Evaluation and Combination. *Sociological Methods: A Sourcebook*. NY, McGraw Hill: pp. 339-357.
- [15] Essex, S. & Chalkley, B. (1998) Olympics Games: catalyst of urban change, *Leisure Studies* 17 pp. 187-206.
- [16] Foster, Gillian. (2020) Circular economy strategies for adaptive reuse of cultural buildings to reduce environmental impacts. *Resources Conservation & Recycling* 152 pp. 1–14.
- [17] Gammon, S., Ramshaw G. (2015) *Heritage and Sport*. The Palgrave Handbook of Contemporary Heritage Research.
- [18] Gignon, A. (2023) Public policies and governance of the 2024 Olympic and Paralympic Games: possible impacts on territorial development in north-east Paris? *Local Economy Special Issue: Sports, Politics & Legacy: Building Back Better?*
- [19] Gratton, C., Preuss, H. (2008) Maximizing Olympic Impacts by Building Up Legacies. *International journal of the History of Sport* 25(14): 1922-1938. Doi: <http://doi.org/0.1080/09523360802439023>
- [20] Hiller, H.H., (2006) Post-event outcomes and the post-modern turn: the Olympics and urban transformation. *European Sport Management Quarterly* 6 pp. 317-332.
- [21] Lacy, P., Long, J., Spindler, W. (2020) *The Circular Economy Handbook: Realizing the Circular Advantage*. Palgrave MacMillan.

- [22] Levoso, A.S., Casol, C.M., Blanco, J.M., Durany, X.G., Lehman, M., Gaya, R.F. (2020). Methodological framework for the implementation of circular economy in urban systems. *Journal of Cleaner Production* 248. 119227.
- [23] Mercader-Moyano, P. (ed.) (2017) *Sustainable Development and Renovation in Architecture, Urbanism and Engineering*. New York, NY: Springer. doi: <http://doi.org/10.1007/978-3-319-51442-0>
- [24] Müller, M. (2015) The Mega-Event Syndrome: Why So Much Goes Wrong in Mega-Event Planning and What to Do About It. *Journal of the American Planning Association* 81(1) pp. 7-17.
- [25] Müller, M., Gogishvili, D., Wolfe, S.D. (2022) The structural deficit of the Olympics and the World up: Comparing costs against revenues over time. *Economy and Space* 54(6) pp. 1200-1218.
- [26] Preuss, H. (2015) A framework for identifying the legacies of a mega sport event. *Leisure Studies* 34 (6): 643–664. doi: <http://doi.org/10.1080/02614367.2014.994552>
- [27] Ricordel P. (2022) Economic component interactions between projects in urban regeneration plans: A network theory framework for plan quality evaluation applied to three French metropolitan
- [28] Ricordel P. (2023) The circular heritage model of Paris 2024 and its possible local legacy perspective. *Local Economy*, London South Bank University, 38(4) pp. 405-417.
- [29] Rudan, E. (2023) Circular Economy of Cultural Heritage—Possibility to Create a New Tourism Product through Adaptive Reuse. *Journal of Risk and Financial Management* 16(3) pp. 1-12.
- [30] Scandizzo, P. & Pierleoni, M. R. (2017) Assessing the Olympic Games: the economic impact and beyond. *Journal of Economic Surveys* 32(1) pp. 1-34.
- [31] Zembri, G., Engrand-Linder, V. (2023) Urban planning law in the face of the Olympic challenge: between innovation and criticism of exceptional urban regeneration. *Local Economy Special Issue: Sports, Politics & Legacy: Building Back Better?*
- [32] Wergeland, E. S. & Hognestad, H. K. (2021). Reusing Stadiums for a Greener Future: The Circular Design Potential of Football Architecture. *Frontiers in Sports and Active Living*, 3, Artikkel 692632. <https://doi.org/10.3389/fspor.2021.692632>

HR in the V4 countries in light of an empirical research

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Abstract: In the period between May 1, 2023 and November 30, 2023, an online questionnaire survey was carried out and a total of 2089 analysable responses was received from various organizations (companies and institutions) in the examined countries (Czech Republic, Poland, Hungary and Slovakia). Our questionnaire used during the survey includes the larger groups of questions to collect the respondent's experiences, opinions and expectations on Human Resources Management activities.

Keywords: HR, V4 countries, country comparions

1 Introduction

1.1 Regional overview

In recent years, the labour markets in the former Eastern European bloc countries and the V4 countries have undergone significant changes, which have also changed the relationship between workers and employers. One of the key issues in these countries is the dramatic increase in labour shortages, which have been influenced by demographic factors, emigration and EU-wide wage differentials. An empirical study has investigated the characteristics of HR systems in the V4 countries, whose authors were

Two or three decades ago, lifelong employment in the same company or organisation was widespread in the V4 countries (Czech Republic, Poland, Hungary, Slovakia). This is now a thing of the past. Today, one of the key issues in these countries is the dramatic increase in labour shortages, which have been influenced by various factors. These include emigration after the change of regime, unfavourable demographic trends, the economic crisis and wage differentials within the European Union. Today, three other crisis factors are linked to the causes mentioned above: the Covid-19 pandemic and its consequences, Russia's war with the Ukraine which has been going on for more than two years, and the recent regional Arab-Israeli war conflict.

In this situation, five universities (University of Silesia, Czech Republic; Hungarian University of Agriculture and Life Sciences and Széchenyi István University, Hungary; University of Szczecin, Poland and Matej Bel University in Banská Bystrica, Slovakia) undertook to collect information on the HR activities of organisations in each of the V4 countries and to compare this information. The online questionnaire survey took place between 1 May 2023 and 30 November 2023, and a total of 2,094 analysable and assessable responses were received from different organisations (companies and institutions) in the four countries.

Characteristics	Czech Republic (CZ)	Hungary (HU)	Poland (PL)	Slovakia (SK)
Population (million people)	10.9	9.8	19.2	5.45
GDP (%)	0.18%	-0.90%	0.23%	1.10%
Unemployment (%)	3.70%	5.10%	3.61%	2.22%
Minimum wage (euro/month)	651	547	641	646
Hourly cost (euro/ working hour)	15.5	10.4	11.5	14.2

Table 1.

Main characteristics of the countries surveyed

Source: [1] Note: the monthly minimum wage in EU countries was between €477 and €2571 in January 2024 [2]

1.2 Survey sample

Nearly 13.92% of the respondents were nationally owned public organisations or companies and 86.08% were private companies. 80.44% of all respondents belonged to organizations employing less than 250 people. The distribution of respondents by sector varies considerably between countries. Respondents providing business services account for the largest share of respondents in the four countries surveyed, with an average of 27.60%. Whereas respondents from the industrial sector accounted for 19.85% of the respondents, and respondents from the retail sector accounted for 14.42% of the respondents. The highest proportion of the organisations surveyed (53.94%) had been in business for more than 15 years [3].

1.3 The role and importance of HR

According to our results, the three most important HR processes and activities in the four countries were (1) employment management and termination, (2) personnel control and (3) talent management. The present survey also shows that the COVID-19 epidemic has had a significant impact on the management of HR functions and tasks in the countries studied and revealed the importance of a number of HR management trends. The impact of teleworking has increased the importance of HR digitalisation during COVID-19.

Various global, regional and local studies [4] show that on average more than 60 percent of the world's organisations have some kind of HR strategy. This figure is much lower for SMEs. In this survey, as we have indicated it earlier, 2,092 respondents from V4 countries have said that 48.85 percent of them have some kind of HR strategy.

2 HR functions

2.1 Jobs and job definitions

A job (job description) is the smallest identifiable unit in the organisation, with a purpose, dynamics, qualitative and quantitative characteristics, and individual responsibility by the job holder [5], [6].

Our survey shows that the average up-to-dateness of job descriptions in the responding organisations is relatively low (23.16%). Respondents in all four countries ranked tasks and duties first, results and responsibilities second and competences third.

2.2 Recruitment-selection

The labour market in the V4 countries has changed significantly over the past decades [7]. Nowadays, these countries are also facing labour shortages in an increasing number of areas, so employers need to take prudent steps to retain their workforce.

Online job advertisements were the most important recruitment and selection tool in the four countries surveyed, followed by letters of recommendation, and the third most common recruitment and selection tool was referrals from friends and acquaintances. The results of a country-by-country survey show that in the Czech Republic, however, the HR department relies almost equally on letters of recommendation and referrals from friends. In Slovakia, human relationships also play a prominent role in recruitment, but firms in Hungary make much less use of the latter option.

selection methods and techniques	CZ	HU	PL	SK	Total
selection based on the applicant's documentation (CV, application form, referrals)	83.41	68.96	69.40	86.72	77.12
interview: structured	86.06	50.39	27.00	88.80	63.06
interview: unstructured	59.38	27.58	26.60	41.15	38.68
tests: expertise/experience	30.29	48.01	5.40	30.99	28.67
tests: skills (thinking, behavior)	29.09	25.99	26.80	32.03	28.48
tests: personality (types)	15.87	34.48	14.00	11.98	19.08
social media profiles	12.26	13.53	11.80	9.64	11.81
tests: intelligence (IQ, EQ)	6.25	17.50	13.20	5.47	10.61
assessment center	4.69	10.87	5.20	7.55	7.08
others	0.36	0.26	1.20	0.00	0.46
Total	100.0	100.0	100.0	100.0	100.0

Table 2.
Use of selection methods and techniques (%)
Source: authors' own editing

2.3 Education-training

One of the important issues in any change process is how and in what way we train and develop the people affected or influenced by the change. Answering this question is difficult because, according to [8: 275] "it is not easy to find a clear causal link between spending on staff development and the economic performance of a company".

Our survey results show that courses/lectures are the most commonly used training methods (48.04%) in the four countries. E-learning, which is gaining momentum in the wake of the covid epidemic, also features prominently among the training methods, especially in Hungarian companies, where 57.82% of the companies surveyed use it. The importance of e-learning is likely to remain outstanding in the future due to its enduring benefits such as flexibility, accessibility from anywhere, from any device, and the possibility of collaboration for geographically dispersed workers. Despite the difficult economic situation, organisations (87.7%) have not cut their training budgets.

2.4 Performance Appraisal / Performance Management

Traditionally, the main purpose of performance appraisal systems and methods used in practice has been to establish pay and incentives [9]. Today, this trend has been complemented by other business objectives (e.g. staff development, promotion, etc.) [10], [11].

Our present research also confirmed our findings from other research (Cranet) that performance appraisal is most often (70.71%) used for incentive (remuneration) purposes. But it is also a welcome fact that training and development was the second most frequently mentioned purpose of performance appraisal.

2.5 Occupational health and safety

Responses from the majority of organisations in the V4 countries participating in our research show that the organisations surveyed recognise the importance of health and safety regulation. The highest number of positive responses (yes) came from Hungary (75.82%), while the lowest number of positive responses (yes) came from the Czech Republic (57.33%).

2.6 Incentives-benefits

The survey shows that the various incentives and benefits account for the largest share (65.18%) both in the V4 region and in each country. There is a significant difference between countries in the use and purpose of bonuses: while in Hungary 75.33% of organisations use this reward, only 54.45% of organisations in the Czech Republic do so. Among the differences between countries, it is important to note that in Hungary almost 80% of organisations provide their employees with a 13th or 14th monthly salary, while in Poland this figure is only 15.8%.

In addition, the most common benefits in Hungary are company mobile phone and car insurance, travel expenses, sick leave, housing allowance, flexible working hours, free drinks, relaxation room, childcare and foreign language courses. Slovakia has the highest rate of pension savings (39.32%).

Compared to the other three countries, Poland leads only in providing life insurance (31.20%) and health insurance (36.40%), with the other benefits playing a less important role in this country. The situation is similar in the Czech Republic, which ranks first in the region in terms of providing extra paid leave. Among the benefits surveyed, flexible working hours (45.78%) and free drinks (45.78%) rank second and third in the region. The use of wellbeing-related benefits such as relaxation space (14.62%) and massage at work (6.25%) were rated relatively low in the region.

2.7 ESS (Employee Self-service) Information System

Our results show that a quarter of respondents (26.04%) in the V4 region and in each country use the ESS. The results suggest that the use of ESS information systems (ESS-SPIS) is not yet widespread in the V4 region. It remains a successful tool for large organisations. More than one third of the surveyed companies in Poland (36.00%) use self-service information systems, while it is in Slovakia that the ESS information system is used by the fewest companies (19.27%).

2.8 HR controlling

In the V4 region, more than a third of the organisations (38.86%) do not use HR controlling solutions at all. However, the majority of organisations with a controlling system (29.3%) use both operational (operative) and strategic controlling tools. One fifth of the surveyed organisations (21.09%) use only operational tools for their controlling processes. On the other hand, there are some organisations (10.75%) that use only strategic controlling tools. A comparison of the countries surveyed shows that the largest proportion of domestic organisations (35.10%) use complex (operational and strategic) HR controlling tools and processes. In a comparison of the four countries surveyed, organisations in the Czech Republic are the least likely to apply personnel controlling solutions. In summary, controlling-based monitoring of HR processes can be identified as an area to be developed in the V4 region, as almost 40% of the surveyed organisations do not use HR controlling tools at all.

2.9 HR outsourcing

The majority of respondents in all V4 countries, with an average of 65.73%, have indicated that they have no experience of outsourcing the HR processes. Positive experiences with HR outsourcing were more common than negative experiences in all countries surveyed, with an average of 27.87% of respondents reporting positive experiences and 6.21% reporting negative experiences. This indicates that the majority of those who tried HR outsourcing found it beneficial and useful.

Conclusions

The research presented here cannot, of course, cover all aspects of the research topic due to the limitations of the scope and the time and capacity available. Furthermore, the aim was not to compare our empirical experiences described here with other publications in the literature, but to publish new information as quickly, efficiently and purposefully as possible. So now we have outlined only the most important characteristics, trends and trends.

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References

- [1] Eurostat. Unemployment statistics. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Unemployment_statistics#Unemployment_in_the_EU_and_the_euro_area,2024 (Accessed: 14 March, 2024)
- [2] Kónya Á. This is where the Hungarian minimum wage is in the EU.(In Hungarian) <https://haszon.hu/megorizni/piacok/minimalber-europai-union2024> (Accessed: 14 March, 2024)
- [3] Poór J., Kőműves Zs. , Szabó-Szentgróti G., Smerek, L. et al. (2024). HR SYSTEM AND ACHIEVING ORGANISATIONAL AIMS - Czechia-Hungary-Poland-Slovakia. (Research monograph) Budapest: Hungarian University of Agriculture and Life Sciences , Visegrad Fund, ISBN: 978-963-623-096-8 (pdf)
- [4] Cranet. Research Network, Cranet Executive Report on International Human Resource Management: Summary and Analysis of 2021-2022 Survey Data . Penn State (US). CRANET, Research Network, Cranet Executive Report on International Human Resource Management. 2023. Available at SSRN: <https://ssrn.com/abstract=4647015>
- [5] Jung, H. Personalwirtschaft. Munich: Oldenburg Verlag, 2008.
- [6] Karoliny M-né & Poór J. Human resource management handbook Systems and applications (6th revised edition). (In Hungarian) Budapest: Wolters Kluwer Publishing House, 2019. <https://mersz.hu/karoliny-poor-emberieroforras-management-kezikonyv-2017>.
- [7] Misiak-Kwit, S., Włodarczyk, K., Mazur-Wierzbicka, E., Smerek, L. & Durian J. The Human Resources Management System in Slovakia and Poland – Chosen Aspects, European Research Studies Journal, XXVI(1), 20-39. 2023. DOI: <https://doi.org/10.35808/ersj/3094>
- [8] Torrington, D.,Hall, L.,Taylor, S.&Atkinson, C. (2014). Human Resource Management. Harlow: Pearson.
- [9] Amstrong, M. & Taylor, S. (2017). Amstrong’s handbook of Human Resource Management Practice. (14thed.) London: KoganPage.
- [10] Indeed (2023). What Are Performance Appraisal Objectives? (With 8 Examples. <https://www.indeed.com/career-advice/career-development/performance-appraisal-objectives> (Accessed: March 04, 2024)
- [11] Peng, J. (2022). Performance Appraisal System and Its Optimization Method for Enterprise Management Employees Based on the KPI Index. Discrete

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Exploring Security Weaknesses in VR Systems

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Abstract: Virtual Reality (VR) systems represent a significant technological advancement with applications in gaming, healthcare, education, and professional training. Despite their transformative potential, VR systems are increasingly vulnerable to security threats due to their complex interactions between hardware, software, and user data. This paper explores the inherent security weaknesses in VR systems through a comprehensive analysis of both hardware and software vulnerabilities. The VR technology landscape is reviewed to understand the critical components and their functions, followed by a detailed examination of various security vulnerabilities, including operating system exploits, application security flaws, physical tampering, and sensor manipulation. The potential impact of these vulnerabilities is illustrated through attack scenarios, emphasizing the risks of unauthorized access, data breaches, and compromised user safety. The paper concludes with a summary of key findings and a table evaluating the threat levels of different vulnerabilities, providing a framework for prioritizing security measures and developing robust defenses against potential threats. Ensuring the security of VR systems is essential for safeguarding user data, maintaining functionality and fostering trust in this rapidly evolving technology.

Keywords: Virtual Reality, Data Privacy, System Resilience, Vulnerability Assessment, Software Protection, Hardware Security

1 Introduction

Virtual Reality (VR) systems represent one of the most transformative technological advancements of the 21st century. By simulating immersive environments, VR has found applications across a wide range of fields, including gaming, healthcare, education, and professional training. In gaming, VR offers unprecedented levels of interactivity and immersion, enabling players to experience digital worlds in a more engaging and lifelike manner. In healthcare, VR is utilized for surgical simulations, pain management, and rehabilitation, providing innovative solutions that enhance patient care and outcomes [1]. Educational institutions leverage VR to create interactive learning experiences that can simulate historical events, complex scientific concepts, and real-world environments, thereby enhancing the learning process [2]. Similarly, professional training programs employ VR to offer realistic

simulations for skills development in fields such as aviation, military training and emergency response [3].

Despite its transformative potential, the increasing reliance on VR technology brings significant security challenges. As VR systems become more sophisticated and pervasive, they also become prime targets for malicious actors. The unique nature of VR, involving intricate interactions between hardware, software, and user data, presents a complex landscape for security vulnerabilities. Understanding and addressing these vulnerabilities is crucial to ensuring the safety, privacy, and integrity of VR systems.

The objective of this paper is to explore the security weaknesses inherent in VR systems, providing a comprehensive analysis of both hardware and software vulnerabilities. To set the stage for this exploration, the second section of the paper reviews the VR technology landscape. This section delves into the various hardware components, such as headsets, sensors, and controllers, that are essential for VR operations. It also discusses the software components, including operating systems, applications, and network protocols, that drive the functionality of VR systems. By examining how these components work together to create immersive experiences, potential points of vulnerability within VR systems are better understood.

The third section of the paper focuses on security vulnerabilities in VR systems. This section provides a detailed analysis of the various ways in which VR systems can be compromised. On the software side, vulnerabilities such as operating system exploits, application security flaws, and network protocol attacks are explored. These vulnerabilities can lead to unauthorized access, data breaches, and system malfunctions. On the hardware side, threats such as physical tampering, sensor manipulation, and wireless communication interception are examined. These threats can disrupt the normal functioning of VR systems, compromise user safety and lead to the loss of sensitive information.

To illustrate the potential impact of these vulnerabilities, the paper presents various attack scenarios and their consequences. For instance, an operating system exploit could allow an attacker to gain full control over a VR system, manipulating its behavior and accessing sensitive user data. Similarly, physical tampering with VR hardware could lead to inaccurate sensor data, resulting in a disorienting and unsafe user experience.

The final section of the paper offers a comprehensive conclusion, summarizing the key findings and highlighting the critical areas that require attention to enhance VR security. This section also includes a table that evaluates the threat levels of different vulnerabilities based on their impact on system functionality, user safety, and the difficulty of executing the attack. By categorizing these vulnerabilities, the paper aims to provide a clear framework for prioritizing security measures and developing more robust defenses against potential threats.

2 VR Technology Landscape

In exploring the technological landscape of VR, it is imperative to understand the fundamental components and architecture that underpin these systems, as they play a pivotal role in the identification and mitigation of security vulnerabilities. VR systems are complex, comprising an intricate blend of hardware and software that work in tandem to create immersive digital experiences. This section delves into the critical elements of VR technology, providing insight into how these components interconnect and the potential security implications thereof.

2.1 Hardware Components

VR headsets are marvels of modern technology, intricately designed with numerous sophisticated hardware components that work together to create an immersive experience. At the core of any VR headset is the display, typically consisting of high-resolution OLED (Organic Light Emitting Diode) or LCD (Liquid Crystal Display) screens [4]. These displays are positioned close to the user's eyes and are essential for delivering the visual content of the VR environment. Each eye receives a slightly different image, creating a stereoscopic 3D effect that provides depth perception. High pixel density and fast refresh rates are critical in these displays to minimize the screen-door effect, where individual pixels become visible, and to reduce motion blur, enhancing the overall realism and immersion.

Integral to the functioning of these displays are the lenses placed between the screens and the eyes. These lenses magnify and focus the images, making them appear at a comfortable distance and providing a wide field of view. Advanced VR headsets feature adjustable lenses to accommodate different interpupillary distances (IPD), which is the distance between the centers of the pupils of the eyes [5]. This adjustability ensures that the visuals remain clear and comfortable, regardless of the user's specific facial anatomy, thereby preventing eye strain and enhancing the immersive experience.

Sensors play a crucial role in the operation of VR headsets. These include accelerometers, gyroscopes, and magnetometers. Accelerometers detect linear acceleration, which helps in determining the headset's position and movement in space. Gyroscopes measure angular velocity, allowing for precise tracking of head rotation. Magnetometers detect the Earth's magnetic field, providing a stable reference point for orientation. Together, these sensors enable six degrees of freedom (6DoF) tracking, capturing both the position and orientation of the user's head [6]. This comprehensive tracking capability is essential for creating a seamless and immersive virtual environment where the user's movements are accurately mirrored in the virtual space.

Modern VR headsets often include external and/or internal cameras, which further enhance the tracking capabilities. External cameras or outside-in tracking systems are typically mounted in the environment and track the position and movements of

the headset and controllers relative to the room. Internal cameras or inside-out tracking systems are embedded in the headset and use computer vision algorithms to map the user's position and movements within the physical space. These cameras can also enable mixed reality experiences by integrating real-world visuals into the virtual environment, creating a more interactive and engaging experience [7].

The processing unit is another critical component of VR headsets, responsible for handling the computationally intensive tasks of rendering VR graphics, processing sensor data and managing user interactions [8]. This unit can be integrated within the headset or housed externally in a connected PC or console. High-performance Graphics Processing Units (GPUs) are particularly important for generating the complex, high-fidelity visuals required for VR without lag or latency, which can cause motion sickness and break the sense of immersion.

Audio is a key aspect of the VR experience, and many headsets come equipped with integrated speakers or headphone jacks. Spatial audio, which provides directional sound cues, is crucial for enhancing the sense of presence [9]. This audio technology makes users feel like sounds are coming from specific locations within the virtual environment, adding to the realism and immersiveness of the experience. High-quality audio is essential for creating an engaging and believable virtual world.

Connectivity options in VR headsets include both wired and wireless solutions. Wired connections, such as USB and HDMI, ensure high-speed data transfer and low latency, which are vital for maintaining a seamless VR experience. Wireless connections, such as Bluetooth and Wi-Fi, offer greater freedom of movement and ease of setup, though they must handle high data rates and low latency to be effective. Advanced wireless solutions may use dedicated transmitters and receivers to achieve the necessary performance levels [10].

The power supply of a VR headset, whether from internal rechargeable batteries or external power adapters, ensures that the device functions reliably during use. Internal batteries provide portability and freedom of movement, while external power adapters offer continuous power for extended sessions without the need for recharging, supporting uninterrupted VR experiences [11].

Controls and buttons on the headset allow users to manage basic functions and interact with the user interface. These may include power buttons, volume controls, and interface navigation buttons. Some headsets also feature touchpads or additional buttons for in-VR interactions, enhancing the user's ability to control and navigate the virtual environment [12].

Comfort is a critical consideration in VR headset design, addressed through adjustable head straps, face cushions, and other ergonomic components. These features ensure that the headset fits securely and comfortably, preventing discomfort and fatigue during extended use. High-quality straps distribute the headset's weight evenly, while face cushions provide a comfortable seal around the eyes, enhancing the overall user experience and thermal conductivity [13].

Storage within the headset, often in the form of internal flash memory, is used to store software applications, user data and settings [14]. Adequate storage capacity is essential for accommodating the large size of VR applications and games, ensuring that users can download and access their content without issues.

Finally, built-in microphones allow users to communicate with others within VR environments, enabling voice commands, multiplayer interactions and social experiences [15]. High-quality microphones ensure clear audio capture, enhancing the overall user experience by facilitating effective communication.

2.2 Software Components

VR headsets are sophisticated devices that rely on a complex interplay of various software components to deliver an immersive and seamless user experience. At the heart of these devices is the operating system (OS), which serves as the foundational software managing all hardware and software resources. The OS handles critical tasks such as memory management, process scheduling, and input/output operations. By providing a stable platform for running VR applications, the OS ensures efficient operation and optimal performance of the VR headset. Common operating systems used in VR headsets include custom versions of Android or Linux, designed specifically to handle the unique demands of VR technology [16].

Complementing the operating system are device drivers, specialized software that enables the OS to communicate effectively with the VR headset's hardware components [17]. Each piece of hardware, whether it's the display, sensors or audio system, requires specific drivers to function correctly. These drivers act as translators, converting the operating system's commands into actions performed by the hardware and vice versa, ensuring smooth interaction between the software and hardware components.

Firmware is another crucial layer of software, embedded directly into the hardware components of the VR headset. This low-level software controls the basic operations of the hardware, such as initializing components at startup and managing fundamental tasks [18]. Firmware provides a stable and consistent environment for higher-level software to operate and firmware updates can enhance performance and fix bugs, thereby improving the overall functionality and security of the VR headset.

The user interface (UI) and user experience (UX) software encompass the graphical interfaces and interaction models that users engage with while using the VR headset. This software manages the visual presentation and interactive elements within the VR environment, including menus, settings interfaces, and in-VR interactions [19]. Effective UI/UX design is critical for ensuring that the VR experience is intuitive, accessible and engaging, thereby reducing the learning curve for new users and enhancing overall satisfaction.

The graphics rendering engine is responsible for generating the visual content displayed in the VR headset. This sophisticated software converts 3D models, textures, lighting and shading into the two-dimensional images seen through the VR headset. Operating in real-time, the graphics rendering engine must maintain high frame rates and minimal latency to prevent motion sickness and ensure a smooth visual experience. Popular graphics engines used in VR include Unity and Unreal Engine, which are renowned for their ability to deliver high-fidelity visuals and complex interactions [20].

Application Programming Interfaces (APIs) and Software Development Kits (SDKs) are vital tools for developers creating VR applications [21]. APIs allow software to interact with the VR hardware and other system components, providing standardized access to features like tracking, rendering and audio. SDKs offer a comprehensive suite of tools, documentation, and sample code to help developers build and optimize VR applications, ensuring they run efficiently on the target hardware. These tools are essential for fostering a vibrant ecosystem of high-quality VR applications.

Security software is another critical component, encompassing measures and protocols designed to protect the VR headset and its data from unauthorized access and threats. This software includes encryption, authentication mechanisms and threat detection systems that safeguard user data and ensure the integrity of VR applications. Regular updates and patches are also necessary to address vulnerabilities and protect against malware and cyber-attacks, thereby maintaining a secure VR environment.

A content management system (CMS) manages the distribution, storage and organization of VR content. The CMS allows users to download, update and organize VR applications and experiences efficiently. Features such as content recommendations, user profiles and cloud synchronization enhance the user experience by making content management straightforward and personalized.

3 Security Vulnerabilities in VR Systems

This section examines the security vulnerabilities in VR systems, focusing on both hardware and software aspects, as well as their details.

3.1 Hardware Vulnerabilities

VR systems, while offering remarkable immersive experiences, also present numerous hardware-based vulnerabilities that can be exploited by attackers, posing significant security risks. These vulnerabilities span various components of the VR hardware, each susceptible to specific types of attacks that could compromise the integrity, functionality and safety of a VR system.

One of the primary vulnerabilities lies in the potential for physical tampering with the VR hardware. This can involve deliberate manipulation or damage to the physical components such as headsets, sensors or cables. This could also involve modifying hardware components, inserting malicious devices or installing unauthorized firmware. Sensor manipulation is another critical vulnerability. VR headsets depend heavily on sensors like accelerometers, gyroscopes and magnetometers for tracking movements and orientation. Attackers can exploit these sensors through electromagnetic interference (EMI) or by spoofing sensor inputs, leading to false tracking data [22]. For example, if an attacker manipulates the accelerometer, the headset could misinterpret user movements, resulting in a disjointed and unsafe virtual environment.

Camera hijacking poses a significant risk, as modern VR headsets often use internal and external cameras for tracking and environmental awareness [23]. Unauthorized access to these cameras can allow attackers to monitor and manipulate the user's physical environment. This breach could lead to privacy violations, such as capturing sensitive data from the user's surroundings or manipulating the visual input to inject malicious or harmful VR content. An attacker could, for instance, alter the camera feed to display misleading visuals, potentially causing physical harm if the user interacts with their surroundings based on incorrect spatial information.

Firmware exploits represent another substantial vulnerability. Firmware, the low-level software embedded in the VR hardware, controls the fundamental operations of the device. If not properly secured, firmware can be exploited by attackers to gain control over the hardware [24]. For example, an attacker could inject malicious code into the firmware, allowing them to disable security features, extract sensitive data, or alter the functionality of the VR headset. This could lead to scenarios where the headset performs unauthorized actions or becomes a conduit for further cyber-attacks.

Wireless communication interception is a critical concern, given that many VR headsets utilize Bluetooth and Wi-Fi for connectivity. These wireless connections can be intercepted and tampered with if not properly encrypted and secured [25]. Attackers could perform man-in-the-middle attacks, intercepting data transmissions between the headset and other devices. This could result in the capture of sensitive information or the injection of malicious data. For example, intercepting the data stream between a VR headset and its controllers could allow an attacker to manipulate the user's inputs, disrupting the VR experience.

Peripheral device exploits highlight vulnerabilities associated with the additional devices connected to the VR system, such as controllers and motion sensors. These peripherals, if not securely connected and authenticated, can introduce vulnerabilities. An attacker could compromise a peripheral device to send malicious inputs to the VR system, potentially disrupting the user experience or gaining unauthorized control. For example, exploiting a vulnerability in a motion sensor

could allow an attacker to alter the tracking data, causing the VR environment to respond inaccurately to user movements.

Battery and power supply manipulation can also pose risks. The power supply and battery systems in VR headsets are crucial for their operation. Attackers could manipulate these systems to cause overheating, leading to potential damage or unsafe operating conditions. For instance, inducing a power surge could damage the headset's internal components or cause it to shut down unexpectedly, disrupting the VR experience and possibly leading to data loss or hardware failure.

Internal storage attacks target the data stored within the VR headset, such as applications and user data. If the internal storage is not properly protected, attackers can access and modify it. This could involve stealing sensitive data, installing malware or corrupting system files. Audio subsystem exploits involve targeting the audio systems in VR headsets, which provide immersive sound experiences. Attackers could capture sensitive audio or inject malicious sounds. For example, exploiting the audio subsystem to eavesdrop on conversations or play harmful audio frequencies could cause discomfort or confusion for the user.

Component wear and tear refers to the physical degradation of VR hardware components such as connectors, wires and lenses due to regular use. Wear and tear might result in intermittent failures or degraded performance, affecting the accuracy of input and output. For example, worn-out connectors could lead to intermittent disconnections, causing disruptions in the VR experience.

3.2 Software Vulnerabilities

VR systems, while providing cutting-edge and immersive experiences, are inherently vulnerable to a myriad of software-based threats that can be exploited by attackers. These vulnerabilities compromise the security, privacy and integrity of VR systems and user data, necessitating a thorough understanding of potential attack vectors to mitigate risks effectively.

Operating System Exploits represent a significant vulnerability within VR systems. The operating system (OS) manages all hardware and software resources, and any weaknesses within the OS can be exploited to gain unauthorized access or control. For instance, attackers might leverage OS vulnerabilities to execute arbitrary code, escalate privileges, or maintain persistent access to the system. Such exploits can lead to a complete compromise of the VR environment, enabling attackers to manipulate system behavior and access sensitive data.

Application Security Flaws are another critical concern. VR applications may contain security flaws such as buffer overflows, code injection or improper input validation [26]. A buffer overflow, for example, occurs when a program writes more data to a buffer than it can hold, allowing attackers to overwrite adjacent memory locations. This can result in the execution of malicious code, enabling attackers to

take control of the system or cause it to crash. Injection flaws, including SQL, NoSQL, OS, and LDAP injections, involve sending untrusted data to an interpreter as part of a command or query. By injecting malicious scripts or commands, attackers can execute unauthorized actions or access data without proper authorization, severely compromising the security of the VR application.

Malicious Software Updates represent another vector for attacks. Distributing malicious software updates can compromise the VR system by introducing malware, spyware or other harmful software. These updates can alter system behavior, steal sensitive information, or render the VR system inoperable. An attacker could, for example, craft a seemingly legitimate software update that, once installed, provides them with remote access to the VR system, enabling further exploitation and data theft.

User Interface Manipulation exploits flaws in the VR user interface to mislead or manipulate users. Attackers can design deceptive interfaces to trick users into revealing sensitive information or performing harmful actions. For instance, a malicious VR application could present a fake login screen, capturing user credentials when entered. This type of attack leverages the immersive nature of VR to create convincing but fraudulent interfaces that deceive users.

Data Leakage occurs when sensitive data within VR applications is improperly handled or stored. This vulnerability can lead to unauthorized parties gaining access to sensitive information, resulting in privacy breaches. For example, if a VR application fails to securely store user profiles, session logs or biometric data, attackers could exploit this weakness to access and misuse this information, compromising user privacy and security.

Session Hijacking is a significant risk, where attackers take over an active VR session by exploiting session management flaws [27]. This allows them to assume control of the session, access private data or perform unauthorized actions. For instance, if session tokens are not adequately protected, an attacker could capture and reuse them to hijack a user's session, gaining access to sensitive data and functionalities.

Man-in-the-Middle (MITM) Attacks involve intercepting and altering communications between the VR headset and other devices. By doing so, attackers can inject malicious data, steal information or disrupt communications [28]. This is particularly critical when data transmissions are unencrypted or weakly encrypted. For example, an attacker intercepting the communication between a VR headset and its controllers could manipulate the data stream to alter user inputs, leading to a compromised and potentially harmful VR experience.

Insecure APIs are a notable vulnerability, as Application Programming Interfaces (APIs) used by VR applications can contain weaknesses. Poorly designed or insecurely configured APIs can expose more data than intended [29]. Attackers can exploit these weaknesses to access and extract data directly from the APIs,

potentially leading to data breaches and unauthorized access to VR system functionalities.

Insecure Deserialization is a vulnerability where flaws in the deserialization process allow attackers to manipulate serialized data to achieve remote code execution [30]. This can lead to executing arbitrary code on the VR platform by deserializing data containing malicious objects. An attacker could craft a malicious payload that, when deserialized by the VR application, executes harmful code, potentially taking over the system.

Account Takeover via Credential Theft is facilitated by weak or reused passwords, lack of two-factor authentication or phishing attacks. Attackers can gain access to user accounts by stealing login credentials, then access personal and sensitive data. For example, phishing emails that trick users into revealing their login information can lead to account takeovers and unauthorized access.

Spyware and Malware represent significant threats, especially when VR systems download insecure sources, phishing emails or compromised third-party software. Spyware can log keystrokes, capture screen data and monitor user actions within the VR environment. Malware infections can lead to data theft, system disruptions, and unauthorized access.

In summary, VR systems are susceptible to a wide range of hardware and software-based vulnerabilities, each with the potential to be exploited by attackers. While there are many more vulnerabilities, this paper focuses on the most critical ones. Understanding these vulnerabilities and potential attack vectors is crucial for identifying security risks and developing robust defenses to protect VR systems from malicious threats.

3.3 Comparative analysis

The categorization of VR system vulnerabilities into threat levels is based on the potential impact each vulnerability can have on system security, functionality and user safety. Critical threats are those that can cause severe disruptions or complete system failure, such as insecure peripheral connections and side-channel attacks, which can compromise the entire security framework and lead to unauthorized control or data theft. Overheating and outdated firmware are also critical because they can cause hardware failure and provide low-level access to attackers.

Threat Level	Hardware Vulnerabilities	Software Vulnerabilities
Low	Component Wear and Tear	Inadequate Logging and Monitoring
Low	Faulty Calibration	User Interface Manipulation
Low	Optical Distortions and Failures	Data Leakage
Medium	Sensor Spoofing	Improper Authentication
Medium	Signal Interference	Insecure Deserialization
Medium	Camera-Based Tracking Compromise	Insecure Software/Firmware
Medium	Unauthorized Hardware Access	API Exploits
High	Physical Tampering	Operating System Exploits
High	Sensor Manipulation	Application Security Flaws
High	Camera Hijacking	Firmware Injections
High	Firmware Exploits	Network Protocol Attacks
High	Wireless Communication Interception	Malicious Software Updates
High	Physical Access Attacks	Session Hijacking
High	Peripheral Device Exploits	Man-in-the-Middle (MITM) Attacks
Very High	Battery and Power Supply Manipulation	Interception of Data Transmissions
Very High	Display Tampering	Compromising Data Storage
Very High	Internal Storage Attacks	Account Takeover via Credential Theft
Very High	Audio Subsystem Exploits	Spyware and Malware
Critical	Outdated Firmware	Code Injection
Critical	Overheating	Cross-Site Scripting (XSS)
Critical	Insecure Peripheral Connections	Side-Channel Attacks

Table 1.
VR Systems Hardware and Software Vulnerabilities
Source: Author

High threats include vulnerabilities that significantly impact system operation and user experience but may not lead to total system compromise. These include sensor manipulation, firmware exploits and man-in-the-middle attacks, which can disrupt

functionality and allow unauthorized access. Medium threats, such as signal interference and insecure software/firmware, can cause notable disruptions and unauthorized access but are typically less catastrophic than high or critical threats. Low threats, like optical distortions and data leakage, primarily degrade user experience and data integrity but pose less immediate and severe risks compared to other vulnerabilities.

This categorization helps prioritize security measures by focusing on the most impactful threats first. Each identified vulnerability exemplifies just a fraction of the numerous security challenges that exist, highlighting the comprehensive and multifaceted landscape of VR system security. Thus, it is evident that virtually every component and aspect of VR systems can be a potential security risk, demonstrating the necessity for robust and prioritized security measures.

Conclusion

Ensuring the security and integrity of VR hardware requires a multi-faceted approach integrating physical security measures, technological safeguards and user education. Preventing unauthorized access is fundamental, achieved by placing VR equipment in locked rooms or secured enclosures, ensuring only authorized personnel have access. Continuous protection is essential both during operational hours and when the equipment is idle to reduce risks of theft, vandalism or unauthorized usage.

Incorporating tamper detection mechanisms into VR systems is also crucial. These mechanisms alert administrators to unauthorized access or modifications, and can disable the device to prevent further tampering, helping to identify and mitigate security threats quickly. Security considerations should be integral to the design and manufacturing of VR hardware. This involves using tamper-resistant components and ensuring critical parts are difficult to access without specialized tools, thus embedding security into the hardware from the outset.

Reliability and security of VR hardware heavily depend on using certified and tested components from reputable manufacturers. These components must meet industry standards and undergo rigorous testing. Additionally, using trusted software applications reduces the risk of introducing vulnerabilities.

Educating users about proper handling and security practices for VR equipment is vital. Training ensures that personnel are aware of security protocols and can recognize and respond to potential threats. This user training promotes a culture of security awareness, significantly reducing the risk of human error leading to security breaches.

Software aspects of VR systems also present substantial security challenges, with applications often requiring significant amounts of sensitive data, making them targets for cyberattacks. Research should focus on developing advanced encryption

techniques and secure communication protocols to protect data integrity and privacy, especially as VR applications increasingly rely on cloud-based services.

The immersive nature of VR introduces additional security concerns, making users susceptible to phishing attacks and social engineering. Research on designing user interfaces and interactions that minimize these risks is imperative, along with developing educational tools and training programs to raise user awareness about potential threats and safe practices in VR environments.

The integration of VR systems with other technologies, such as the Artificial Intelligence (AI), opens new security vulnerabilities. Understanding these implications and developing strategies to secure interconnected devices is necessary. Additionally, the regulatory and ethical framework surrounding VR security must evolve with the technology, focusing on developing standards and guidelines that ensure ethical use while safeguarding against misuse.

In conclusion, despite significant advancements in addressing VR security weaknesses, continuous research is crucial to stay ahead of emerging threats. Investing in thorough studies encompassing hardware, software, user experience, and regulatory aspects will help build more secure and resilient VR systems. Ensuring VR security is critical to unlocking its full potential.

References

- [1] Lungu, A. J., Swinkels, W., Claesen, L., Tu, P., Egger, J., & Chen, X. (2021). A review on the applications of virtual reality, augmented reality and mixed reality in surgical simulation: an extension to different kinds of surgery. *Expert review of medical devices*, 18(1), pp. 47-62.
- [2] Mahmoud, K., Harris, I., Yassin, H., Hurkxkens, T. J., Matar, O. K., Bhatia, N., & Kalkanis, I. (2020). Does immersive VR increase learning gain when compared to a non-immersive VR learning experience?. In *International Conference on Human-Computer Interaction* (pp. 480-498). Cham: Springer International Publishing.
- [3] Yamamoto, G. T., & Altun, D. (2021). Virtual reality (vr) technology in the future of military training. Unpublished manuscript.
- [4] Su, Z., Zhanghu, M., & Liu, Z. (2021). P-12.5: Investigation on AR/VR Displays Based on Novel Micro-LED Technology. In *SID Symposium Digest of Technical Papers* 52, pp. 609-612.
- [5] Brickler, D., & Babu, S. V. (2021). An evaluation of screen parallax, haptic feedback, and sensory-motor mismatch on near-field perception-action coordination in VR. *ACM Transactions on Applied Perception (TAP)*, 18(4), pp.1-16.

- [6] Singh, M., Shankar, R. A., & Jung, B. (2021). Inside-out magnetic tracking for virtual/augmented reality applications. *IEEE Sensors Journal*, 21(24), 28097-28106.
- [7] Banquero, M., Valdeolivas, G., Trincado, S., García, N., & Juan, M. C. (2023). Passthrough mixed reality with oculus quest 2: A case study on learning piano. *IEEE MultiMedia*, 30(2), pp. 60-69.
- [8] Hosny, Y. S. S., Salem, M. A. M., & Wahby, A. (2020). Performance optimization for standalone virtual reality headsets. In *2020 IEEE Graphics and Multimedia (GAME)* pp. 13-18. IEEE.
- [9] Gupta, R., He, J., Ranjan, R., Gan, W. S., Klein, F., Schneiderwind, C., ... & Välimäki, V. (2022). Augmented/mixed reality audio for hearables: Sensing, control, and rendering. *IEEE Signal Processing Magazine*, 39(3), 63-89.
- [10] Hu, F., Deng, Y., Saad, W., Bennis, M., & Aghvami, A. H. (2020). Cellular-connected wireless virtual reality: Requirements, challenges, and solutions. *IEEE Communications Magazine*, 58(5), 105-111.
- [11] Radoeva, R., Petkov, E., Kalushkov, T., Valcheva, D., & Shipkovenski, G. (2022). Overview on hardware characteristics of virtual reality systems. In *2022 International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA)* pp. 01-05. IEEE.
- [12] Fahmi, F., Tanjung, K., Nainggolan, F., Siregar, B., Mubarakah, N., & Zarlis, M. (2020). Comparison study of user experience between virtual reality controllers, leap motion controllers, and senso glove for anatomy learning systems in a virtual reality environment. In *IOP Conference Series: Materials Science and Engineering (Vol. 851, No. 1, p. 012024)*. IOP Publishing.
- [13] Wang, Z., He, R., & Chen, K. (2020). Thermal comfort and virtual reality headsets. *Applied ergonomics*, 85, 103066.
- [14] Raymer, E., MacDermott, Á., & Akinbi, A. (2023). Virtual reality forensics: Forensic analysis of Meta Quest 2. *Forensic Science International: Digital Investigation*, 47, 301658.
- [15] Rodríguez, I., & Puig, A. (2021). Open the microphone, please! conversational ux evaluation in virtual reality.
- [16] Kapoor, A., & Sharma, S. (2016). Implementation of a Virtual Reality Operating System (VROS) for the next generation of computing. In *2016 6th International Conference-Cloud System and Big Data Engineering (Confluence)* pp. 731-736. IEEE.
- [17] Kadav, A., & Swift, M. M. (2012). Understanding modern device drivers. *ACM SIGPLAN Notices*, 47(4), 87-98.

- [18] Tan, C. J., Mohamad-Saleh, J., Zain, K. A. M., & Aziz, Z. A. A. (2017, July). Review on firmware. In Proceedings of the International Conference on Imaging, Signal Processing and Communication (pp. 186-190).
- [19] Saleh Ali Alkhalifah, E. (2023). The importance of UI & UX Design in Virtual Reality for Showcasing Umrah Rituals: Impact of Age and Cybersickness in User Experience. 255-224, (12)6, مجلة الفنون والعلوم الانسانية.
- [20] Scorpio, M., Laffi, R., Teimoorzadeh, A., Ciampi, G., Masullo, M., & Sibilio, S. (2022). A calibration methodology for light sources aimed at using immersive virtual reality game engine as a tool for lighting design in buildings. *Journal of Building Engineering*, 48, 103998.
- [21] Parisi, T. (2015). Learning virtual reality: Developing immersive experiences and applications for desktop, web, and mobile. " O'Reilly Media, Inc."
- [22] Barua, A., & Al Faruque, M. A. (2020, October). Special session: Noninvasive sensor-spoofing attacks on embedded and cyber-physical systems. In 2020 IEEE 38th International Conference on Computer Design (ICCD) (pp. 45-48). IEEE.
- [23] Lee, J., & Lee, K. (2022). Spy in Your Eye: Spycam Attack via Open-Sided Mobile VR Device. *IEICE TRANSACTIONS on Information and Systems*, 105(10), 1817-1820.
- [24] Kachur, A., Lysenko, S., Bodnaruk, O., & Gaj, P. (2023). Methods of improving security and resilience of VR systems' architecture.
- [25] Baha'A, A., Almazari, M. M., Alazrai, R., & Daoud, M. I. (2021, May). Exploiting Wi-Fi signals for human activity recognition. In 2021 12th International Conference on Information and Communication Systems (ICICS) (pp. 245-250). IEEE.
- [26] CQR Company. (2023, February 10). Improper input validation. Retrieved from <https://cqr.company/web-vulnerabilities/improper-input-validation/>
- [27] Li, L., Chen, C., Pan, L., Zhang, L. Y., Zhang, J., & Xiang, Y. (2023, October). SigA: rPPG-based Authentication for Virtual Reality Head-mounted Display. In Proceedings of the 26th International Symposium on Research in Attacks, Intrusions and Defenses (pp. 686-699).
- [28] Vondráček, M., Baggili, I., Casey, P., & Mekni, M. (2023). Rise of the metaverse's immersive virtual reality malware and the man-in-the-room attack & defenses. *Computers & Security*, 127, 102923.
- [29] SecuritySenses. (2023, November 16). APIs - The hidden cause of data breaches. Retrieved from <https://securitysenses.com/posts/apis-hidden-cause-data-breaches>

- [30] OWASP Foundation. (n.d.). Insecure deserialization. Retrieved from https://owasp.org/www-community/vulnerabilities/Insecure_Deserialization

The behaviour of the albanian consumer towards genetically modified products

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Abstract: Population growth has made food sufficiency impossible, and the lack of Food has led to the search for alternative ways of providing it. Genetically modified organisms have been seen as a solution to one of the world's biggest problems today. The study of consumer behavior is crucial for orienting the offer of different products. This aspect is also essential for products containing genetically modified organisms, foods created by organisms whose DNA has been altered using genetic engineering and molecular biology techniques. In studies done in different countries, consumers are skeptical of these products. The results of our work go along the same lines, which show that consumers do not tend to go towards GMO products and do not have enough information about them. In this study, we will try to answer our main research questions: How well do consumers know genetically modified foods, and what is their attitude towards GMOs? Are Albanians sufficiently informed about them, and what is their approach to these products?

Keywords: product, consumer behavior, genetically modified organisms

1 Introduction

Genetically modified organisms have been seen as a solution to one of the world's biggest problems today. Population growth has made food sufficiency impossible. According to the World Bank report (2020), nearly 690 million people - or 8.9 percent of the global population- are hungry. Food insecurity can worsen the quality of nutrition and increase the risk of various forms of malnutrition, potentially leading to undernutrition and overweight. The cost of healthy meals is unaffordable for more than 3 billion people in the world (World Bank 2021)

As mentioned above, the lack of Food leads to the search for alternative ways such as GMOs. The part of genetic technology that combines hereditary material (genes) from different organisms (plants, animals, and microorganisms) is called recombinant DNA technology or genetic engineering. The organism that arises from a combination of genes is a genetically modified organism (GMO). Food containing or derived from a genetically modified organism constitutes genetically modified Food (WHO 2021). Using DNA recombination technology, an organism is created with specific desired properties in food production to achieve resistance to insects and viruses, tolerance to herbicides, and improved nutritional value of Food.

New technologies affect people's decision-making trends. Changes arise through new processes and products, often improving some dimensions of living and making others worse. In many cases, costs are uncertain in the form of a probability of a threat, usually referred to as risks. This is because new technologies are associated with scientific uncertainty, considering that not all social and individual consequences of their initiation are fully known.

Moreover, innovations impact people's social life, generating conflicts with their previous views and values. This is particularly important in the case of Food and nutrition, when people are faced with daily decisions about how to eat better (Barrena et al., 2009). A consumer's perspective on introducing new GMO products (which are added to pre-existing products) largely depends on the existing information in the system. Therefore, releasing more information about food-related risks shapes people's perception of risk. Consequently, people act on perceived risks, carefully balancing benefits and costs, both in the short term and especially in the long term. Given that the long-term effects are not known with certainty, we will usually refer to these effects as risks, given that there is some information about individuals to form an expectation or a probability of the risk qualitatively. The same can be applied to benefits, which mainly influence product acceptance based on individual subjective knowledge (Boccaletti, S. & Moro, D, 2000)

GMO products are products that are not very familiar to Albanian consumers. The main goal of this paper is to analyze consumer preferences towards GMO products through a survey. The paper continues as follows: in the second chapter, the theoretical background and the review of the literature are analyzed, which includes data on the definition of genetically modified organisms, the benefits and risks that come from them, as well as the main approaches that different authors have

proposed. In the third chapter, the methodology followed for conducting the study is analyzed, where the survey of 50 consumers in the city of Tirana was used as the primary method, as well as the research question and the hypotheses of the paper. In the fourth chapter, we present the analysis of the results, which we showed in survey data reports; in the fifth chapter, we have the conclusions drawn from the study.

2 Literature review

Technological advances in food production are considered inevitable changes in today's food industry, and many new foods or food ingredients consumed worldwide have been produced through genetic modification since the mid-1990s. However, most consumers remain uninformed about genetically modified foods; thus, it is natural that they do not fully understand the scientific basis of their technology, including its potential benefits and risks. Previous studies of this technology show that consumers perceive this as more of a threat than a benefit. The attitude towards a product is based on knowledge about the product itself and its attributes, called bottom-up attitude formation (Bech-Larsen & Grunert, 2003). However, attitudes do not depend only on one specific product but on a good part of them. The more people are aware of GMOs, the more they perceive the benefits to outweigh the risks; however, they are generally unaware of whether or not they consume GMO foods. This result is consistent with many other studies, which found that despite consumers' somewhat greater information about GMO products and their expected benefits, they nevertheless maintain a negative attitude toward GMO foods. This theoretical model has been empirically supported by several studies such as (Moon, 2001) and (Sawhney M. et al., 2004), etc., which state that consumers associate, as a whole, more negative thoughts than positive ones for agro-biotechnology. In addition, evidence suggests that individual behaviors are driven by personal perceptions or beliefs about risks rather than technical assessments of risk provided by experts (Frewer et al., 1998).

2.1 What are genetically modified organisms?

GMOs result from DNA recombination procedures, biotechnological procedures that allow genetic improvements of Food or organism. This 'recombination' can be accomplished by moving genes from one organism to another. GMO (Genetically Modified Organism) refers to a living organism whose genetic material has been modified by humans through genetic engineering techniques (Cunningham et al., 2001).

2.2 Advantages and risks of GMO use

Advantages:

With an ever-increasing global population and an estimate that a child dies of hunger every two seconds, this technology holds great promise as it benefits farmers and society worldwide. The positive sides of genetically modified crops are:

- better taste
- increase in nutritional values
- resistance to diseases and pests
- rapid production of crops.

Seeds are genetically modified for many reasons, including improving insect resistance and generating healthy crops. This can reduce the risk of crop failure and make crops more resistant to extreme weather. The technology could eliminate seeds and produce a longer shelf life, which allows "safe transportation for people in places where there is no access to high-nutrition foods." Environmental benefits: fewer chemicals, time, and machinery because soils need crops, which can help reduce environmental pollution, gas emissions, and soil erosion.

Better nutrition: "By modifying certain foods in terms of minerals or vitamins, companies can supply much-needed nutrients and help fight malnutrition around the world," according to the Food and Agriculture Organization of the United Nations. They also state that one of the positive sides of GMOs is that farmers can produce Food with more calories (Galán et al., 2008).

Risks:

The researchers warn that there are no long-term, large-scale analyses to prove genetically modified foods safety (GMOs). They draw attention to several potential risks.

- Allergic reaction: if a gene, which produces a protein that causes allergic reactions, ends up in, for example, cereals, people suffering from food allergies could be exposed to a significant risk.
- Greater poisonous ability: some experts think that genetic modification could enhance the natural poisons of plants in unforeseen ways. When a gene becomes active in a plant and gives the desired effect, it can produce natural poisons. Toxicity is also caused by toxins released by plants resistant to insects or herbicides. Resistance to herbicides is due to the insertion into the deoxyribonucleic acid (DNA) of plants, a gene of bacterial origin that confers resistance to herbicides (IYIZOBA, H. J. C, 2016).
- Antibiotic resistance: as part of the genetic modification of plants, scientists use marker genes to determine whether the desired gene has been successfully introduced. Since most marker genes confer resistance to antibiotics, scientists fear that this may contribute to the growing problem of antibiotic resistance. But other scientists argue that these marker genes are genetically arranged disorderly before use, reducing this risk.

- Damage to the human organism: in this case, the consumer, by eating Food with GMOs, is getting a new DNA that has not been fed with before and thus risks damaging not human DNA but damages the permanent bacteria of the digestive system by thus causing significant disturbances in the process of food digestion. Human studies show that genetically modified Food can leave behind material after consumption, possibly causing long-term problems. For example, genes inserted into genetically modified soybeans can transfer the DNA of bacteria that live inside us, as well as insecticide toxin produced by genetically modified corn has been found in the blood of pregnant women (Harward University Blog 2015)

2.3 Objective and subjective knowledge of consumers

Consumer knowledge influences their attitudes toward GMO foods and other consumer goods. Previous studies showed a positive relationship between consumers' understanding of GMO technology and their attitude toward GMO foods (Boccaletti, S. & Moro, D, 2000). Consumer knowledge of this technology also relates to consumer perception of the benefits and risks of GMO foods. It is essential to regulate biased perceptions and intentions regarding these products (Curl et al., 2015). When consumers have a high level of involvement in a particular product category that is an area of personal interest, their product knowledge increases. Further, increased consumer knowledge typically increases the likelihood of seeking new information as part of the decision-making process within the product category.

Consumer knowledge is divided into objective and subjective because of the difference between what consumers think they know something and what they know. This change can affect consumer attitudes and purchase intention toward foods. Knowledge, namely accurate information about channels collected over a long period by consumers, memories, and current understanding of the consumer, have a close relationship with the ability of consumers to select products (Park & Lessig, 1981).

In contrast, subjective knowledge is based on direct experience by consumers and the interpretation of these experiences and suggests a close relationship between product choice and subjective knowledge. Although objective and subjective knowledge is related, previous studies have shown that objective knowledge is rarely the same as subjective knowledge. Leung et al. (2013) reported that although subjective and objective knowledge is interrelated, they cannot be replaced and should be measured separately. Some studies have shown that these two compounds have a weak or moderate relationship. According to Kruger & Dunning (1999), despite having little objective knowledge, consumers may think that they have sufficient knowledge; moreover, although the level of their objective knowledge may be high, they may sometimes judge by subjectivity. Therefore, measuring the two constructs separately and identifying the imbalance between them will help

determine which type of knowledge influences consumer responses to GMOs, providing more complete insights into the food industry.

Given that genetically modified organisms are a relatively new phenomenon, the number of studies conducted concerning consumer preferences and information about them is limited. Most European consumers do not have a particularly positive attitude toward GMOs (Bonny, S., 2003). Different elements are formed based on this attitude. Below is an overview of the main determinants of consumer attitudes towards GMOs (mainly) in European countries. It is essential since the impact of these attitudes on consumer purchase intentions regarding the description of genetically modified food products is high. According to the attitude model of Grunert et al. (2000), attitudes toward GMOs are determined by the perception of risk and benefits. In turn, beliefs about (potential) risks and benefits are powerfully explained by consumer knowledge and more general attitudes (e.g., attitude toward technology, consumer trust in government, and food producers) rooted in socio-economic, demographic, and cultural characteristics. The Fishbein model (1963) suggests that, under certain conditions of high involvement, an individual's attitude toward an object is determined by the sum of the beliefs they have about the consequences or attributes of that object weighted by how they are evaluated and are commonly referred to as outcome beliefs and outcome estimates. Involvement is the perceived degree and personal importance accompanying product choice (Akpyomare et al., 2013). Multi-attribute models, such as Fishbein's, assume that consumers use formal learning as a hierarchical effects approach in which beliefs lead to their purchase behavior and attitudes.

Regarding the risk side related to GM (genetically modified) Food, consumers mainly perceive the possible risks for human health and the environment (Bereano, 1999). On the other hand, consumers' ethical concerns focus on internal beliefs that GM is wrong (Frewer et al., 1998). Such situations are more significant concerning whether animal or human DNA is involved rather than plant microorganisms. Another aspect that consumers are concerned about is the religious acceptability of these products. For Christians, there is a concern for the integrity of God's creation and humanity's relationship with God. Muslims and Jews focus on the prescribed diet and worry if genetically modified Food contains genes from animals whose meat is forbidden, such as pigs (Thomson, 2003). Another ethical concern concerns the right to choose freely as consumers. For example, vegetarians should be able to avoid food products produced from genetically modified plants into which genes have been transferred from animals. Another issue related to GMOs is dealing with the position of the Third World.

Some disagree that using technology in Food will reduce food shortages and malnutrition in developing countries. Third-world countries lack the financial resources to establish GM applications that can benefit their populations, and it is unlikely that foreign multinationals will spend time or money on altruistic research to help them (Nielsen et al., 2003). Evidence on attitudes has become more evident in European countries since the publication of the Eurobarometer after 1991. Interestingly, evidence suggests some reluctance to introduce foods, reflecting

recent Eurobarometer surveys (Gaskell et al., 2004), revealing evidence of an ongoing progressive resurgence in human support for GMOs from 1999 to 2002. Surprisingly, a return to skepticism has been noted in the following years. This evidence reveals a division of European consumers along several dimensions, mainly classified into three groups regarding their perception of GMOs: optimistic, pessimistic, and undecided. In addition to this general attitude, national differences are also remarkable. It found that support for GMOs was observed by 2002 in only four countries - Spain, Portugal, Ireland, and Finland.

However, this changed in 2005, when the top supporting countries were - Spain, Malta, Portugal, the Czech Republic, Ireland, Italy, and Lithuania. Indeed, in a recent study in Ireland using cluster analysis techniques, it was found that there was still a significant segment (25%) that could best be described as anti-GMO products and others (20%) who had complex reservations about the wholesale introduction of GM products (O'Connor et al., 2006). (Grunert et al., 2000b) when analyzing product attitudes confirms the negative attitude of Nordic populations toward GMO products. The same conclusion has been reached in several surveys of consumers in Poland, who generally distrust genetic modification, primarily when it may occur in food products (Szczurowska, T, 2005).

3 Methodology used

The main research question of this study is:

How well do consumers know genetically modified foods, and what is their behavior towards GMOs?

Based on the above data, we propose the hypotheses of the study:

H1: Albanians are not sufficiently informed about GMOs

H2: Consumers generally have a negative attitude toward GMO products.

The methodology used to realize this work is based on a questionnaire developed concerning consumers' knowledge about products that contain genetically modified organisms. The questionnaire was completed by 50 consumers of the city of Tirana. It includes questions about consumers' information about GMO products and the advantages and disadvantages they think these products bring. The central part of this paper is the data provided by the questionnaire, which is divided into two sections. The first section includes questions related to the age, gender, educational level, and income level of the respondents. The second section contains inquiries about how well consumers know GMO products, where they got information about them, and how consumers prefer them.

3.1 Results and interpretations

The studies conducted in Albania about genetically modified products are not numerous, and the information consumers possess is limited. However, from studies conducted in other countries, a reluctance of consumers to consume GMOs has been noticed. We analyze the survey results to see if this also happens in Albania.

According to the answers to this questionnaire, it turns out that more than half of the participants usually consume organic Food, that is, about 56% of them. At the same time, 31% of them do not know what they are consuming since they have no guarantee that the information they are given is entirely accurate. About 13% of them stated that they consume conventional foods and that none have chosen GMO foods, at least not with their knowledge.

We conclude that 43% of the participants have enough information on GMO products from the obtained results. However, about 44% of the majority expressed little knowledge but would like to know more. Meanwhile, only 13% said they did not have enough information, and none of them knew about GMO products.

An exciting finding of this questionnaire is that the primary source of obtaining information is the Internet, surpassing even television or radio and the press. This shows the ease of information reaching people in the Internet age.

We also learned from this survey that consumers against GMO products dominate. They represent about 53% of the participants, while some of them were undecided about GMO products, i.e., 16% of them. While those in favor of these products makeup 31% of the consumers asked.

Also, this survey highlighted the willingness of the participants to buy GMO products. About 40% say they believe sometimes, while only 2% said they always buy. At the same time, the majority, or 58%, stated that they do not buy at all or are unaware of the lack of security.

According to the answers received, 40% of the consumers asked had no opinion regarding the difference between GMO plants and traditional plants. 56% said the differences make them think, while the remaining 4% believe there is no difference between these two types of plants.

Also, from the answers received, we found that most (47%) consumers are against GMO technology. While 37% say, they can accept this technology if they know its benefits, and 16% say they agree.

Regarding the importance of these products for the future, consumers have answered that it is essential for the future, seeing at what levels technology is advancing today. However, some think that these products will not be necessary in the future.

Regarding the fact in which aspect GMO products would have the most impact according to the results of the survey, we see that the majority think that the effect will be on health, in second place is the impact on the economy and then the positive language that will have in the environment.

According to the answers received, 55% of the participants in this survey did not consume GMO products at all during the Pandemic, while only 18% answered that they did, and 27% did not know if they finished GMO products.

Regarding whether they will use GMO products in the next few days, the consumers answered as follows: equally, 42% say that they will not consume or are not sure, and only 16% say that they will consume.

Conclusions

Population growth has led to increased food shortages, and GMO products have been seen as one of the alternative solutions. When consumers are faced with new products, studying their behavior toward them is essential. In this context, this study would be critical because it reveals the preferences of Albanian consumers toward GMO products. The study was conducted by developing a survey in the city of Tirana.

Referring to the results achieved by this study, we can reach the conclusions that:

- Consumers show a reluctance to consume GMO products.
- Most consumers know about GMO products, but not enough, and want to learn more. The Internet is the primary source of this information, which shows why most have little knowledge.
- The information that consumers want to know more about is the impact of this technology on human health. Consumers do not feel safe, which is shown in the results that most of them are against GMO technology.
- According to this result, we conclude that the most significant impact of this technology will be on the economy and the environment due to the non-use of Herbicides and Insecticides.

At the end of the analysis, we could prove the two hypotheses raised at the beginning. Albanians are not sufficiently informed about GMOs, and about 44% answered that they want to know more about GMOs. We also confirmed that 53% of consumers surveyed are against GMO products.

References

- [1] Akpoyomare, O. B., Adeosun, L. P. K., & Ganiyu, R. A. (2013). The Influence of Product Attributes on Consumer Purchase Decision in the Nigerian Food and Beverages Industry: A Study of Lagos Metropolis. *American Journal of Business and Management*, 2(1), 196. <https://doi.org/10.11634/216796061706211>
- [2] Barrena, R., Casals, E., Colón, J., Font, X., Sánchez, A., & Puntès, V. (2009). Evaluation of the ecotoxicity of model nanoparticles. *Chemosphere*, 75(7), pp. 850–857. <https://doi.org/10.1016/j.chemosphere.2009.01.078>

- [3] Bech-Larsen, T., & Grunert, K. G. (2003). The perceived healthiness of functional foods. *Appetite*, 40(1), pp. 9–14. [https://doi.org/10.1016/S0195-6663\(02\)00171-X](https://doi.org/10.1016/S0195-6663(02)00171-X)
- [4] Bereano, P. L. (1999). {BLR 2934} Human Tissues-Informed Consent-National Bioethics Advisory Commission: The National Bioethics Advisory Commission Report on the Use of Human Biological Materials and Research: Ethical Issues and Policy Guidelines. *Biotechnology Law Report*, 18(4), pp. 322–325. <https://doi.org/10.1089/blr.1999.18.322>
- [5] Boccaletti, S. & Moro, D. (2000). Consumer willingness-to-pay for GM food products in Italy.
- [6] Bonny, S. (2003). Why are most Europeans opposed to GMOs?: Factors explaining rejection in France and Europe. *Electronic Journal of Biotechnology*, 6(1), pp. 7–8.
- [7] Cunningham, J. M., Kim, C.-Y., Christensen, E. R., Tester, D. J., Parc, Y., Burgart, L. J., Halling, K. C., McDonnell, S. K., Schaid, D. J., Walsh Vockley, C., Kubly, V., Nelson, H., Michels, V. V., & Thibodeau, S. N. (2001). The Frequency of Hereditary Defective Mismatch Repair in a Prospective Series of Unselected Colorectal Carcinomas. *The American Journal of Human Genetics*, 69(4), pp. 780–790. <https://doi.org/10.1086/323658>
- [8] Curl, C. L., Beresford, S. A. A., Fenske, R. A., Fitzpatrick, A. L., Lu, C., Nettleton, J. A., & Kaufman, J. D. (2015). Estimating Pesticide Exposure from Dietary Intake and Organic Food Choices: The Multi-Ethnic Study of Atherosclerosis (MESA). *Environmental Health Perspectives*, 123(5), 475–483. <https://doi.org/10.1289/ehp.1408197>
- [9] Fishbein, M. (1963). An Investigation of the Relationships between Beliefs about an Object and the Attitude toward that Object. *Human Relations*, 16(3), pp. 233–239. <https://doi.org/10.1177/001872676301600302>
- [10] Frewer, L. J., Howard, C., & Shepherd, R. (1998). Understanding public attitudes to technology. *Journal of Risk Research*, 1(3), pp. 221–235. <https://doi.org/10.1080/136698798377141>
- [11] Galán, F., Nuttin, M., Lew, E., Ferrez, P. W., Vanacker, G., Philips, J., & Millán, J. D. R. (2008). A brain-actuated wheelchair: Asynchronous and non-invasive Brain-computer interfaces for continuous control of robots. *Clinical Neurophysiology*, 119(9), pp. 2159–2169. <https://doi.org/10.1016/j.clinph.2008.06.001>
- [12] Gaskell, G., Allum, N., Wagner, W., Kronberger, N., Torgersen, H., Hampel, J., & Bardes, J. (2004). GM Foods and the Misperception of Risk Perception. *Risk Analysis*, 24(1), pp. 185–194. <https://doi.org/10.1111/j.0272-4332.2004.00421.x>

- [13] Grunert, K. G., Bech-Larsen, T., & Bredahl, L. (2000a). Three issues in consumer quality perception and acceptance of dairy products. *International Dairy Journal*, 10(8), pp. 575–584. [https://doi.org/10.1016/S0958-6946\(00\)00085-6](https://doi.org/10.1016/S0958-6946(00)00085-6)
- [14] Grunert, K. G., Bech-Larsen, T., & Bredahl, L. (2000b). Three issues in consumer quality perception and acceptance of dairy products. *International Dairy Journal*, 10(8), pp. 575–584. [https://doi.org/10.1016/S0958-6946\(00\)00085-6](https://doi.org/10.1016/S0958-6946(00)00085-6)
- [15] Iyizoba, H. J. C. (2016). Proceedings in interlocutory applications: injunctions, stay of proceedings and execution.
- [16] Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, 77(6), pp. 1121–1134. <https://doi.org/10.1037/0022-3514.77.6.1121>
- [17] Leung, A. K. -y., Lee, S., & Chiu, C. (2013). Meta-Knowledge of Culture Promotes Cultural Competence. *Journal of Cross-Cultural Psychology*, 44(6), pp. 992–1006. <https://doi.org/10.1177/0022022113493137>
- [18] Moon, H. (2001). The two faces of conscientiousness: Duty and achievement striving in escalation of commitment dilemmas. *Journal of Applied Psychology*, 86(3), 533–540. <https://doi.org/10.1037/0021-9010.86.3.535>
- [19] Nielsen, C. P., Thierfelder, K., & Robinson, S. (2003). Consumer preferences and trade in genetically modified foods. *Journal of Policy Modeling*, 25(8), pp. 777–794. <https://doi.org/10.1016/j.jpolmod.2003.07.001>
- [20] O'Connor, E., Cowan, C., Williams, G., O'Connell, J., & Boland, M. P. (2006). Irish consumer acceptance of a hypothetical second-generation GM yogurt product. *Food Quality and Preference*, 17(5), pp. 400–411. <https://doi.org/10.1016/j.foodqual.2005.05.003>
- [21] Park, C. W., & Lessig, V. P. (1981). Familiarity and Its Impact on Consumer Decision Biases and Heuristics. *Journal of Consumer Research*, 8(2), 223. <https://doi.org/10.1086/208859>
- [22] Sawhney, M., Balasubramanian, S., & Krishnan, V. V. (2004). Creating growth with services. *MIT Sloan Management Review*.
- [23] Szczurowska, T. (2005). Poles on biotechnology and genetic engineering. TNS OBOP. Plant Breeding and Acclimatization Institute, Radzikow.
- [24] Thomson, J. (2003). 3. Genetically modified food crops for improving agricultural practice and their effects on human health. *Trends in Food Science & Technology*, 14(5–8), pp. 210–228. [https://doi.org/10.1016/S0924-2244\(03\)00072-4](https://doi.org/10.1016/S0924-2244(03)00072-4)

Identifying Key Factors Influencing Nursing Care Quality: A Systematic Literature Review

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Abstract: Objective: This literature review evaluates the factors that influence the quality of nurses' service to patients, with the aim of increasing their overall well-being, work experience and creating a more supportive and satisfying work environment in the field of nursing.

Methods: A systematic review was conducted following Preferred Reporting Items for Systematic Reviews. Electronic databases including Scopus, PubMed, SAGE Journal were searched for scientific articles on factors influencing the quality of nursing care. After review and removal of duplicates, we analyzed the full text of articles to identify potentially relevant studies for eligibility and then extracted data from matched articles.

Results: The literature search resulted in 20 articles, that met all inclusion criteria were included systematic review after full text review.

Conclusion: The literature shows that the quality of work life of nurses is influenced by three main factors: personal (socio-demographic), professional and psychological. Identifying the factors is critical for finding the right solution to improve the quality of service at work and to overcome the factors that reduce the quality of service in nursing care.

Keywords: Factors influencing the quality of nursing care, Hospital, Patient, Quality, Nursing care.

1 Introduction

The quality of health care in the environments where health services are provided depends on the nurses and affects their quality of life at work. The quality of life at work is the parameter that evaluates the ability of nurses to meet personal needs through experience in the workplace, achieving work goals [1]. Nowadays, the quality of life at work is a key factor, on which many studies are being conducted and different conclusions are drawn on how to improve the quality of life at work. With the increase of the geriatric age, the workload of nurses almost all over the world has increased, leading directly to the occurrence of burnout in nurses and affecting the nurse-patient relationship. These have become important factors affecting the construction and development of nursing disciplines [2] [3]. Quality Work Life is a multidimensional concept that encompasses an employee's feelings about various aspects of their work environment. These aspects include job content, working conditions, fair and adequate compensation, opportunities for career advancement, autonomy in decision-making, involvement in decision-making processes, occupational health and safety, workplace safety, job security, workplace relationships, personal relationships, and the stability of life at work [4] [5] [6] [7]. The quality of life at work is expected to be the key element in the sustainability of the nursing staff, which directly affects the provision of the necessary number of nurses in every institution where health services are offered. To address the problems, a wide range of issues must be taken into consideration, such as: workload, professional leadership and clinical support, continuous training for professional growth, facilities, planning and decisions, professional recognition, provision of insurance for diseases caused in the workplace and higher wages to increase motivation for work [8].

Various studies concluded that more than half of employed nurses, especially nurses of intensive care units, are very dissatisfied with the quality of their work life [9] [10].

As far as the findings are concerned, the most frequently influencing work factors are experience in years of work and night shifts, which have a direct impact on the quality of work life among nurses. [11] [12] [13] [14]. Some other studies showed that monthly income is another factor that directly affects the quality of work life [15][16]. Additional bonuses, recognition in the workplace, increase in duties have an impact on the quality of work life of nurses [11][17]. Regarding the findings regarding the factors that reduce the quality of nurses' work: work overload, failure to maintain balance between work and family, lack of vacations and lack of nursing staff are the most frequently encountered factors that have a negative impact on the quality of the work of nurses [18]. Support, opportunity for promotion, continuing professional education and work department also affect the quality of nurses' work [19] [1] [20].

2 The aims and objectives

The purpose of this study is to provide a comprehensive analysis of the various factors that influence the nursing care of patients. Identification of challenges and deficiencies that affect the provision of non-quality nursing care. Giving recommendations for improving the working conditions of nurses.

The main objective of this systematic review is: to evaluate the effectiveness and quality of the factors that affect the quality of work of nurses.

3 Methodology

As a first step, to conduct this systematic review, we identified and retrieved relevant research studies from various academic databases including Scopus, PubMed, SAGE Journal, Elsevier and Google Scholar, to identify relevant articles. Only peer-reviewed articles were included to ensure the reliability and validity of the findings. Relevant articles published within the last ten years were considered for inclusion. Selection criteria included studies that examined factors affecting the quality of nursing care, nurses' job satisfaction, staffing levels, resource availability, and the impact of policies and regulations on nursing care delivery.

The method of data analysis consisted in the content analysis of each study included in the literature review to identify the common factors that influence the quality of nursing care in terms of the purpose of the study, objectives, results and conclusions. The data collection instrument consisted of two parts. The first part consisted of questions on demographic information that affect the quality of work of nurses (including gender, age, education, marital status, type of hospital, monthly salary). The second part was information on other factors that affect the quality of work of nurses, such as Work-Related Predictors, Psychological Predictors. We then synthesized the findings to identify common themes and patterns across the studies. This allowed us to draw significant conclusions and identify the main factors that influence the quality of nursing care provided to patients.

The following table provides detailed information on the studies included in this literature review, the authors of the study, the date of publication, the journal where it was published and the size of the sample included in each study. In addition, the factors influencing the quality of nursing care in each analyzed study were analyzed and presented in tables, and these factors were classified into three groups (demographic factors, work-related factors and psychological factors).

4 Results

Initially, 213 articles resulted from the systematic search. After careful review of each article, only 20 met all inclusion criteria and were ultimately included in the

systematic review. The study selection process is schematized in Figure 1. This selection process ensures that the final set of articles closely matches the research objectives and inclusion criteria, increasing the reliability and relevance of the systematic review.

Table 1 presents the findings from the 20 articles selected for the systematic review, all of which discussed socio-demographic factors. The most prevalent factors influencing the quality of work life for nurses included differences in education level, age, and marital status. Other influential factors were nationality, area of residence, religion, gender, and family situation.

Income or salary was identified as a decisive factor affecting nurses' quality of work life. Inequities in compensation led to dissatisfaction and stress, negatively impacting the quality of their work.

The department in which nurses worked also played a significant role in their quality of life. Studies indicated that nurses in intensive care units were generally dissatisfied with their work life quality, while those working in ambulatory settings reported a better quality of life.

Overall, a good quality of nursing work life was associated with higher nursing positions and factors such as work department, educational status, the availability of safe rest periods, and the inclusion of small breaks in work schedules. Additionally, nurses reported higher levels of burnout and stress compared to other human and health service professionals, including social workers and hospital staff.

Conclusions

Based on the articles included in the study, several key conclusions can be drawn. First, there is a clear need for the development of policies that support nurses in their work, specifically addressing factors that impact the quality of their performance. Additionally, workplace inequality must be tackled, as it significantly affects the psychological well-being of nurses. Measures to reduce this inequality are essential.

Particularly for nurses working in tertiary health care, there is a pressing need for supportive policies. This sector reported higher instances of issues such as inequality, emotional burden, job dissatisfaction, and concerns about salary. Therefore, targeted interventions in tertiary care are crucial.

Moreover, it is evident that more research is needed in Albania to understand the factors affecting the quality of nurses' work. The literature review highlighted a significant gap in comprehensive studies in this area within the country. Addressing this gap through further research will provide valuable insights and inform future policy decisions.

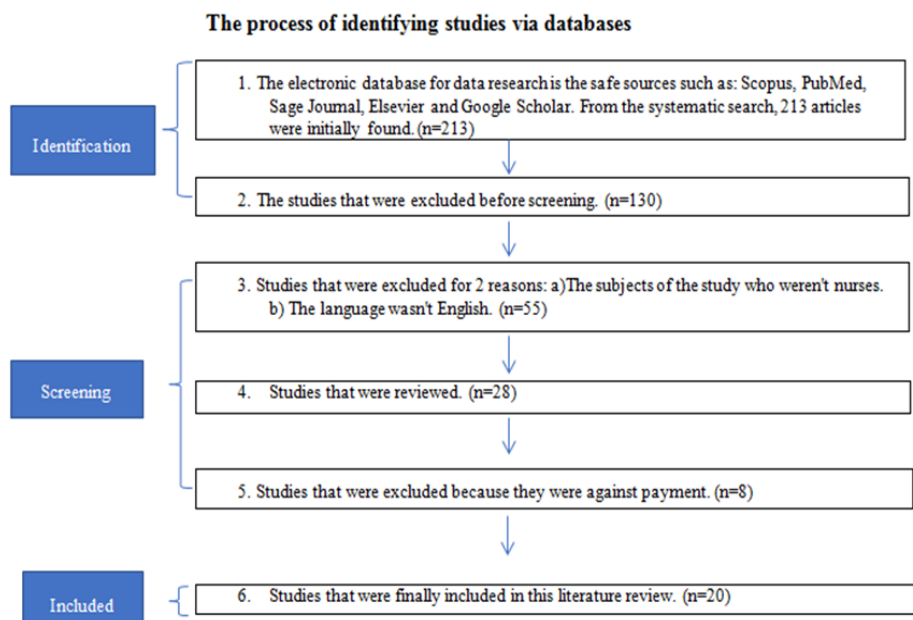


Figure 1
The process of identifying studies via databases

	Authors	Participants Gender	Demographics Factors	Work-Related Factors	Psychological Factors	Journal
1	Suleiman et al. 2019[21]	186 nurses Male:48.4% Female:51%	Age, Marital status, Educational status,	Working hours, Night shift; Payment per month	Job Stress	Journal of Occupational Health
2	Biresaw et al. 2020 [22]	461 nurses Male:51% Female 49%	Age, Marital status,	Current nursing position; Working department;	Job stress	International Journal of Africa Nursing Sciences (IJANS)

			Educational status, Religion	Receive risk allowance; Shift of your work; Working hours per week		
3	Alzoubi et al. 2024 [23]	250 nurses Male:50%; Female:50%	Age, Marital status; Educational status	Type of shift; Workplace noise; Smoking status	Job burnout	Frontiers in Public Health
4	Akter et al. 2017 [24]	288 nurses Male12.5% Female 87.85%	Age, Marital status; Educational status	Salary, Work environment	Stress level	International Nursing Review
5	Al-Maskari et al. 2020 [25]	374 nurses Male:9.3% Female:90.7%	Age, Marital status, Educational status,	Work Satisfaction, Workload	Stress level	Sultan Qaboos University Medical Journal (SQUMJ)
6	Teixeira et al. 2019 [26]	109 nurses Male 24.8% Female75.2%	Age group, Marital status, Educational status,	Working positions, Working status, Working service,	Job Satisfaction Level	SciELO Brazil Scientific Electronic Library Online
7			Age,		Stress level	

	Almalki et al. 2012 [9]	508 nurses Male 32.7% Female 67.3%	Marital status; Educational status, Nationality,	Shift type, Nurse position, Workload intensity, Workload predictability, Salary		Human Resources for Health
8	Komjakraphan et al. 2017 [16]	102 nurses Male 5.9% Female 94.1%	Age group, Marital status, Educational status,	Nurse position, Workload intensity, Workload predictability, Salary Years of experience	Job satisfaction, Burnout,	Quality of Work Life among Nurse Practitioners
9	Jin et al. 2021 [27]	167 nurses Male: 54.5% Female: 45.5%	Age, Educational status, Religion			Child Health Nursing Research
10	Galan et al. 2019 [28]	346 nurses	Age, Marital status, Educational status,			International Nursing Review
11	Szentirmai et al. 2020 [29]	135 nurses	Age, Marital status, Educational status,		Job burnout	Value in Health
12	Abd El Rahman et al. 2021[30]	160 nurses	Age group, Marital status, Educational status,	Morning shift, Night shift, Evening shift		Menoufia Nursing Journal

		Male 18.8% Female 81.2%		Years of experience,		
13	Hernández-Cruz et al. 2017[31]	71 nurses Male 22.5% Female 77.5%	Age group, Marital status, Educational status,	Years of experience		Revista Latino-Americana de Enfermagem
14	Mutair et al. 2022 [32]	860 nurses Male 7.2% Female 92.8%	Age, Nationality, Marital status, Educational level,	Hours shift, Job nature, Years of experience		Nursing Reports
15	Gabrani et al. 2016 [33]	246 nurses	Age, Marital status, Educational status,	Nature of work, Salary satisfaction, Quality supervision	Job Stress	International Journal of Healthcare Management
16	Podgorica et al. 2024 [34]	20 nurses Male 45%	Age, Educational status,	Inadequate physical environment, Insufficient material resources, Constraints related to time and staff. Years of experience	Mental stress	PLOS ONE

		Female 55%				
17	Van et al. 2020 [35]	160 nurses Male 8.8%; Female 91.2%	Age, Marital status, Educational level,	Type of staff, Nurse position, Salary Years of experiences		Central European Journal of Nursing and Midwifery
18	Casida et al. 2019 [36]	104 nurses Male 17% Female 83%	Age, Marital status, Educational level, Religion	Current nursing position; Working department;	Job Burnout	Progress in Transplantation (PIT)
19	Kelbiso et al. 2017 [15]	253nurses Male: 47.8% Female 52.2%	Age, Marital status, Educational status,	Work environment, Institution, Working department; Salary Years of experiences		Nursing Research and Practice
20	Hemanathan et al. 2017 [37]	100 nurses Male:2% Female: 98%	Age, Marital status; Educational status; Type of family;	Night shift; No. of breaks; Principal nursing position; Area of working;		JOJ Nurse Health Care

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References

- [1] B. A. Brooks and M. A. Anderson, "Defining quality of nursing work life," *Nursing Economics*, vol. 23, no. 6, 2005.
- [2] Y. W. Lee, Y. T. Dai, C. G. Park, and L. L. McCreary, "Predicting quality of work life on nurses' intention to leave," *Journal of Nursing Scholarship*, vol. 45, no. 2, 2013, doi: 10.1111/jnu.12017.
- [3] Y. W. Lee, Y. T. Dai, and L. L. McCreary, "Quality of work life as a predictor of nurses' intention to leave units, organisations and the profession," *J Nurs Manag*, vol. 23, no. 4, 2015, doi: 10.1111/jonm.12166.
- [4] M. Y. Hsu and G. Kernohan, "Dimensions of hospital nurses' quality of working life," *J Adv Nurs*, vol. 54, no. 1, 2006, doi: 10.1111/j.1365-2648.2006.03788.x.
- [5] A. M. Mosadeghrad, E. Ferlie, and D. Rosenberg, "A study of relationship between job stress, quality of working life and turnover intention among hospital employees," *Health Serv Manage Res*, vol. 24, no. 4, 2011, doi: 10.1258/hsmr.2011.011009.

- [6] J. Connell and Z. Hannif, "Call centres, quality of work life and HRM practices: An in-house/outsourced comparison," *Employee Relations*, vol. 31, no. 4, 2009, doi: 10.1108/01425450910965423.
- [7] D. Raj Adhikari and D. K. Gautam, "Labor legislations for improving quality of work life in Nepal," *International Journal of Law and Management*, vol. 52, no. 1, 2010, doi: 10.1108/17542431011018534.
- [8] D. Blaauw, P. Ditlopo, and L. C. Rispel, "Nursing education reform in South Africa--lessons from a policy analysis study," *Glob Health Action*, vol. 7, 2014, doi: 10.3402/gha.v7.26401.
- [9] M. J. Almalki, G. FitzGerald, and M. Clark, "Quality of work life among primary health care nurses in the Jazan region, Saudi Arabia: A cross-sectional study," *Hum Resour Health*, vol. 10, 2012, doi: 10.1186/1478-4491-10-30.
- [10] N. D. Nayeri, T. Salehi, and A. A. A. Noghabi, "Quality of work life (QWL) and productivity among Iranian nurses," *Contemp Nurse*, vol. 39, no. 1, 2011, doi: 10.5172/conu.2011.39.1.106.
- [11] L. F. Edelman, T. S. Manolova, C. G. Brush, and C. M. Chow, "Signal configurations: Exploring set-theoretic relationships in angel investing," *J Bus Ventur*, vol. 36, no. 2, 2021, doi: 10.1016/j.jbusvent.2020.106086.
- [12] B. Kaddourah, A. K. Abu-Shaheen, and M. Al-Tannir, "Quality of nursing work life and turnover intention among nurses of tertiary care hospitals in Riyadh: A cross-sectional survey," *BMC Nurs*, vol. 17, no. 1, 2018, doi: 10.1186/s12912-018-0312-0.
- [13] T. Moradi, F. Maghaminejad, and I. Azizi-Fini, "Quality of Working Life of Nurses and its Related Factors," *Nurs Midwifery Stud*, vol. 3, no. 2, 2014, doi: 10.5812/nms.19450.
- [14] S. Venkataraman, S. Anbazhagan, and S. Anbazhagan, "Quality of nursing work life among staff nurses in a tertiary care hospital in Puducherry," *Int J Community Med Public Health*, vol. 5, no. 9, 2018, doi: 10.18203/2394-6040.ijcmph20183469.
- [15] L. Kelbiso, A. Belay, and M. Woldie, "Determinants of Quality of Work Life among Nurses Working in Hawassa Town Public Health Facilities, South Ethiopia: A Cross-Sectional Study," *Nurs Res Pract*, vol. 2017, 2017, doi: 10.1155/2017/5181676.
- [16] P. , B. K. , & J. P. (2017). Komjakraphan, "Quality of work life among nurse practitioners working at Primary Care Setting in Thailand. ," *Journal of Research in Nursing-Midwifery and Health Sciences*, vol. 37, pp. 98–105, 2017.

- [17] S. A. Vagharseyyedin, Z. Vanaki, and E. Mohammadi, "The nature nursing quality of work life: An integrative review of literature," *Western Journal of Nursing Research*, vol. 33, no. 6, 2011. doi: 10.1177/0193945910378855.
- [18] M. M. Shazly and S. F. Fakhry, "Nurses' perception of the quality of nursing work life and related priorities for improvement in Ain shams university specialized hospital," *J Am Sci*, vol. 10, no. 1s, 2014.
- [19] B. A. Brooks and M. A. Anderson, "Nursing work life in acute care," *J Nurs Care Qual*, vol. 19, no. 3, 2004, doi: 10.1097/00001786-200407000-00014.
- [20] B. A. Brooks et al., "Assessing the quality of nursing work life," *Nurs Adm Q*, vol. 31, no. 2, 2007, doi: 10.1097/01.NAQ.0000264864.94958.8e.
- [21] K. Suleiman, Z. Hijazi, M. Al Kalaldehy, and L. Abu Sharour, "Quality of nursing work life and related factors among emergency nurses in Jordan," *J Occup Health*, vol. 61, no. 5, 2019, doi: 10.1002/1348-9585.12068.
- [22] H. Biresaw, B. Boru, and B. Yimer, "Quality of nursing work life and associated factors in Amhara Region Referral Hospitals, Northwest Ethiopia: A cross sectional study," *Int J Afr Nurs Sci*, vol. 13, 2020, doi: 10.1016/j.ijans.2020.100214.
- [23] M. M. Alzoubi et al., "Assessment of the quality of nursing work life and its related factors among critical care nurses," *Front Public Health*, vol. 12, 2024, doi: 10.3389/fpubh.2024.1305686.
- [24] N. Akter, T. Akkadechanunt, R. Chontawan, and A. Klunklin, "Factors predicting quality of work life among nurses in tertiary-level hospitals, Bangladesh," *Int Nurs Rev*, vol. 65, no. 2, 2018, doi: 10.1111/inr.12401.
- [25] M. A. Al-Maskari, J. U. Dupo, and N. K. Al-Sulaimi, "Quality of work life among nurses a case study from ad Dakhiliyah Governorate, Oman," *Sultan Qaboos Univ Med J*, vol. 20, no. 4, 2020, doi: 10.18295/squmj.2020.20.04.005.
- [26] G. Silveira Teixeira, R. C. Da Penha Silveira, V. Aline Mininel, J. Teixeira Moraes, and I. K. Da Silva Ribeiro, "Quality of life at work and occupational stress of nursing in an emergency care unit," *Texto e Contexto Enfermagem*, vol. 28, 2019, doi: 10.1590/1980-265X-TCE-2018-0298.
- [27] I. Jin and H. H. Cho, "Factors influencing the quality of nursing care as perceived by mothers of hospitalized children in South Korea," *Child Health Nursing Research*, vol. 27, no. 3, 2021, doi: 10.4094/chnr.2021.27.3.266.
- [28] K. Gaalan, W. Kunaviktikul, T. Akkadechanunt, O. A. Wichaikhum, and S. Turale, "Factors predicting quality of nursing care among nurses in tertiary care hospitals in Mongolia," *Int Nurs Rev*, vol. 66, no. 2, 2019, doi: 10.1111/inr.12502.

- [29] E. Szentirmai et al., "PNS236 Understanding the Factors Affecting Quality of Nursing Care Focused on Staffing and Satisfaction of Nurses," *Value in Health*, vol. 23, 2020, doi: 10.1016/j.jval.2020.08.1680.
- [30] A. Abd El Rahman, M. Ibrahim, and G. Diab, "Quality of Nursing Documentation and its Effect on Continuity of patients' care," *Menoufia Nursing Journal*, vol. 6, no. 2, 2021, doi: 10.21608/menj.2021.206094.
- [31] R. Hernández-Cruz, M. G. Moreno-Monsiváis, S. Cheverría-Rivera, and A. Díaz-Oviedo, "Factors influencing the missed nursing care in patients from a private hospital," *Rev Lat Am Enfermagem*, vol. 25, 2017, doi: 10.1590/1518-8345.1227.2877.
- [32] A. Al Mutair et al., "Quality of Nursing Work Life among Nurses in Saudi Arabia: A Descriptive Cross-Sectional Study," *Nurs Rep*, vol. 12, no. 4, 2022, doi: 10.3390/nursrep12040097.
- [33] A. Gabrani, A. Hoxha, J. Gabrani Cyco, E. Petrela Zaimi, E. Zaimi, and E. Avdullari, "Perceived organizational commitment and job satisfaction among nurses in Albanian public hospitals: A cross-sectional study," *Int J Healthc Manag*, vol. 9, no. 2, 2016, doi: 10.1179/2047971915Y.0000000019.
- [34] N. Podgorica, E. Pjetri, A. W. Müller, and S. Perkhofer, "Difficulties and challenges experienced by nurses in eldercare institutions in Albania: A qualitative content analysis," *PLoS One*, vol. 19, no. 3 March, 2024, doi: 10.1371/journal.pone.0300774.
- [35] L. T. H. Van, K. Volrathongchai, N. V. Q. Huy, T. N. M. Duc, D. van Hung, and T. T. M. Lien, "Quality of work life among nurses working at a provincial general hospital in Vietnam: A cross-sectional study," *Central European Journal of Nursing and Midwifery*, vol. 11, no. 4, 2020, doi: 10.15452/CEJNM.2020.11.0030.
- [36] J. M. Casida, P. Combs, S. E. Schroeder, and C. Johnson, "Burnout and Quality of Work Life Among Nurse Practitioners in Ventricular Assist Device Programs in the United States," *Progress in Transplantation*, vol. 29, no. 1, 2019, doi: 10.1177/1526924818817018.
- [37] Hemanathan, R., Sreelekha, P. P., and Golda, M., "Quality of work life among nurses in a tertiary care hospital," *Health Care*, vol. 5, no. 4, 2017

Social responsibility as a marketing communication tool. Slogan or change? Case study of Falco-Vulcano Energia KC Szombathely Crucial Catch campaign

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Abstract: In our study, we examined the impact of the CSR campaign of the five-time Hungarian basketball champion Falco-Vulcano Energia KC Szombathely. It can be shown that since the 2010s, social responsibility has been a frequently used marketing communication tool of Western European sports clubs. In the 2020s, due to pandemics, wars and irresponsible corporate governance, people, potential consumers, are becoming more and more aware of CSR. At the same time, commercially based sports clubs have a very

important role in shaping society. Three research questions were asked to investigate the CSR activities of the basketball club in Szombathely.

*- What impact does it have on the marketing communication of the team? - **The "campaign-themed" content shared during the campaign triggered a total of 2607 interactions.***

*- Can it shape the awareness of the fans? - **88.3% of respondents knew what problem the campaign was highlighting***

*- Do the fans support the CSR actions of the team? - **85% of respondents said that repeating such a campaign regularly helps to raise awareness and raise awareness of the problem.***

1 Introduction

It can be pointed out that in the 2010s, a new marketing communication tool was the social responsibility of sports companies, especially professional sports clubs [1]; [2]; [4]; [11]. "Under the concept of corporate social responsibility, companies voluntarily integrate social and environmental considerations into their business operations in addition to their legal obligations and shape their relations with the groups (consumers, employees, suppliers, etc.) that affect their activities along these principles. A consciously formed attitude is different from a purely profit-oriented attitude towards employee rights, the enemy of corruption and business ethics..." [5]. Nowadays, researchers agree that the main motivation of (sports) companies are to do well because being identified with a good cause is also good business [1]; [2]; [4]; [6]; [7]; [8]; [9]; [10]; [11]; [12]. It can be observed that firms that are actively involved in CSR are those that are profitable or see CSR as an investment and want to sustain it in the long term [3]; [6]. In the 2020s, due to the impact of pandemics, wars and irresponsible corporate governance, people, potential consumers, are becoming more conscious of the perception of CSR and a new concept, greenwashing, has emerged. Greenwashing already existed in the 2010s, but in sports organisations, fans and analysts have now realised this negative trend, whereby the business outcome has become more important than the cause itself when it comes to CSR activities. Several researchers have contrasted the 'business argument' with the actual CSR case [3]; [8]; [9]. CSR programmes are more sketched by today's people and consumers, so sports companies now need to not only communicate but also act for their chosen cause. If both communication and actual action take place, CSR programmes can spark true consumer engagement between the company and its people.

On the other side of the issue, professional sports clubs, the business-based sports enterprise, have a very important role in shaping society. The operation of a sports club has an environmental, economic and social impact. In the case of Hungarian sports clubs of all kinds, both terms of responsibility and communication strategy, CSR is a blank spot. This may be because it requires a long-term and large capital

investment, which not all companies can afford [1]; [2]; [3]. In Hungarian sports companies, CSR is also rarely manifested because short-term profit-making is more important [10]; [11]; [12]. However CSR, like storytelling, has the potential to personalise the relationship between consumers and the sports company and to create empathy and a sense of belonging to the community. From a marketing communication point of view, it is very important to know the consumers' perspective, as they are the "target" of CSR programmes. The Szombathely basketball club Falco-Vulcano Energia KC Szombathely, the focus of our research, did exactly that. With a smaller marketing budget, they try to convey as much value as possible in their communications. I wonder how a Szombathely basketball team's Crucial Catch campaign - a movement known from the American Football League (NFL) to raise awareness of screening programmes that play an important role in cancer prevention - can deliver value and exceed its communication goals. What do team fans say about standing up for a cause? These are some of the questions we sought to answer in our research.

2 Method

Our research can be divided into two parts. In the first stage, we carried out a documentary analysis of CSR and its role in the communication strategy of sports clubs and federations. We also conducted a case study in Hungary, where we investigated the Crucial Catch campaign of the Hungarian basketball team Falco-Vulcano Energia KC Szombathely, its effectiveness and short-term effects. We evaluated the team's communication strategy and used a questionnaire with fans to find out how effective a CSR programme initiated by a sports company can be in a local market in Hungary.

3 Results

The total reach (total number of posts reached) during the almost 3-month campaign was 41,167 (29 pieces of content shared), which was 17,748 on Facebook and 23,419 on Instagram. The average reach of the content shared by the team was 1,419, which is roughly in line with the reach average for the Yellow and Black. Based on engagement data (number of reactions to content), the campaign "performed better" than match-related content illustrated in Figure 1.

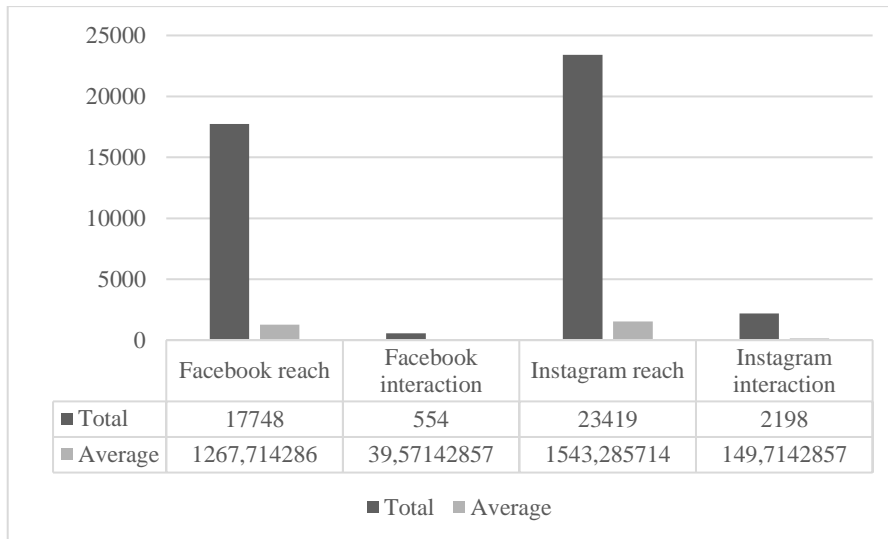


Figure 1.
Social Media Reach & Engagement Rate data

The "campaign-themed" content shared during the campaign generated a total of 2,607 interactions from people. During our analysis, it was striking that Instagram pages had a significantly higher engagement rate (interaction/reach). The average engagement rate for the 15 posts published on Instagram was 9.7%, while the same rate for the Facebook page was 3.1%. The team's social media communications were average and above average in terms of reach and engagement rate. It can be seen that the team put sufficient effort into getting the message out to people. However, in addition to social media, they also communicated elsewhere, which, as the questionnaire showed, helped a lot in getting the message to people and fans who do not use social media. The team used the following platforms:

- Facebook
- Instagram
- Website
- Other online newspapers (bb1.hu, sportsmarketing.hu)
- Printed media
- At home matches, loudspeaker

76.7% of respondents said that they heard about the team's action on Facebook, while 73.3% said that they heard about the team's action from a message at the match. The impact of the campaign was assessed using a self-designed questionnaire. The average age of respondents was 43.4 years and the standard deviation was 15.8. The youngest respondent was 18 years old and the oldest was 77 years old! In all cases, we wanted to see if a campaign launched by a sports team could get the message across - in our case, it was the sponsor and the problem. 91.7% of those surveyed knew that the beneficiary of the fundraising was the

Alpokalja Foundation for Children with Cancer. Perhaps more important in the longer term was the following question: What problem does the Crucial Catch campaign raise awareness of? 88.3% of the respondents knew the answer, which was that the problem the club in Szombathely wanted to raise awareness about was the importance of screening for cancer. We also had a third question to get the message across, asking respondents to write down the motto of the campaign. 51.7% of the respondents could accurately recall the slogan **NOT ONLY BUY IT, WEAR IT TOO**. 32.8% noted the printed I helped you text on the T-shirt as the campaign slogan, while 14.5% of respondents could not remember the slogan. Respondents were also asked about team involvement and its importance. 85% of the respondents said that repeating such a campaign regularly helps to raise awareness and raise awareness of the problem.

Conclusions

In terms of the results presented, the conclusions can be divided into three main parts: achievement, problem recognition, and understanding of the importance of the problem. The first aspect is supported by the engagement rate of 9.7% on Instagram and 3.1% on Facebook. The higher-than-usual interaction also means that the message has triggered an emotion in the readers of the post, which is the basis for a CSR campaign. It can be concluded that the club has formulated its message with sufficient depth, explaining the problem accurately and, as a result, has created a sufficient emotional impact on consumers. Similar matchday and Facebook reach (73.3%-76.7%) for awareness of the campaign could be observed, which could mean that those attending the match were aware of the Facebook platform as well as the venue, thus developing an emotional connection with the club that allows them to be part of the club's events not only on matchdays but also beyond, in the online space and thus in their everyday lives.

The most important "yardstick" for CSR-based marketing campaigns is that the message they are trying to convey is understood by the target audience. The Falco-Vulcano KC Szombathely's "Crucial Catch" campaign raised awareness of the importance of cancer screening, and the Alpokalja Foundation for Children with Cancer was named as a supporting partner. The questions on this issue were equally accurate, with 91.7% of respondents identifying the beneficiary of the collection and 88.3% recognising the problem identified by the campaign (the importance of screening). The feedback suggests that a clear and successful marketing communication was carried out, conveying both the key message and the rationale of the campaign. The high figures for respondents' interactivity, reach, and understanding of the problem and the message reflect that they were emotionally attached to the campaign, and therefore aligned with their values and were on board with the initiative taken by the club.

An important aspect is to identify the campaign slogan, which describes the details of the outreach. More than half of the respondents correctly remembered

the slogan, indicating a deep immersion in the campaign, as they remembered a less strong detail after the "on the surface" and first information, i.e. they understood and accepted the details of the initiative. The most important indicator of the alignment between the club and the supporters was the response data on the regular repetition of the campaign. The policy started by Falco, in which they are a strong advocate of CSR campaigns, is an important hallmark of a modern-day professional sports company, but it says a lot about the club from the opinions expressed by the supporters about the campaign. The confluence of values is shown by the fact that 85% of respondents would support a regular repetition of similar campaigns, making CSR an important topic for them, which could provide the club with a lot of extra opportunities to involve its audience in future CSR campaigns, thus raising awareness of the cause and issue it presents.

References

- [1] Babiak, K. és Trendafilova, S. (2011): CSR and Environmental Responsibility: Motives and Pressures to Adopt Green Management Practices. *Corporate Social Responsibility and Environmental Management*, 18(1), pp. 11-24.
- [2] Babiak, K. és Wolfe, R. (2006): More than just a game? Corporate social responsibility and Super Bowl XL. *Sport Marketing Quarterly*, 15(6), pp. 214-224.
- [3] Borghesi, R., és Houston, F.J., (2014): Corporate Socially Responsible Investments: CEO, Altruism, Reputation, and Shareholder Interests. *Journal of Corporate Finance*, June, available at http://www.researchgate.net/profile/Richard_Borghesi/publication/261327891_Corporate_Socially_Responsibly_Responsible_Investments_CEO_Altruism_Reputation_and_Shareholder_Interests/links/00463534fe65fd36f7000000.pdf (2022.04.22).
- [4] Chen, B., H., Chen, M., H., Tai, P., N. és Hsiung, W., C. (2015): Constructing the Corporate Social Responsibility Indicators of Professional Sport Organization, *International Journal of Business Administration*, DOI: 10.5430/ijba.v6n5p75
- [5] Deák, K., Györi, G., Báron, P. és Ágoston, L. (2006). Több mint üzlet: Vállalati társadalmi felelősségvállalás. Társadalmi és környezeti szempontok integrációja az üzleti működésbe. DEMOS Magyarország Alapítvány
- [6] Farcene, N. & Bureana, E. (2015): History of "Corporate Social Responsibility" Concept *Annales Universitatis Apulensis Series Oeconomica*, 17(2), pp. 31-48.

- [7] Phillips, R., Schrempf-Sterling, J. és Stutz, C. (2020). The Past, History, and Corporate Social Responsibility. *Journal of Business Ethics* 166(1), pp. 203–213.
- [8] Tóth, D. Z., Dancs, H., és Gósi, Zs. (2019)a: A sportvállalatok társadalmi felelősségvállalásának hatása a szombathelyi utánpótlás kosárlabdázók érzelmi fejlődésére. MSTT, Nyíregyháza, 2019.06.05-07.
- [9] Tóth, D. Z., Dancs, H. és Gósi, Zs. (2019)b: A társadalmi felelősségvállalásból származó értékek átadása az utánpótlás edzői feladatok között. 11th International Conference of J. Selye University Pedagogical Sections absztraktkötet pp. 151-163.
- [10] Tóth, D. Z. (2020): Marketing Practices of a Sportorganization - The marketing value of Falco - Vulcano KC Szombathely Basketball Team. In: Keszthelyi, András; Szikora, Péter; Fehér-Polgár, Pál (szerk.) 18th International Conference on Management, Enterprise, Benchmarking. Proceedings (MEB 2020). Budapest, Magyarország : Óbudai Egyetem Keleti Károly Gazdasági Kar. pp. 212-220.
- [11] Tóth, D. Z. (2021): A társadalmi felelősségvállalás motivációi a sportszektorban. In: Gósi, Zsuzsanna; Boros, Szilvia; Magyar, Márton (szerk.) Sport a Covid-19 pandémia árnyékában: Tanulmányok a sporttudomány témaköréből. Budapest, Magyarország: Akadémiai Kiadó, pp. 159-171.
- [12] Tóth, D. Z., Farkas, M., Csárdi, Cs. & Dancs, H. (2023). Storytelling as a marketing communication tool New Trends in Sports Marketing example Hungarian Basketball Champion - FALCO KC, Management, Enterprise, and Benchmarking in the 21st Century; 2023, pp. 5-15.

Empowering the Circular Economy in Albania through Big Data Analytics: Opportunities, Case Studies, and Regional Insights

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Abstract: The adoption of a circular economy, which is defined by the concepts of reduction, reuse, and recycling, is essential for achieving sustainable development. Big data analytics is becoming a powerful tool in this transformation, providing outstanding knowledge into optimizing resources, managing waste, and implementing sustainable practices in many industries. This article examines the use of big data analytics to promote the circular economy in Albania, a country facing distinct problems and opportunities in the Western Balkans region. The study conducts a thorough examination of big data methods, including data mining, machine learning, and predictive analytics. It suggests specific sectors, such as manufacturing, healthcare, waste management, agriculture, and tourism, as areas where intervention should be focused. The article showcases three case studies that demonstrate the successful incorporation of big data analytics into circular economy plans, drawing on international best practices. Moreover, it examines the present condition and future prospects of Albania and the Western Balkans in embracing new technologies, relying on existing secondary data and success stories from the region. The results indicate that Albania has considerable potential to utilize big data analytics in promoting a more sustainable and efficient economy. Additionally, recommendations are provided for policy makers, industry leaders, and academic stakeholders to effectively address the difficulties associated with this revolutionary process.

Keywords: Circular Economy; Big Data Analytics; Sustainability; Resource Optimization; Waste Management

1 Introduction

The need for sustainable development is more evident than ever as global economies face the dual challenges of resource depletion and environmental degradation. The circular economy, characterized by waste reduction and efficient resource utilization, presents a promising approach to achieving sustainability [1]. However, fully harnessing the circular economy's potential requires inventive data management and analysis methodologies. Big data analytics is a powerful tool in this context because it can handle large datasets and generate practical insights [2], [3]. This article examines the use of big data analytics to enhance the circular economy in Albania, which is located in the distinct socio-economic and environmental context of the Western Balkans.

2 Understanding Big Data Analytics

Big data analytics is a methodical process of analyzing vast and intricate datasets to uncover valuable hidden insights and patterns. It involves various methods and approaches designed to extract useful information from large amounts of organized and unorganized data. The primary goal of big data analytics is to discover significant correlations, trends, and linkages that can provide information for decision-making, improve procedures, and stimulate innovation in many fields. This section encompasses several strategies and methodologies designed to extract practical insights from large amounts of organized and unorganized data. The primary goal of big data analytics is to discover significant correlations, trends, and linkages that might provide valuable insights for decision-making, streamline processes, and foster innovation in many fields. These technologies can be directly used in Albania's waste management system to optimize waste collection routes, increase recycling rates, and forecast waste generation patterns. This will significantly enhance resource efficiency and promote environmental sustainability.

2.1 Key Tools and Technologies

2.1.1 Data Mining

Data mining involves exploring and analyzing vast datasets to identify patterns, anomalies, and relationships. Through techniques such as clustering, classification, and association rule mining, data mining algorithms can uncover hidden insights that are not readily apparent through traditional data processing methods [4].

2.1.2 Text Mining

Text mining, also known as text analytics or natural language processing (NLP), focuses on extracting valuable information and insights from unstructured text data.

Text mining algorithms can sift through large volumes of textual data to extract meaningful patterns and sentiments by applying sentiment analysis, entity recognition, and topic-modeling techniques [5], [6].

2.1.3 Machine Learning & Deep Learning

Machine learning and deep learning techniques enable computers to learn from data and make predictions or decisions without being explicitly programmed. Machine learning algorithms like linear regression, decision trees, and neural networks can analyze large datasets to identify patterns and make predictions. Deep learning, a subset of machine learning, involves training artificial neural networks with multiple layers to perform more complex tasks, such as image recognition and natural language processing [7], [8].

2.1.4 Predictive Analysis

Predictive analysis uses historical data, statistical algorithms, and machine learning techniques to forecast future trends and behaviors. By analyzing past patterns and behaviors, predictive analytics algorithms can generate insights and predictions that inform decision-making and drive proactive strategies [9].

2.1.5 Artificial Intelligence (AI)

Artificial intelligence encompasses a range of technologies and methodologies that enable computers to perform tasks that typically require human intelligence. From machine learning algorithms to natural language processing and computer vision, AI techniques are increasingly applied in big data analytics to automate tasks, uncover insights, and drive innovation [10].

2.1.6 Business Intelligence (BI)

Business intelligence involves data collection, integration, analysis, and visualization to inform decision-making and drive business strategy. BI tools and technologies enable organizations to transform raw data into actionable insights, facilitating data-driven decision-making and performance optimization [11].

2.2 Applications and Implications

Data analytics is widely used in multiple businesses and sectors, such as healthcare, banking, retail, manufacturing, and government. Big data analytics has exceptional prospects for innovation, effectiveness, and value generation, encompassing predictive maintenance, fraud detection, tailored marketing, and supply chain optimization. Nevertheless, along with these prospects arise obstacles such as apprehensions regarding data privacy, ethical deliberations, and the requirement for proficient expertise and resilient infrastructure. Organizations must effectively

address the problems associated with big data analytics to fully capitalize on data-driven decision-making.

Big data analytics holds immense promise for revolutionizing the circular economy by optimizing resource utilization, reducing waste generation, and fostering sustainable practices across various sectors. In manufacturing, predictive analytics can forecast equipment failures, minimize downtime, and optimize resource usage [12], [13]. These insights also aid in designing sustainable products. In waste management, big data improves collection, sorting, and recycling efficiency by optimizing routes and predicting demand [14].

Additionally, in agriculture, big data enables more sustainable practices by optimizing resource use and improving crop yields through detailed analysis of soil health data, weather patterns, and crop performance metrics. This helps farmers make informed irrigation and pest management decisions, promoting efficiency and reducing wastage [15]. Integrating these analytics into circular economy practices offers significant environmental, economic, and social benefits, supporting a sustainable future.

In Albania's waste management context, these technologies can be directly applied to optimize waste collection routes, improve recycling rates, and predict waste generation patterns, contributing significantly to resource efficiency and environmental sustainability.

2.3 Best Practices and Case Studies from Around the World

Three global case studies illustrate the successful application of big data analytics in circular economy practices focusing on waste management:

1. Food-Waste Reduction in Global Businesses
2. Enevo in Belgium
3. Sensoneo in Slovakia

Waste Management: Food-Waste Reduction in Global Businesses

Literature Review and Case Study Analysis

Research emphasizes the critical role of big data in enhancing supply chain efficiencies and reducing food waste. Studies such as those by [16] illustrate how predictive analytics can forecast discrepancies in demand and supply, thereby minimizing overproduction and excess inventory, which are primary contributors to food waste [16]. In this case, 41 global businesses utilized big data analytics to optimize operations and reduce waste. These businesses effectively used big data to streamline production schedules, manage inventory, and optimize distribution paths, reducing food waste and enhancing profitability [17].

Objective	To explore how global businesses across the food supply chain use big data analytics to reduce waste and enhance resource efficiency.
Methodology	Through internet searches and expert referrals, researchers found 41 companies. Using business data, they examined the usage of big data analytics and its impact on food waste reduction. Companies were assessed by their supply chain position and waste hierarchy—prevention, redistribution, reuse, recycling, and recovery.
Findings	Companies optimizing linear supply networks for material efficiency reduced waste best with big data. It optimizes operations, resource allocation, and efficiency for these firms. Companies that sold cosmetically damaged food or turned food waste into new goods were less likely to use big data but could benefit from it.
Implications	The study emphasizes the need for tailored big data applications based on a company's supply chain function. It shows how big data may be expanded to have greater environmental and economic implications.

Waste Management: Enevo in Belgium

Literature Review and Case Study Analysis

The integration of sensor technology and data analytics in waste management has been increasingly studied, and it has shown significant improvements in operational efficiency and environmental sustainability [18]. Enevo implemented an intelligent waste management system in Brussels, utilizing sensors to monitor dumpster fill levels and optimize collection routes. This led to fewer collection trips, reduced emissions, and improved recycling rates, demonstrating the effective use of big data in urban environments [19].

Objective	To evaluate the impact of sensor-based data analytics on urban waste management efficiency and sustainability.
Methodology	The study analyzed waste collection data before and after implementing Enevo's system. Metrics such as the number of collections, vehicle emissions, and recycling rates were tracked to assess improvements.
Findings	Implementing Enevo's technology resulted in a 20% reduction in waste collection trips and a significant improvement in recycling compliance, highlighting big data's role in enhancing resource efficiency and reducing environmental impact.

Implications	This case shows how intelligent waste management solutions may change cities. Further study and investment in such technology could improve city sustainability worldwide.
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Waste Management: Sensoneo in Slovakia

Literature Review and Case Study Analysis

Big data's role in enhancing the efficiency of waste management systems through better decision-making and operational adjustments is well-documented [20]. Sensoneo's deployment in Slovakia involved using sensors and data analytics to monitor waste levels and optimize collection routes, reducing operational costs and increasing recycling efficiency.

Objective	To investigate the effectiveness of data-driven technologies in improving waste management practices in mid-sized European cities.
Methodology	The study involved continuously monitoring waste management activities in selected Slovak cities and analyzing data collected from Sensoneo's sensors regarding waste levels and collection frequencies.
Findings	Sensoneo's technology enabled a 30% reduction in collection costs and improved the recycling rate by optimizing the collection schedule based on actual waste generation data.
Implications	The successful application of Sensoneo's system illustrates the critical role of big data in modernizing waste management. It could serve as a model for other cities seeking similar efficiency and sustainability improvements.

3 Methodology

Data Collection

The study used secondary data from Eurostat, covering recycling rates and waste management metrics across Western Balkan countries, focusing on Albania from 2000 to 2022. This dataset was supplemented by local waste management data from the Albanian government and relevant NGOs involved in waste management and environmental sustainability initiatives.

Data Analysis

The analysis involved several steps: initially, a descriptive analysis was conducted to understand waste generation and recycling rate trends, calculating the mean, median, and standard deviation to assess the distribution and variability over the years. Trend analysis using time series techniques identified trends in Albania's recycling rates, highlighting significant improvements and periods of notable change. The comparative analysis placed Albania's data against that of neighboring Western Balkan countries to evaluate its performance in regional environmental efforts, providing insights into its progress in waste management. Finally, a gap analysis identified data gaps, particularly in the early years, discussing their potential implications on the accuracy and reliability of the trend analysis.

4 Results and Discussions

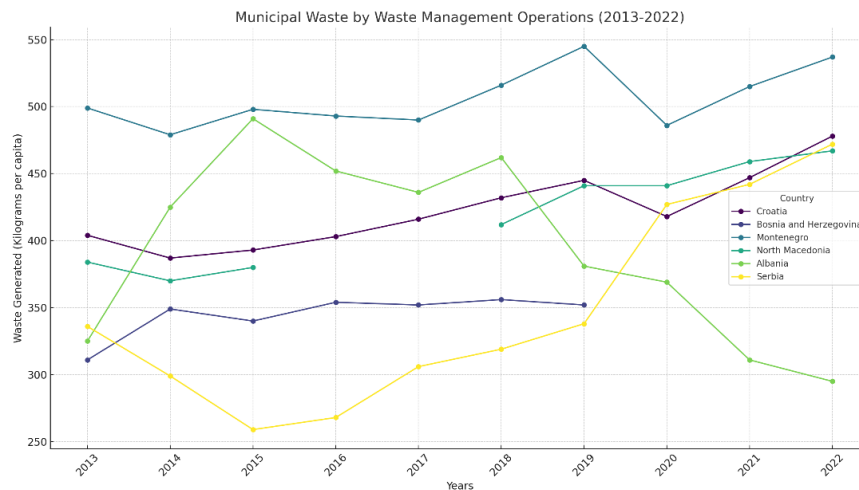


Figure 1.

Municipal waste by waste management operations in Western Balkans Countries

Source: Eurostat⁸

This analysis examines per capita waste generation across Western Balkan countries—Croatia, Bosnia and Herzegovina, Montenegro, North Macedonia, Albania, and Serbia—over ten years from 2013 to 2022. The study uses descriptive statistics and visual trend analysis to reveal patterns and implications of waste management practices in these nations. The data shows an upward trend in waste generation over the decade. Albania's waste generation increased from 376.5 kg per

⁸ https://ec.europa.eu/eurostat/databrowser/view/env_wasmun/default/table?lang=en

capita in 2013 to 449.8 kg per capita in 2022. The standard deviation values indicate significant variability within each country annually and across the region. Serbia recorded the minimum waste generation at 259 kg per capita in 2015, while Montenegro had the maximum at 537 kg in 2022. This range highlights the impact of local management efficiencies and policy effectiveness on waste production levels.

Country	Croatia	Bosnia and Herzegovina	Montenegro	North Macedonia	Albania	Serbia
Count	10	7	10	8	10	10
Mean	425.3	377.89	498.1	416.33	388.8	366.6
StdDev	29.78	60.19	23.62	37.37	78	76.8
Min	387	311	479	370	295	259
25th Percentile	403	340	490	380	325	299
50th Percentile (Median)	418	352	499	412	369	336
75th Percentile	445	356	516	445	436	427
Max	478	478	545	467	491	472
CAGR	0.02	0.06	0.01	0.03	-0.01	0.05

Table 1
Descriptive statistics and Compound Annual Growth Rate (CAGR) for the trend components of municipal waste for each country

Visual and Trend Analysis

Graphs illustrate diverse trajectories in waste generation among Balkan countries. Albania shows fluctuations, indicating variability in policy effectiveness and economic conditions. Croatia and Montenegro display consistent increases in waste production, aligning with their economic development and urbanization. In contrast, Bosnia, Herzegovina, and Serbia demonstrate stability in their waste generation, suggesting practical but static waste management systems.

Trend component analysis, performed using time series decomposition, highlights underlying annual waste generation data trends. This method, applied using Python and the **statsmodels** library, separates the data into trend, seasonality, and residuals. The focus on the trend component reveals Albania's need for improved waste

management strategies. While Montenegro and Croatia experience a steady rise in waste production, other countries show no significant directional trends, reflecting the complex interplay of economic, policy, and societal factors. The absence of clear trends in several countries indicates potential counteracting factors, such as improved waste reduction strategies or economic downturns, influencing overall waste generation.

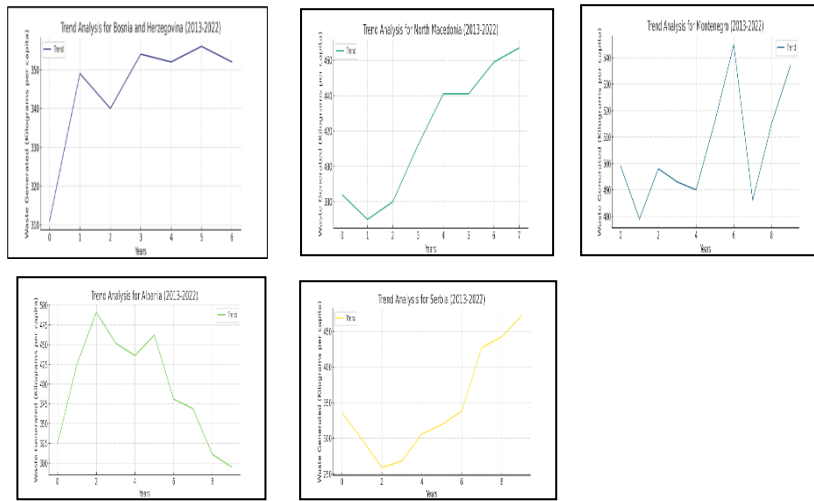


Figure 2
Trend Analysis of five Western Balkans Countries

Discussion

The upward trends in waste generation in countries like Montenegro and Croatia underscore the need for proactive waste management strategies, including enhanced recycling programs, waste reduction at the source, and increased public awareness and engagement. The variable trends across the region suggest that one-size-fits-all policies may not be effective, necessitating localized strategies tailored to each country's specific conditions and needs. This study highlights the critical importance of continuous monitoring and adaptive policy frameworks to manage waste generation effectively in the Western Balkans, which is crucial for environmental sustainability and the health and well-being of the region's

populations.

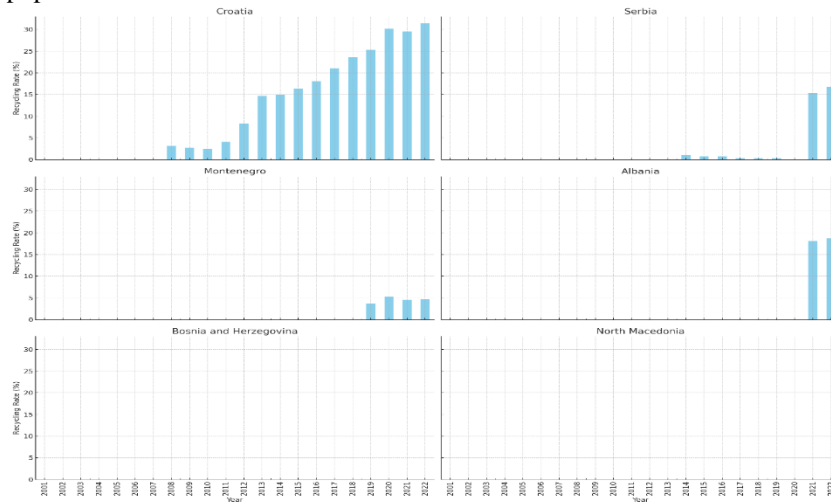


Figure 3.
Western Balkans countries' recycling rate of municipal waste
Source: Eurostat⁹

This other graph outlines the recycling rate of municipal waste. The statistics show a gradual increase in recycling rates over the years where data is available. Due to the very sparse data in the early years, many statistics (like mean and standard deviation) start becoming meaningful only later when more data points are available. Croatia and Serbia show measurable improvements and provide the most consistent datasets. Other countries like Montenegro, North Macedonia, and Albania show entries only in recent years, limiting trend analysis but indicating starting points for these countries about recycling initiatives. Bosnia and Herzegovina have minimal data, mostly zeros, indicating no reporting or significant recycling activity captured.

This analysis highlights the challenges and progress in recycling within the Western Balkans region, suggesting a general positive trend in recent years where data is more available. This could reflect increased efforts towards environmental sustainability in these countries.

⁹ https://ec.europa.eu/eurostat/databrowser/view/cei_wm011/default/table?lang=en

Conclusions and Recommendations

Allocate resources towards the implementation of robust data collection systems that are outfitted with Internet of Things (IoT) devices and sensors. This will enable the improvement of waste management practices and the establishment of standardized data reporting protocols across various municipalities. The utilization of machine learning and predictive analytics is employed to optimize the allocation of resources and deploy sensor-equipped smart receptacles that enable real-time monitoring of waste. Formulate policies grounded in empirical evidence by leveraging big data analytics and promoting public-private partnerships to foster innovation and improve waste management and recycling processes. These suggestions intend to improve the waste management practices in Albania to produce data-driven and sustainable solutions consistent with the circular economy. By implementing this proactive approach, achieving environmental sustainability goals concurrently with economic growth and improving community welfare would be possible.

This research underscores the substantial influence that big data analytics can exert in enhancing refuse management within the circular economy framework of Albania. A comprehensive data analysis from 2000 to 2022 has revealed significant advancements and trends that can potentially guide future endeavors.

Technological efficacy has been enhanced through the implementation of cutting-edge technologies like machine learning, predictive analytics, and IoT devices. These technologies have increased operational efficiencies, optimized recycling processes, and enhanced forecasting. International case studies substantiate these benefits, which illustrate reduced costs, increased recycling rates, and sustained feasibility.

Empirical evidence shows a notable increase in recycling rates and efficacy over the last three years. This implies that implementing strategies and technologies in adherence to global standards of excellence has yielded favorable results. Comparing Albania's performance to that of other nations reveals its progress and pinpoints regional cooperation and enhancement opportunities.

Integrating big data analytics into the waste management processes of Albania offers a promising pathway toward realizing a circular economy. Positive trends indicate a commitment to improving environmental management, offering a hopeful outlook on achieving sustainability goals. For Albania to fully actualize its environmental stewardship and waste management potential, advanced technologies and data-driven methodologies must be implemented.

References

- [1] M. Del Giudice, R. Chierici, A. Mazzucchelli, and F. Fiano, "Supply chain management in the era of circular economy: the moderating effect of big data," *The International Journal of Logistics Management*, 32(2), pp. 337–356, Apr. 2021, doi: 10.1108/IJLM-03-2020-0119.
- [2] A. Belhadi, K. Zkik, A. Cherrafi, S. M. Yusof, and S. El fezazi, "Understanding Big Data Analytics for Manufacturing Processes: Insights from Literature Review and Multiple Case Studies," *Comput Ind Eng*, 137, p. 106099, Nov. 2019, doi: 10.1016/j.cie.2019.106099.
- [3] B. Fang et al., "Artificial intelligence for waste management in smart cities: a review," *Environ Chem Lett*, 21(4), pp. 1959–1989, Aug. 2023, doi: 10.1007/s10311-023-01604-3.
- [4] Xindong Wu, Xingquan Zhu, Gong-Qing Wu, and Wei Ding, "Data mining with big data," *IEEE Trans Knowl Data Eng*, 26(1), pp. 97–107, Jan. 2014, doi: 10.1109/TKDE.2013.109.
- [5] H. Hassani, C. Beneki, S. Unger, M. T. Mazinani, and M. R. Yeganegi, "Text Mining in Big Data Analytics," *Big Data and Cognitive Computing*, vol. 4, no. 1, p. 1, Jan. 2020, doi: 10.3390/bdcc4010001.
- [6] A. K. Kushwaha, A. K. Kar, and Y. K. Dwivedi, "Applications of big data in emerging management disciplines: A literature review using text mining," *International Journal of Information Management Data Insights*, 1(2), p. 100017, Nov. 2021, doi: 10.1016/j.jjime.2021.100017.
- [7] H. El Bilali and M. S. Allahyari, "Transition towards sustainability in agriculture and food systems: Role of information and communication technologies," *Information Processing in Agriculture*, 5(4), pp. 456–464, Dec. 2018, doi: 10.1016/j.inpa.2018.06.006.
- [8] J. Kumari, E. Kumar, and D. Kumar, "A Structured Analysis to study the Role of Machine Learning and Deep Learning in The Healthcare Sector with Big Data Analytics," *Archives of Computational Methods in Engineering*, 30(6), pp. 3673–3701, Jul. 2023, doi: 10.1007/s11831-023-09915-y.
- [9] M. Seyedan and F. Mafakheri, "Predictive big data analytics for supply chain demand forecasting: methods, applications, and research opportunities," *J Big Data*, 7(1), p. 53, Dec. 2020, doi: 10.1186/s40537-020-00329-2.
- [10] N. N. Misra, Y. Dixit, A. Al-Mallahi, M. S. Bhullar, R. Upadhyay, and A. Martynenko, "IoT, Big Data, and Artificial Intelligence in Agriculture and Food Industry," *IEEE Internet Things J*9(9), pp. 6305–6324, May 2022, doi: 10.1109/JIOT.2020.2998584.

- [11] Y. Niu, L. Ying, J. Yang, M. Bao, and C. B. Sivaparthipan, "Organizational business intelligence and decision making using big data analytics," *Inf Process Manag*, 58(6), p. 102725, Nov. 2021, doi: 10.1016/j.ipm.2021.102725.
- [12] A. Majeed et al., "A big data-driven framework for sustainable and smart additive manufacturing," *Robot Comput Integr Manuf*, 67, p. 102026, Feb. 2021, doi: 10.1016/j.rcim.2020.102026.
- [13] I. A. R. Moghrabi, S. A. Bhat, P. Szczuko, R. A. AlKhaled, and M. A. Dar, "Digital Transformation and Its Influence on Sustainable Manufacturing and Business Practices," *Sustainability*, 15(4), p. 3010, Feb. 2023, doi: 10.3390/su15043010.
- [14] F. Lucivero, "Big Data, Big Waste? A Reflection on the Environmental Sustainability of Big Data Initiatives," *Sci Eng Ethics*, 26(2), pp. 1009–1030, Apr. 2020, doi: 10.1007/s11948-019-00171-7.
- [15] A. Kamilaris, A. Kartakoullis, and F. X. Prenafeta-Boldú, "A review on the practice of big data analysis in agriculture," *Comput Electron Agric*, 143, pp. 23–37, Dec. 2017, doi: 10.1016/j.compag.2017.09.037.
- [16] E. Papargyropoulou, R. Lozano, J. K. Steinberger, N. Wright, and Z. bin Ujang, "The food waste hierarchy as a framework for the management of food surplus and food waste," *J Clean Prod*, 76, pp. 106–115, Aug. 2014, doi: 10.1016/j.jclepro.2014.04.020.
- [17] F. Ciccullo, R. Cagliano, G. Bartezzaghi, and A. Perego, "Implementing the circular economy paradigm in the agri-food supply chain: The role of food waste prevention technologies," *Resour Conserv Recycl*, 164, p. 105114, Jan. 2021, doi: 10.1016/j.resconrec.2020.105114.
- [18] T. Anagnostopoulos et al., "Challenges and Opportunities of Waste Management in IoT-Enabled Smart Cities: A Survey," *IEEE Transactions on Sustainable Computing*, 2(3), pp. 275–289, Jul. 2017, doi: 10.1109/TSUSC.2017.2691049.
- [19] M. Farooq, J. Cheng, N. U. Khan, R. A. Saufi, N. Kanwal, and H. A. Bazkiaei, "Sustainable Waste Management Companies with Innovative Smart Solutions: A Systematic Review and Conceptual Model," *Sustainability*, 14(20), p. 13146, Oct. 2022, doi: 10.3390/su142013146.
- [20] E. Park, A. del Pobil, and S. Kwon, "The Role of Internet of Things (IoT) in Smart Cities: Technology Roadmap-oriented Approaches," *Sustainability*, 10(5), p. 1388, May 2018, doi: 10.3390/su10051388.

Creating a Decentralized Blockchain to Store University Data and Payment of University Course Material Through the Use of a Smart Contract

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Abstract: The use of blockchain technology gives universities the opportunity to create their own blockchain. By rethinking the Bologna program applied in education, in the future, universities will be able to work together even more closely in the field of joint curriculum development. It can be observed that different universities teach the same subjects. As a result, university lecturers have even more burdens outside of teaching, as lecturers must prepare the same teaching materials for each university. The aim of the research is to create a blockchain in practice, as well as to present it in detail, where university lecturers could upload uniformly prepared teaching materials. In the long run, a unified and universally accepted university curriculum will certainly bring many advantages. If the university also wants to upload paid course content to the blockchain, a smart contract must be used. With the help of a smart contract, payments for teaching materials would be carried out in an automated manner, so additional burdens could be taken off the shoulders of universities. Since the blocks in the blockchain are closely built on top of each other, it is difficult to modify them with the educational materials stored in them. Since universities must provide students with up-to-date knowledge, the teaching materials must also be up to date. The modification of teaching materials at specified intervals could be solved using the Soft-Fork blockchain process.

Keywords: Study Material, Smart Contract, Soft-Fork

Introduction

Today, blockchain technology is still considered a novelty, even though new ideas in this area appear daily. IT professionals are still getting to know blockchain-based solutions and are trying to take advantage of its potential.

Blockchain technology has not yet spread in university education, although it is already successfully used in many areas, such as:

- Health records stored in a blockchain allow patients to make their structured data available to doctors. Such patient electronic health record databases would make entries tamper-proof while empowering patients to grant access to their electronic health records [1].
- Nowadays, many banks and other financial institutions are looking into and implementing blockchain security systems that are reducing the risk of cyber threats and fraud. The NASDAQ recently announced a plan to launch a Blockchain-based digital ledger which allows them to boost their equity management capabilities [2].
- The world is facing an expansion in the quantity and diversity of digital data that are generated by both users and machines. Blockchain technology comes providing significant solutions for the best way to store, organize, and process Big Data [3].
- Musicians can sign smart contracts with the label. The advantage of this is that by concluding decentralized and completely transparent contracts, it is possible for them to be paid on time and, in case of success, to receive even higher royalties. The smart contract implements the predetermined conditions without any external influence. Last but not least, Spotify acquired the media blockchain in 2017 [4].

To securely store and access the data, the course materials can be uniformly uploaded to the blockchain, as it can be observed that different universities do not teach the same subject in the same case. By applying blockchain technology, teaching materials can be standardized, so that lecturers do not have to process them again and again at each university. If the student was to change universities, the teaching materials would be the same as those of the previous university, so education would become even more efficient. An important part of the Bologna program is that the curriculum of the universities is similar so that when the student changes universities, the student can take the subjects he has already taken with him, so he does not have to repeat them again. Due to the use of blockchain technology, this check is not necessary, as the curriculum is uniform in all cases. It may happen that the study materials of some courses are paid for, in which case the study materials of the university blockchain can be accessed through a smart contract. Using the smart contract, the course material can be purchased automatically, without human intervention.

The research is structured according to the following structure:

- Examination of decentralized On-Chain and Off-Chain solutions for university data storage creation of an UEDSC blockchain,
- Creating a university blockchain,
- Sale of university study materials using a smart contract,
- Executing a Soft-Fork on the UDSC Blockchain.

1 Investigaiton of Available Blockchain Types from the Perspective of Storage of University’s Teaching Materials

By using a decentralized data storage solution, the data is more secure than in the case of cloud-based storage, since it is distributed across a number of nodes. Furthermore, storage systems use public key encryption. Data is distributed flexibly between nodes, and smart contracts are also used automatically for the purpose of execution [5]. Advantages of decentralized data storage:

- The performance is balanced, as the nodes share the data volumes proportionally,
- High availability. Most of the hubs are available 24 hours a day. If some nodes become unavailable, the others will continue to serve the user.
- High degree of independence. Each node is independently responsible for following the rules, thus forming the blockchain ecosystem. It is not restricted by an outside person or authority and regulates its operation.
- The users' data is fragmented and then sent encrypted to the nodes. In the event of a DDoS attack, the system remains operational.
- If some nodes do not work or become unreachable in the event of an attack, the other nodes can continue to function without interruption. In the centralized system, if the central server stops, the whole system will most likely be inoperable, that's why it is data cannot be accessed [6].

There are two major implementations of decentralized blockchain-based data storage. This is the Off-Chain and On- Chain blockchains.

Off-Chain does not store each individual data per node, instead it records their hash value. The actual storage of the data would take place on the university's hard drive. This data is fragmented into multiple copies before saving [7].

On-Chain is the most secure blockchain-based data storage solution, as all data is saved in every block. As a result, the operation of the network can slow down, extremely may become unavailable due to overload. In addition, the nodes preserve all data and are constantly synchronized with each other. If an attack occurs, the data will not be lost. This is an expensive but safe solution [8]. The first figure below shows the structure of the private blockchain.

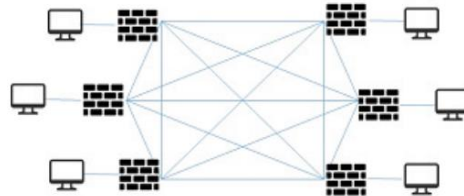


Figure 1
Private blockchain [9]

Before I create my own blockchain that is suitable for storing university data, I will examine what ready-made blockchain-based data storage solutions are available that may be suitable for storing university data. These are the following:

- File Coin and
- IPFS (InterPlanetary File System).

File Coin, like other decentralized services, has the following disadvantages:

- High volatility, therefore surrounded by considerable uncertainty,
- Difficult to scale,
- In many cases, they are slower than their centralized counterparts. The speed is very data-miner dependent [10].

The purpose of IPFS is to connect all computer systems to the same file system. It also works on a Peer-to-Peer basis. The advantage is that there is no central server and that the data is stored in different locations around the world.

Compared to other systems, it offers a high-performance block storage model in which content and destination links are located. It also combines DHT (Distributed Hash Tables) solutions with self-authenticating namespaces. The advantage is that IPFS nodes do not need to trust each other, thus reducing the possibility of failure. Its only drawback is that it does not provide a strong data protection and cryptographic solution [11].

After reviewing IPFS and File Coin data storage solutions, I have concluded that for the highest database security available, I will create my own university blockchain where I can personally control access rights to the data. To keep the On-Chain blockchain fast, I will maximize the block size to 1 MB.

2 Creation of a University Blockchain

In the case of the constitution of a self-sufficient, faculty-based blockchain, the educational institution may determine the advantageous and convenient conditions of data storage. These may be the following:

- Broader access to the blockchain in question,
- The definition of the size of blocks,
- The definition of terms of use,
- The original block (genesis block) to which will all the other blocks will connect, stays in the domain of the faculty,
- The limiting of access to the blockchain (only the authorized persons may use it),
- The definition of data protection policy,
- The blockchain may be started on multiple servers to uphold the security,
- The nodes are more easily monitored,
- The system will become more transparent,
- The eventual data compromising will be more easily identified [12;13].

When creating the university blockchain called UDSC (University Data Storage Chain), the first step is to create the genesis block. The creation of the genesis block is shown in the second figure.

```

{
  "config": { // the config block defines the settings for our custom chain and has certain attributes to
create a private blockchain
    "chainId": 987, // identifies UDSC blockchain
  }
  "homesteadBlock": 0, // Homestead version was released with a few backward-incompatible
protocol changes, and therefore requires a hard fork. UDSC chain however won't be hard-forking for
these changes, so leave as 0
  "eip155Block": 0, // Homestead version was released with a few backward-incompatible protocol
changes, and therefore requires a hard fork. UDSC chain however won't be hard-forking for these
changes, so leave as 0
  "eip158Block": 0
},
  "difficulty": "0x400", // This value is used to control the Block generation time of a Blockchain. The
higher the difficulty, the statistically more calculations a Miner must perform to discover a valid block
  "gasLimit": "0x8000000",
  "alloc": {}
}

```

Figure 2
Creating a genesis block [14].

The faculty-based blockchain may be constituted in the following manner, presented in the third figure. This blockchain called UDSC needs to be created for the purpose of storing the university teaching materials.

```

University chain-util generate UDSC
the default settings would be used:
/default ~ university chain/UDSC/chainsettings.dat
chainsettings.dat include:
Database addresses [receiver (cloud storage) IP address, sender (university) IP address],
Database system addresses [receiver (university database) IP address, sender IP address],
Terms of GDPR database.
Next, the UDSC blockchain would be initialized, and the genesis block would be created
universitychain UDSC
The server will be started in those few seconds after the genesis block has been found, then the node
address needs to be connected:
UDSC@192.168.0.1:8008
After these steps, the connection can be attempted from a second server:
universitychain UDSC@192.168.0.1:8008
After the message confirming the chain has been initialized, permission is not given for connection to
the database. The address would be copied and pasted: 192.168.0.2
finally, permission for connection would be granted:
universitychain UDSC grant 192.168.0.2 connect.

```

Figure 3
The creation of an UDSC blockchain [8;12;13]

3 Payment of University Course Material Through the Use of a Smart Contract

A Smart Contract is a digital contract that controls the user's digital assets, formulating the participant's rights and obligations, and will automatically execute by computer system [9].

A smart contract is one based on blockchain technology a solution that automatically executes the conditions defined therein by bypassing an external third party as an enforcer. It only executes instructions that which are defined in advance in the contract terms. These conditions are called triggers. The following 4 conditions are required when concluding a smart contract:

- For the subject of the contract, which is actually the subject of the contract,
- To define conditions precisely. The provisions of the contract can only be implemented if they are fulfilled,
- For authentication. The subject of the contract and its conditions must be authenticated with a digital signature,
- Lastly, a blockchain is also needed where the contract can be created [15].

After the creation of the university UDSC blockchain, the course materials become accessible to students after entering the appropriate username and password. However, as part of some courses, lessons may become paid. This is especially typical for online education. If paid content is uploaded to the blockchain, then by definition it can only be accessed after payment. The smart contract is a big help in this. By applying a smart contract, paid course materials stored in the blockchain become available to students after they have been paid for them. The fourth figure below shows the smart contract-based payment method.

```
1 contract University study material {
2 uint public price ;
3 uint public university's stock ;
4 /.../
5 function updatePrice ( uint _price ){
6 if ( msg. student == university )
7 price = _price ;
8 }
9 function buy ( uint quant ) returns ( uint ){
10 if ( msg. value < quant * price || quant > stock )
11 throw ;
12 stock -= quant ;
13 /.
```

Figure 4
Sale of university study materials using a smart contract

4 Possible Soft-Fork of UDSC University Blockchain

If the lecturers want to modify the curriculum uploaded to the existing blockchain to the blockchain, then a Soft-Fork must be performed on the university UDSC blockchain to ensure the continued smooth operation of the blockchain. This means that the system Soft Fork comes to play when the system comes to a new version or new agreement, and it isn't compatible with the previous version, the new nodes couldn't agree with the old nodes. Because the computing power of new nodes has greater weight than old nodes, the old nodes will never be approved by the new nodes, but new nodes and old nodes will continue to work on the same chain. There is also a concept of compatible chains that are made when new nodes and the old nodes agree on the consensus and the new nodes can also join in with the old nodes as well [16]. The fifth figure shows the Soft-Fork of the UDSC blockchain.

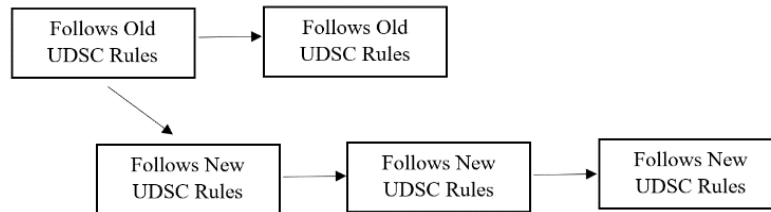


Figure 5

Soft-Fork on UDSC blockchain [17].

5 UDSC Connect with Other University Blockchain

To be able to connect a blockchain with another blockchain, you need a blockchain bridge. In general, blockchains are separate closed systems that have their own ecosystem. If we want to connect the university UDSC blockchain with another blockchain, a blockchain bridge must be used. In practice, this would mean that if the other universities also have their own blockchain, interoperability and closer cooperation could be established between them. In the case of a decentralized bridge, the main goal is that there is no need for an external party that can cheat. As a result, a smart contract and a decentralized network are needed, as well as validators who pay attention to compliance with the rules.

In addition to using the blockchain bridge, the Polkadot blockchain can also be used to connect the UDSC blockchain with other university blockchains, as Polkadot aims to create a framework between blocks that want to create a common connection between each other. Blockchains can connect to Polkadot and thus work in parallel.

Conclusions

Even though universities are open to new solutions and use modern teaching methods, the potential inherent in blockchain technology is not yet fully exploited.

By creating a unified and universally accepted university blockchain, cooperation between universities can be made even closer. The storage of uniform teaching materials in a blockchain is considered a forward-looking solution nowadays, which is currently underutilized.

By applying a smart contract, even paid content becomes available to students. Since there is a need for continuous curriculum development, the modification in the blockchain can be solved with the help of Soft-Fork.

Depending on the possibility, it would be advisable for universities to create their own common blockchain, rather than renting a ready-made blockchain suitable for data storage, since in this way they would be able to regulate the operating conditions of the blockchain and the authorizations themselves.

References

- [1] I. Radanović, L. Robert: Opportunities for use of blockchain technology in medicine, *Applied health economics and health policy* 16, Springer, 2018. pp. 583-590.
- [2] S. Demirkan, I. Demirkan, A. McKee: Blockchain technology in the future of business cyber security and accounting, *Journal of Management Analytics* 7.2, 2020, pp. 189-208.
- [3] E. Karafiloski, M. Anastas: Blockchain solutions for big data challenges: A literature review, *IEEE EUROCON 17th International Conference on Smart Technologies*. IEEE, 2017.
- [4] S. Perera, S. Nanayakkara, M. Rodrigo, S. Senaratne, R. Weinand: Blockchain technology: Is it hype or real in the construction industry, *Journal of industrial information integration*, 2020, p. 17.
- [5] P. Jiang, F. Guo, K. Liang, J. Lai, Q. Wen: Searchchain: Blockchain-based private keyword search in decentralized storage, *Future Generation Computer Systems*, 107, 2020, pp.781-792.
- [6] R. Amer: Centralized vs Decentralized Storage, Redefining Storage Solutions with Blockchain, <https://blockgeeks.com/guides/centralized-vs-decentralized-storage-redefining-storage-solutions-with-blockchain-tech/> (accessed: 2023.02.09), 2020.
- [7] S. van de Alex: Ethereum blog, How to build serverless applications, <https://blog.ethereum.org/2016/07/12/build-server-less-applications-mist> (accessed: 2023.02.09), 2016.

- [8] Krisztian Bálint: Possibilities for the Utilization of an Automatized, Electronic Blockchain-based, Students' Attendance Register, using a Universities' Modern Security Cameras, Acta Polytechnica Hungarica, DOI: <http://doi.org/10.12700/APH.18.2.2021.2.7> , 18(2), 2021, pp. 127-145.
- [9] L. Iuon-Chang, L.Tzu-Chun: A survey of blockchain security issues and challenges, International Journal of Network Security, 19(5), pp.653-659, 2017.
- [10] T. Gábor, D. Kiss: An introduction to the world of cryptocurrencies, Economy and Finance1(5) 2018.
- [11] S. Wang, Y Zhang: A blockchain-based framework for data sharing with fine-grained access control in decentralized storage systems, IEEE Access, 6, 2018, pp.38437-38450.
- [12] Krisztián Bálint: The connection of a Blockchain with Students' Attendance Register based on Security Cameras, IEEE 19th International Symposium on Intelligent Systems and Informatics (SISY 2021), Subotica, Serbia, 2021, 191 p. pp. 67-70.
- [13] Krisztian Bálint: Data Security Structure of a Students' Attendance Register Based on Security Cameras and Blockchain Technology, IEEE Joint 22nd International Symposium on Computational Intelligence and Informatics and 8th International Conference on Recent Achievements in Mechatronics, Automation, Computer Science and Robotics (CINTI-MACRo 2022) : ProceedingsBudapest, Magyarország 418 p. pp. 185-189. , 6 p, 2022.
- [14] Krisztián Bálint: Modern, Decentralized Blockchain-Based Solutions for Saving Video Footage, IEEE 18th International Symposium on Intelligent Systems and Informatics (SISY 2020) Danvers (MA), Amerikai Egyesült Államok: IEEE, 2020, 185 p. pp. 11-14.
- [15] G, Budai: Blockchain is the world of cryptocurrencies and smart contracts, Budapest University of Economics, Faculty of Economics, Zalaegerszeg, 2018.
- [16] M. Memon, U.A. Bajwa, A. Ikhlas, Y., Memon, M. Malani: Blockchain beyond Bitcoin: block maturity level consensus protocol. IEEE 5th International Conference on Engineering Technologies and Applied Sciences (ICETAS), 2018, pp. 1-5.
- [17] A. Tchakerian: Research Project the Blockchain Revolution Prospects and limitations, Research Dissertation for Master 2 Grande Ecole Programme, Researchgate project, 2019.

From Waste to Wealth: Exploring the Viability of Profitable Recycling Businesses in Developing Economies

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Abstract: This paper investigates the potential of establishing profitable recycling businesses in developing countries. Utilizing a literature review approach, we analyze the circular economy (CE) framework, recycling sector opportunities, and waste management strategies within these nations. While acknowledging the challenges associated with developing such industries, our analysis identifies potential avenues for success. To inform effective strategies and feasible solutions, we examine the growth patterns of the US recycling market and the

implementation of the circular economy in Africa. We posit that recycling can be a viable and profitable venture in developing countries, contingent upon the presence of specific enabling factors.

Keywords: circular economy (CE), recycling, developing countries, profitability, waste Management

1 Introduction

A waste crisis has emerged worldwide wherein billions of tons of waste are generated annually. Developing countries, in particular, grapple with insufficient or non-existent waste management systems, making waste management challenges more pronounced [1]. Recycling holds the potential to resolve this issue by minimizing waste and opening up economic opportunities. Yet, the establishment of profitable recycling industries in developing countries is hindered by inadequate infrastructure, limited financing, and unsupportive regulatory and policy structures. Additionally, it is worth investigating the possibility of public-private collaborations to encourage financially successful recycling businesses and the effects of such industries on society and the environment in emerging economies.

The purpose of this study is to find out how the recycling business can work in developing countries as an activity that can bring profit and, at the same time, have a positive effect on the environment such as waste, pollution, and CO₂ reduction. It is a well-known fact that recycling has been a successful activity in a number of developed countries. Yet, it is unclear which sectors of the recycling business are more profitable, especially considering the fact that developed and developing countries have different conditions under which recycling activities are conducted.

Exploring the most profitable recycling sector that can have a beneficial long-term impact in developing countries, as well as the challenges and opportunities that it may face in those areas will be under scrutiny. Many stakeholders such as governments, investors, and a variety of businesses might find this research beneficial to find new business opportunities as well as support the field of sustainability. That is why the aim of this research is to analyze recycling business models covering all its sectors, to perceive the potential opportunities and to comprehend the intricacies of a recycling business in developing countries in order to explore its possible profitability and its sustainability effect.

The research objectives will include the exploration of the recycling activities at current levels in developing countries, the analysis of possible obstacles to establishing a recycling business in developing countries, the evaluation of recycling models in developed countries and their profitability, the detection of long-term benefits recycling activities pose on the environment, the discovery of developing countries laws and regulations, the exploration of the advantages for

developing countries in terms of social and economic fields [2], and the provisions of possible profitable recycling business sectors for developing nature.

After the research and data collection methods a literature review will be presented. The Results section will include the detailed analysis and discussion of the present situation regarding the recycling sector in the selected developing countries and the paper closed with a discussion and conclusions sections.

2 Research Method and Data Collection

The research basically relies on secondary data and apart from the literature secondary data analysis is carried out. The literature review presents a comprehensive and in-depth literature review of available research addressing recycling as a profitable business in emerging and developing economies. Academic journals, prior research papers, and reports from organizations including the World Bank or the United Nations may fall under this category.

As primary research economic analysis is conducted focusing on the financial performance and profitability of recycling businesses in developing countries. This may include analyzing market demands for recycled products, recycling process costs, and the potential revenue streams that can be generated. Annual reports published by acknowledged companies and public datasets are used as source for analysis.

The primary research is conducted by the usage of secondary data. Developing countries are combined together in order to find out which recycling practices as well as practices of circular economy can bring profit and improve the environment in those specific regions. Due to the nature of the research which aims to find out the situation in a number of countries and touches a variety of sectors and businesses to which is hard to gain access to, it would be very costly and time-consuming to collect data. The most suitable method was the usage of secondary data which is obtained from such sources as books, journal articles, research papers, and governmental reports. These sources can provide a broad spectrum of information to answer the main questions of the research.

We will mainly rely on and utilize sources for the literature review in which we will choose carefully and thoroughly while paying attention to selecting the most relevant, credible, and up-to-date sources that highlight and gives insights on matters related to our topic such as circular economy using as outlined by [3], [4], recycling industries and waste management in developing countries while comparing these practices with some developed countries such as the United States of America. The selection criteria for these sources relies mostly on published academic articles and journals, books written by prominent researchers, and reports

published by well-known and relevant institutes such as World Bank and World Economic Forum with the intention to validate and prove the reported data.

3 Literature Review

Global waste management is critical to sustainable development, yet it is often overlooked in development theory and global education. Sub-Saharan Africa is expected to experience the largest increase in waste generation, and the region is already facing a growing waste management crisis [1]. The main conclusion of the dissertation by Thorleifsson [1] is that there are fundamental industry barriers that companies have limited ability to influence, but they urgently need to overcome them [1]. The industry is fragmented; many small actors are acting alone and several industrial synergies.

A roadmap for sustainable waste management in developing countries can be found in the book by Hossain et al. [5]. An experienced team of sustainability researchers provides a brief overview of modern waste management practices that serve as a guide for waste management professionals [5]. Along with flow charts and problem examples, the authors provide readers with the information they need to support decision-making by country, city size, population, waste generation, type, geographic location, etc. The book begins with an overview of modern waste management practices, including waste generation, collection, recycling, composting, recycling, and waste disposal.

The book “Waste Management Practices in Developing Countries” edited by Godfrey [6] provides information on waste management practices in developing countries, as well as the application of research and innovation to find suitable solutions to improve waste management [6]. Each chapter is selected with a focus on the accumulation of organic waste, a major waste stream in developing countries. Some chapters deal with waste mismanagement practices as well [7].

Based on the International Workshop on Controlled Life-Cycle of Polymeric Materials held in Stockholm, Sweden, the work by Albertsson and Huang [8] offers detailed discussions of degradable polymers and the recycling of plastic materials – analyzing important current topics such as renewable resources, degradation and test methods, processing and products, environmental issues, future materials, and global governmental policies [8].

The background and strategy paper published by the United Nations Industrial Development Organization (UNIDO) [9] proposes that the development of industrial and post-consumer waste recycling facilities would be an ideal starting point for the UNIDO to consolidate and expand its activities in the area of the

circular economy [9]. The research outlines a broad policy framework that provides some guidance on how this goal can be achieved [9]. Unfortunately, the development of the recycling market has largely neglected in recent decades. For example, the US, like many other countries, has become dependent on China and other countries for the final markets for materials. US since recyclers recognized the profitability of selling low quality products to the Chinese market, which the abundant and tolerant Chinese markets could absorb. Therefore, the growth of single-stream recycling developed in the United States which (with higher pollution rates) together with the relatively low oil and natural gas prices (crushing virgin plastic resin prices), and reduced U.S. production of many materials have all contributed to lower demand for recycling in the US domestic markets [10].

Recycling plastics into new materials is a vital step in addressing the problems presented by plastic waste since it may greatly reduce the quantity of waste that ends up in the environment [11]. Plastic waste is difficult to decompose in the environment and will endure a very long period in landfills and the ecosystem [12]. Through the implementation of plastic recycling techniques, plastic items may still be produced and consumed while producing less garbage that will harm the environment and land up in landfills. A significant portion (about 40%) of the plastics used globally are consumed by packaging. Annual global use of plastic packaging materials is over 78 million tons. Just 14% of plastic packaging gets recycled globally, with the remaining 40% being dumped in landfills, 32% leaking into the environment, and 14% being burned and/or utilized for energy recovery [13]. The global non-fiber recycling rate increased steadily between 1990 and 2014 at a rate of 0.7% per year, whereas the global non-fiber incineration rate rose by an average of 0.7% per year between 1980 and 2014. If these trends continue as it is estimated, by 2050 the global combustion rate will reach 50% and the global recycling rate will reach 44%, resulting in a decrease in the global waste rate of non-fiber plastics from 58% in 2014 to 6% [14].

3.1 The Circular Economy

This research claims that circular economy (CE) is practiced much less in developing countries compared to developed nations. Ahmed et al. [15] in their work aim to explore the circular economy model in a developing country, in Bangladesh to pursue a higher level of sustainability in the region. This work attempts to portray possible challenges as well as prospects of the CE being practiced in Bangladesh using qualitative and quantitative data. Despite the prospects, CE stays not widely practiced in the region. The study also tries to reveal the existing barriers in Bangladesh that prevent CE from being widely practiced [15].

In the work by Murphy and Resonfield [16] a collection of articles is presented that attempts to demonstrate how to move from theory to practice regardless of CE. The traditional approach to the life cycle of goods is also compared to the CE's approach to the life cycle. It is also discussed how CE could be profitable not only in

developed nations but also in developing countries. Customers' new demand for durable goods is discussed as well. Different sectors are considered and possible models are offered for those particular sectors [16].

In the WEF report [17], the work of the ACEA (the African Circular Economy Alliance) is discussed. The mission of this alliance is to deliver economic growth, to create jobs as well as to contribute to sustaining the environment. The sectors chosen by the ACEA (food systems, packaging, the built environment, electronics, fashion, and textile) are the most important to the region due to their high circularity potential as well as economic significance [17].

The circular economy is a model of production and consumption that involves sharing, renting, reusing, repairing, refurbishing, and recycling pre-existing materials and commodities to form a closed-loop system that reduces waste and keeps resources in use for as long as is practical. A circular economy aims to diverge from the traditional linear economy, which is predicated on resource extraction, consumption, and final waste disposal. In a circular economy, resources are not discarded since goods are made to have several lifecycles [18]. Recycling is a crucial part of the circular economy since it entails gathering, classifying, and processing garbage to make new products, which cuts down on the use of raw materials and waste [19].

The circular economy seeks to establish a sustainable system that minimizes waste, uses resources effectively, and safeguards the environment. In 2022, it was predicted that the entire global income from transactions involving the circular economy, which includes the categories of used, rented, and refurbished items, would be over 339 billion dollars. By 2026, this is expected to more than double [20].

Based on the literature review the following research questions were formulated:

RQ1: Which sectors of the recycling activities could be the most profitable in the developing countries?

RQ2: What are the possible obstacles to establishing recycling businesses in the developing nations?

RQ3: What are the social and economic advantages of recycling practices in developing nations?

4 Results

In order to be able to compare the recycling possibilities and the profitability potential in the recycling business in developing countries the performance in the USA is analyzed in detail.

4.1. Waste Management and Recycling in the US

In the USA the Municipal Solid Waste (MSW) production totaled 292.4 million tons in 2018, up by around 23.7 million from 2017. Compared to 1990 and 2017 MSW grew by 40.37% and 8.82% respectively. The per capita daily MSW figure was 4.9 pounds per person in 2018 up by 8.89% from 2017 [21]. Figure 1 displays MSW generation between 1960 and 2018 in the USA, which shows that paper and paperboard generation grew exponentially till around 2005 when a radical drop can be detected.

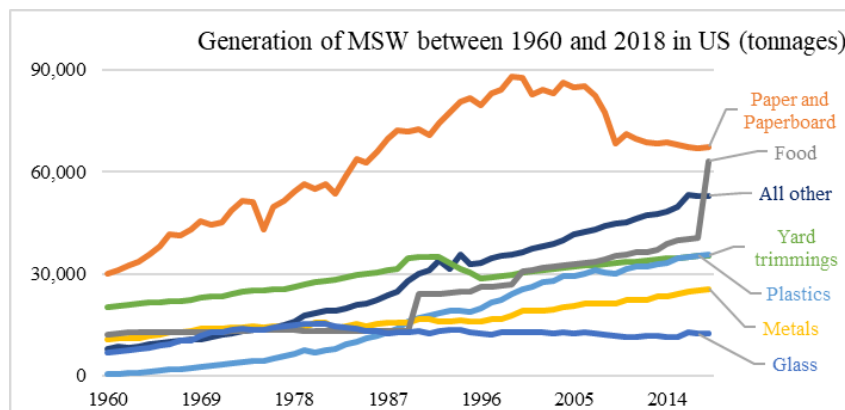


Figure 1

Municipal waste generation in the US between 1960 and 2018

There was an inflexion point in the middle of the 1980s in glass waste generation and from those years glass waste generation is continuously decreasing. The production of plastic products in 2018 was 35.7 million tons or 12.2 percent of total production. From 2010 to 2018, this increased by 4.3 million tons, and it was mostly driven by the categories of durable goods, containers, and packaging.

On the other hand, food waste generation sharply grew from 2017 to 2018, which should be taken into consideration in the future. Plastic waste generation has been continuously increasing from 1960, which also call for attention since plastic recycling has been one of the major issues in the last decade. From 8.2% of generation in 1990 to 12.2% of generation in 2018, plastics generation has increased. Over the previous eight years, the generation of plastics as a percentage of overall generation has ranged from 12.2 to 13.2 percent [21].

Figure 2 displays the distribution of MSW generated in 2000 and 2018. In 2000 paper and paperboard production made up the largest share of MSW (36.18%), which decreased to 23.05% by 2018. On the other hand, the share of food waste, metal waste and even plastics waste increased, there was a significant increase in food waste generation from 12.66% in 2000 to 21.59% in 2018, which means a 105.64% increase in 18 years.

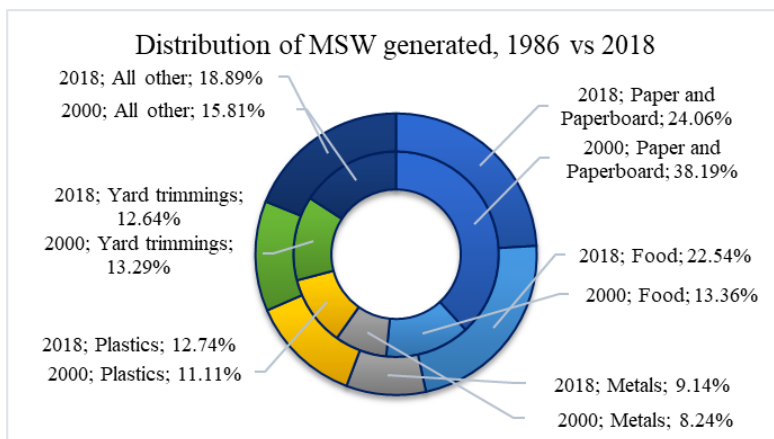


Figure 2

Total MSW generated by material in 2000 and 2018 based on [21] (developed by authors)

Paper and paperboard products made up the largest amount of all the materials in MSW, accounting for 23.05% of total output in 2018 (Figure 1). Less paper and paperboard were produced between 2000 and 2018, down from 87.7 million tons to 67.4 million tons, down by 23.2%. Newspaper production has decreased since 2000, and this trend is expected to persist, primarily due to increased news digitization but also in part due to smaller pages. Office-type (high-grade) paper output has dropped as well, at least in part as a result of procedures including an increasing dependence on electronic report filing [21].

The generated waste is managed in different ways in the US. Apart from recycling the waste is combusted with or without energy recovery, it is used for landfill, or it is composted. In 2018 out of the municipal waste generated 69.1 million tons were recycled, which is a bit more than 25% of the waste generated (26.36%). Figure 3 shows, however, that the recycling amount as well as the share of recycling have both increased since 1960 till the end of the last decade. There was large drop in the generated waste and its share, and while waste generation seems to increase since then, the share of recycling could not recover till 2018.

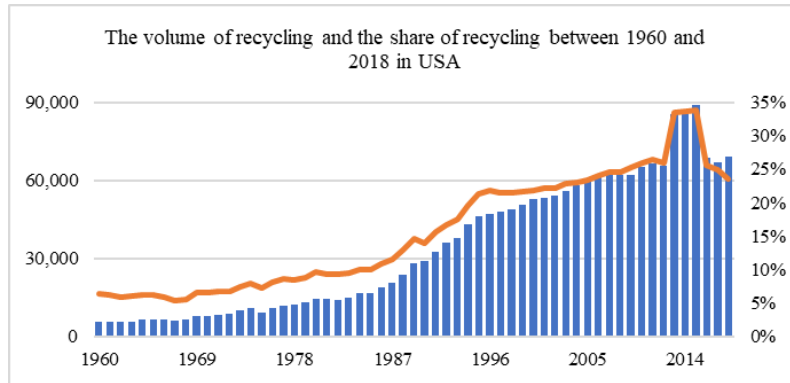


Figure 3
Volume and share of recycling from 1960 to 2018

Looking at the distribution of recycling by material and comparing 2000 and 2018 it can be seen that paper recycling dropped from 70.85% share to 66.54%, which a significant drop, however, if the share of paper waste production is considered, which has significantly dropped from 2000, it is still the most popular and used type of recycling (Figure 4).

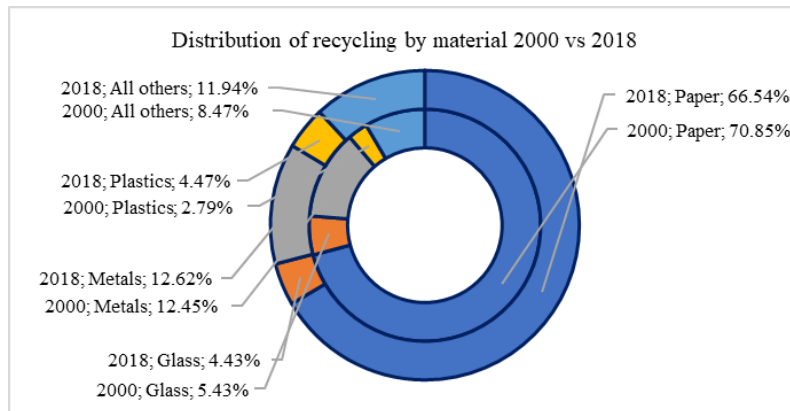


Figure 4
Recycling of Municipal Solid Waste

Moreover, 69 million tons of MSW were recycled in total, with paper and paperboard making up around 67 percent of that total. Glass, plastic, and wood made up between 4 and 5 percent, while metals made up roughly 13 percent.

There was a significant but relatively still very low share of recycling of plastics, the share of glass and metal recycling stagnated while other material recycling increased from 8.74% to 11.94% from 2000 to 2019.

Analyzing the historical time series data of the volume of recycled material an S curve can be detected for each type of material between 1960 and 2018. Figure 5 display the volume of recycled material between 1960 and 2018, the volume of paper recycling is on the right axis, while the others are on the left axis, due to a large difference between paper recycling and all the other material recycling.

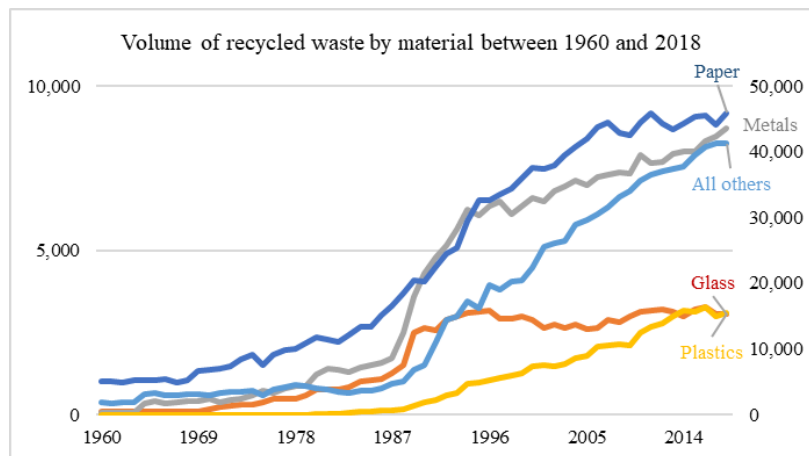


Figure 5
Volume of recycled waste by material 1960-2018

The rapid growth of recycling till 1990 turned into a lower growth, depicting a turning point in 1990. Since then the growth of recycling slowed down and signaling saturation in certain fields. As the volume of paper waste generation continuously decreasing it is expected that the volume of recycling will slowly decrease. A similar phenomenon should be detected in plastics recycling as the generation of plastics waste is expected to decrease resulting saturation even if the volume of recycling is increasing. Next to paper recycling metal recycling shows an accelerated growth in the last thirty years. Glass recycling, however, has been stagnating since 1990s, in which area a continuous increase should be expected [22].

Corrugated boxes (32.1 million tons) and mixed nondurable paper products (8.8 million tons), newspapers/mechanical papers (3.3 million tons), lead-acid batteries (2.9 million tons), major appliances (3.1 million tons), wood packaging (3.1 million tons), glass containers (3 million tons), tires (2.6 million tons), mixed paper containers and packaging (1.8 million tons), and a few consumer electronics were the most recycled products and materials in 2018 [21]. These items made up the majority of the MSW recycling in 2018, 90% overall.

4.2 Average Price index of recycled materials

When analyzing profitability considering the prices of the secondary material market is a must. Figure 6 presents indicators of the average prices of recyclables in the European Union (EU), considering the secondary price materials. The indicator aims to present relevant data and provide a broader overview of the secondary material market. Secondary materials are waste materials that are recycled and can be used in manufacturing processes, instead of alongside 'virgin' raw materials [23].

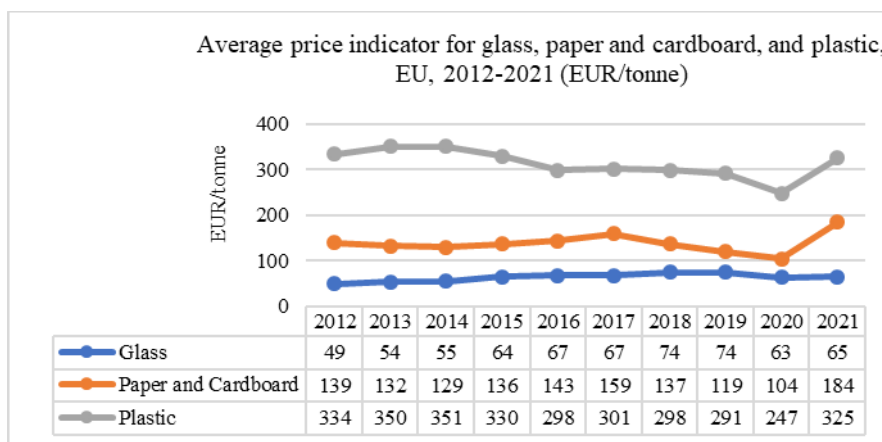


Figure 6

Average price indicator 2012-2021 (EUR/ton)

In the case of glass prices, after continuously increased they peaked in May 2018 (86 EUR/tonne) and July 2018 (84 EUR/tonne) in the observed period between 2015 and 2021. In 2019 the price remained stable between 57 and 82 euros per tonne, while it slightly dropped in 2020 and 2021. In 2021 the average price indicator could increase to a yearly 64.06 EUR/tonne after the January low price of 59 EUR/tonne [23].

Regarding paper, after a five-year stagnation from 2016 the average yearly price could reach a peak of 157 euros per tonne in 2017, but it was followed by a steeper decrease in the average yearly price to quickly to 137 euros in 2018, 118 euros in 2019, and 104 euros in 2020. The turning point was in 2020 when the average price rose to 184 euros per tonne in 2021. After the COVID-19 epidemic, there was a considerable rise in prices, hitting its peak for the whole time of 213 EUR/tonne in November 2021 [23].

The plastics market seems to have performed worse regarding the average price compared to the glass and the paper secondary market as after a peak in 2013 and 2014 (350 EUR/tonnes and 351 EUR/tonnes respectively) a considerable average price decrease can be detected till 2020. For plastics, the average price dropped to

298 EUR/tonne in 2016, then climbed during the next two years to 301 EUR/tonne in 2017, and then decreased for the following three years to under 300 EUR/ton again. The average price dropped sharply to 247 EUR/tonne in 2020, however a sharp increase can be seen in 2021 reaching a high of 325 EUR/tonne. Price growth in 2021 was significant, rising from 245 EUR/tonne in January to a high of 400 EUR/tonne in December [23].

4.3 Costs of recycling of materials

A second factor that determines the profitability of the recycling market is the size of costs. After presenting the MSW generated, recycled, and the purchasing price, the next stage will determine the cost of recycling for each sector.

Aluminum costs between \$0.65 and \$1.07 per pound (\$1300 and \$2140 per tonne), copper costs between \$2.13 and \$2.43 per pound (\$4260 and \$4860 per tonne), stainless steel costs between \$0.32 and \$1.64 per pound (\$640 and \$3280 per tonne), and brass costs between \$1.59 and \$1.76 per pound (3180\$ and \$3520 per tonne). These are the rates for recycled scrap metals [24].

Recycling just does not work as well as well-meaning recyclers would think because of expensive and time-consuming recycling processes, according to a former regional administrator for the Environmental Protection Agency (EPA) and current president of Beyond Plastics, a national organization. The countrywide plastic recycling rate is only 8.5 percent. [25]. Recycling is more cost-effective than trash collection and disposal due to the fact that the cost of a successful curbside recycling program is between \$50 and \$150 per ton, but the cost of garbage collection and disposal ranges between \$70 and \$200 per ton. Recycling programs also help the environment [26]. There is a chance that recycling programs will turn a profit, but only if transportation, sorting, and processing costs are kept under this amount per ton of the typical mix of recyclables collected by a homeowner, which is estimated to be worth about \$125 per ton when the recycled materials are sold to manufacturers.

Depending on the area, the kind of glass, and the recycling procedure, many factors affect the average cost of recycling glass. The long-term financial gain comes from using recycled glass, which lowers costs for glass container producers, and benefits the environment [27]. 'The end market for recycled glass is mostly domestic, typically located within 300 miles of its end markets' [28, p. 1], and 81 percent of US recycling systems feature glass alternatives for residents, according to the Glass Packaging Institute [28]. While typical glass recycling rates in Europe and several US states with bottle deposit laws are closer to 70%, the country's rate has been stuck at about 33% for many years. More than 1.1 million people are employed by the glass recycling business, which has a gross annual income of \$236 billion. However, the profitability of recycling glass might vary depending on the type of glass recycled and the market demand [29].

Depending on the region, the sort of paper, and the recycling procedure, a business's typical recycling cost varies. Business owners should examine the rates at their local recycling facilities to see what they might be able to collect, according to howtostartanllc.com [30], which states that recycling facilities establish the rates that paper recycling firms collect. The facility has different payment rates for different types of materials. Newspapers are paid at a rate of \$50 per ton, cardboard at a rate of \$75 per ton, and high-grade office paper at a rate of \$2,120 per ton as examples [30]. For a paper recycling firm, the smallest initial expenses are \$62 and the maximum start-up costs are \$38,061 [31]. Recycled paper currently costs, on average, 59.47 cents per pound nationwide [32].

4.4 Profitability of recycling

Based on the data presented regarding the amount of waste generated and recycled, as we also explored the prices and costs of recycling waste the net of each recycling sector is needed to explore the profitability of each sector in order to determine which recycling sector is the most profitable.

Depending on the category of plastic, the recycling procedure, and the market demand, different polymers have different net profits. According to maycointernational.com [33], 500,000 pounds of plastic waste may provide a profit of \$100,000 if we assume a median scrap price of \$0.20 per pound. Recycling sales to consumers like plastic manufacturers generated \$339,395, exceeding their annual projections by \$13,395 [33]. But it may be difficult to make money from recycling plastics, especially if the materials are not properly classified and treated [34]. The market for recycled plastics was estimated to be worth USD 47.60 billion in 2022, and from 2023 to 2030, it is anticipated to increase at a compound annual growth rate (CAGR) of 4.9% [35].

The nature of metal, the recycling procedure, and the market demand all affect the net profit of recycling metal. Due to the increased value of metals, scrap metal recycling facilities have the potential to increase their profitability, according to upperinc.com [34]. According to the International Centre for Trade and Sustainable Development (ICTSD), scrap vehicle metal may bring in between \$65 and \$115 per ton, while appliances can bring in \$0.15 per pound [36]. The cost and value of recycled scrap metal varies depending on the metal. Aluminum for instance, costs between \$0.65 and \$1.07 per pound, copper costs between \$2.13 and \$2.43 per pound, stainless steel costs between \$0.32 and \$1.64 per pound, and brass costs between \$1.59 and \$1.76 per pound [24]. However, recycling scrap metal is a powerful economic stimulant. In the US, the metal recycling business produced over \$64 billion in 2020 and recovered nonferrous metals worth \$40 billion, including aluminum, and lead.

The type of paper, the recycling procedure, and the market demand all affect the net profit of recycling paper. The primary source of income for paper recycling, according to thesmallrich.com [37], is the availability of the primary raw material

(scrap paper), which is relatively inexpensive, and the final goods produced from this source are often sold for a high price, providing a healthy profit margin for the producer [30]. Starting a paper recycling business is a lucrative venture that offers its owners significant profits. One may easily make Rupees (INR) 10–15,000 per day which is approximately equivalent to 133\$ to 200\$ (USD) in the recycling industry [38].

The form of glass, the recycling procedure, and the market demand all have an impact on the net profit of recycling glass. According to alliedmarketresearch.com the worldwide recycled glass market is expected to expand to \$5,544.9 million by 2025, while it is increasing by a compound annual growth rate of 5.7% from 2020 to 2025 [39]. In 2017, the market was predicted to be worth \$3,529.2 million. More than 1.1 million people work in the glass recycling sector, which has annual gross sales of \$236 billion [29]. Employing recycled glass is cost-effective in the long run, lowers costs for glass container makers, and is good for the environment because glass can be recycled endlessly and it is 100% recyclable.

Numerous contributing elements, including location, the type of recycled materials, and the market demand, can have a significant impact on how profitable a newly founded recycling firm is. Nevertheless, after examining the volume of MSW produced, recycled, and their costs

In summary, the scrap metal industry appears to be the most profitable as we examined the recycling costs and net profits of each sector using the secondary data gathered. Business owners in developing nations should perform market research to analyze all the aspects before deciding which industry sector is more profitable for that particular place and conditions because many factors might affect profitability.

4.5 Possible obstacles of recycling

For the PESTEL analysis in this research paper, we chose Brazil, Ethiopia, and Indonesia in order to fully examine the difficulties that recycling companies in various developing countries confront. This rigorous selection ensures a thorough examination of the geographic, economic, cultural, regulatory, and environmental elements that influence recycling challenges. It includes Southeast Asia, East Africa, and South America. With their unique cultural origins and ranging from the economic element of growing markets (Brazil and Indonesia) to a low-income economy (Ethiopia), these selected nations provide a thorough grasp of the numerous obstacles in waste management. The study is further deepened by differences in regulations and particular environmental concerns, such as the biodiversity of Brazil and the deforestation problems in Indonesia. All things considered; these nations provide a comprehensive viewpoint on the difficulties faced by recycling companies in emerging countries.

4.5.1 Political obstacles

According to Trading Economics, Indonesia's Corruption Index was 34 points out of 100 (0 very corrupt and 100 clean) in 2022 [40]. There is a lack of government support to organize recycling processes in the country. The infrastructure for recycling is poorly organized and the mostly informal sector is involved in recycling [41]. Brazil's Corruption Index was 38 points out of 100 [42]. Regarding recycling, there is no support at governmental level, no money is invested in the recycling infrastructure by the government [43]. Ethiopia's Corruption Index was also 38 points out of 100 in 2022 [44]. There is political instability in Ethiopia [45] and there is no sufficient infrastructure for waste collection and management. Furthermore, there is lack of governmental initiatives, while a high level of bureaucracy exists [46].

4.5.2 Economic obstacles

Indonesia has high barriers for investors and it is hard to attract foreign direct investment, which makes Indonesia's economic growth slower [47]. A major issue with getting foreign capital is that there is a lot of paperwork and intellectual property isn't protected well enough. This tough situation not only makes it harder for foreign business to happen, but it also makes it harder to protect intellectual property. Businesses that use e-commerce sites also have to pay extra taxes, which makes doing business even more difficult. This heavy governmental load makes foreign investors less likely to spend and limits businesses' ability to grow in this situation. The lack of satisfying infrastructure and ineffective supply management chain for recycling lead to cost increase in the recycling sector [48]. There is also lack of investment in Brazil, therefore not enough financial resources are invested in recycling. Poorly organized logistics increases transportation costs in Brazil. [49], which leads to the absence of modern technologies. Modern technologies are presented in non-sufficient numbers. The separation processes of waste are not well defined thus waste collection is a difficult and expensive process [43]. The political instability in Ethiopia affects economic inadequate distribution of funding to the recycling industry, which is a significant problem, mostly due to poor organization of financial management and planning. The insufficient financial resources in this field are further worsened by the absence of government-level cost restrictions. This scenario not only interferes with the ability to effectively plan finances, but also adds to the difficulties encountered by the recycling industry in obtaining the required funds for its operations and projects [46].

4.5.3 Social obstacles

There is no demand for recycled products in Indonesia because there is a lack of awareness and there are some misconceptions. The culture and attitude do not show great support towards recycling processes. Households do not show a willingness to take part in recycling processes [50]. People's level of awareness of recycling processes and their importance stay low in Brazil, not enough attention is paid to

informal waste pickers, even though they play a significant role in recycling processes. Furthermore, not enough support or training is provided for waste workers in Brazil [43]. Even in Ethiopia attitude and awareness stay a problem. Even though, awareness has been increased in the country, the attitude has stayed unchanged. No emotions are attached to the recycling processes and there is no will to pay for recycling services. People whose work is related to recycling in Ethiopia get low social status, and waste workers are not paid enough [46].

4.5.4 Technological obstacles

Limited availability of advanced recycling technologies, outdated waste management systems, and the need for investment in modern recycling equipment and processes can pose technological barriers. There are challenges related to infrastructure development and the digital divide in developing countries [51], [52], [53].

The recycling technology available in Brazil may not be as advanced as in other countries, and importing such technology can be expensive [54]. Limited access to technology and technical expertise could also be an issue. The country has experienced significant political changes and reforms in recent years. The Brazilian Information Technology market (IT) was valued at \$46.2 billion and is expected to grow 8.2% in 2022, according to a report [55].

Most production sites have grinders to process the production offcut into reusable re-granulate that is utilized for production and mostly exported to gain foreign currency. The main reason for this is the technology gap, which prevents the pre-treated feedstock (e.g. PET-flakes, paper pulp) to be processed into raw materials that can be used in production [56]. Getahun Mekuria, Ethiopia's minister of innovation and technology, points out that services account for 65% of global GDP – far more than agriculture or manufacturing [57].

4.5.5 Environmental obstacles

Indonesia is grappling with significant plastic waste pollution, particularly in coastal areas. Managing and recycling plastic waste can be complex due to the diverse range of plastic types and contamination levels. Addressing the plastic waste issue and establishing effective recycling practices are crucial for a sustainable recycling business. One of the waste management strategies is waste recycling, an alternative for the reutilization of recoverable portions of resources, especially in times of higher consumption of goods and services [58].

The inappropriate disposal of waste is a serious problem faced by the Brazilian society today . The dumps attract pickers who scavenge material and survive selling this material to the recycling industry. This form of work promotes the recycling industry in the state of Rio de Janeiro and throughout the country. About 60% of recycled plastic is collected from dumps by pickers. But, it is verified that the

recycling industry cannot be based on recyclable material collection by human beings in dumps [59].

On average, every citizen in Addis Ababa, Ethiopia's capital, is estimated to generate about 51 kg of waste per year. About half of that waste is organic, which includes predominantly food waste. About 7.92 kg, or 15.5% of the total waste generated, is plastic. Higher-income people typically use (and throw away) more plastic than their lower-income peers, with the former also using more different types of plastic [60].

4.5.6 Legal obstacles

The involvement of producers in the waste management circle is pertinent to ensure a progressive step towards the efforts of embracing all sectors to extend and intensify the works of waste management in Indonesia [61]. Their roles are regulated through the Ministry of Environment and Forestry of the Republic of Indonesia Regulation Number 75 Year 2019 on the Roadmap of Waste Reduction by Producers [62].

Understanding and complying with waste management regulations, permits, and licenses are necessary for operating a recycling business in Brazil. The establishment and operation of a recycling business may require obtaining permits and licenses from relevant authorities. These permits and licenses may vary depending on the location, scale, and nature of the recycling operations. It is important to comply with the necessary legal requirements and obtain the required permits and licenses [63, p. 12].

The major environmental body in Ethiopia is the Environmental Protection Authority (EPA). The EPA is responsible for federal-level environmental protection by formulating the national environmental policy [64]. The government issues environmental proclamations that are aimed at various sectors of the environment (land, biodiversity, etc.).

In summary, the PESTEL analysis has identified several external factors that affect the recycling industry in Indonesia. Political factors such as government regulations impact waste management practices, while economic factors such as growing consumption patterns impact waste generation rates. Social factors such as changing attitudes towards waste and urbanization influence the amount and types of waste generated. Technological advancements will continue to influence recycling practices. Environmental factors such as climate change are significant drivers for the industry. Legal factors related to the enforcement of waste management regulations pose a challenge. This analysis highlights that the recycling industry in Indonesia is vulnerable to external factors, but there are opportunities for growth and innovation to meet the demands of the industry. To be successful in this market, the industry must adapt to changing external conditions, and take advantage of government support and technological advancements.

Recycling has gained attention significantly in the past decade due to the positive impact it offers in the areas of the environment, economic growth, and society as a whole. Effective recycling programs can help the earth and the economies of both Brazil and Ethiopia, which are both growing countries. With its wide range of plants and animals and growing cities, Brazil can benefit from recycling programs that cut down on waste, protect natural resources, and help local businesses. Even though there is not a lot of information specifically about Brazil, the general benefits of recycling suggest that tailored methods could have good results. Similarly, recycling is very important in Ethiopia, where sustainable development is a top priority. It helps create jobs, protect the environment, and make towns better and healthier. Even though there is not a lot of information available about Ethiopia, the country's drive to environmentally friendly methods fits well with the possible benefits of recycling. Setting up recycling programs in Ethiopia could help the economy grow and protect the earth at the same time. Recycling allows us to reduce the amount of waste we transport to landfills, preserve natural resources, and use fewer resources. Additionally, recycling can boost the local economy and generate work opportunities.

5 Discussion

Recycling has obtained significant attention in developing countries as a promising and sustainable business opportunity, offering both economic and environmental benefits [65]. If applied effectively, recycling initiatives and programs can generate job opportunities, create income from waste, and play a big role in reducing greenhouse gas emissions [66]. This can help empower local communities and promote local economic growth, by providing sustainable livelihoods and a way out of poverty. In addition, recycling plays a crucial role in supporting environmental challenges by minimizing waste in landfill and protecting natural resources.

5.1 Environmental concerns

Our environment benefits greatly from recycling. We make the world healthier for present and future generations by recycling our waste [67]. Regarding natural resource conservation, recycling lessens the need to remove resources like minerals, water, and lumber for new products. The most recent EPA study states that municipal solid waste recycling and composting prevented the emission of nearly 193 million metric tons of carbon dioxide, in comparison with 2018 [21] thus reducing the burden on the world climate. Recycling helps to preserve energy, for instance, recycling 10 plastic bottles can result in energy savings sufficient to run a laptop for over 25 hours. Finally related to waste and pollution reduction, recycling helps to divert garbage from landfills and incinerators, which lessens the adverse impacts of emissions and pollution.

5.2 Economic benefits

Key findings on the economic advantages of the recycling industry in 2020 were published by the EPA in an update to the National Recycling Economic Information (REI) Study. This report discusses the number of jobs, incomes, and tax receipts related to recycling. The study found that in a single year, recycling and reuse activities supported 681,000 jobs, \$37.8 billion in wages, and \$5.5 billion in tax revenue across the US [68]. This translates into 1.17 job opportunities, \$65.23 in paychecks, and \$9.42 in tax income for every 1,000 tons of recycled materials.

5.3 Social and Community benefits

Typically situated in underdeveloped regions of the country, waste management facilities have the potential to negatively impact human health, asset values, aesthetic and recreational values, and land productivity. In many areas, recycling offers a healthier and more sustainable alternative [67].

Given the environmental, economic, and social advantages of recycling that have been established in developed countries that have large economies, such as the United States, it makes reasonable sense to assume that the same benefits could be employed as well in developing countries. By minimizing the amount of waste dumped in landfills and the need to mine new raw materials from nature, recycling may considerably help the environment [69]. Recycling can additionally boost the economy by reducing waste management expenses and creating jobs in the recycling industry. In addition, recycling can improve social conditions by reducing pollution and promoting a cleaner, healthier living environment for communities [70]. Recycling may have various benefits and challenges in developing countries compared to large economies but we could not do a proper comparison due to the lack of accessible data for developing countries, although generally recycling offers universally beneficial advantages. Developing countries must develop and implement effective recycling systems to take advantage of the numerous advantages that recycling may offer [71].

Moving forward, researchers and stakeholders must focus on realistic and feasible strategies that can successfully establish community-based recycling programs in developing countries. In addition, understanding the economic weight and cost of different recycled materials is vital in prioritizing recycling efforts and maximizing profitability. To facilitate comprehensive analysis and meaningful comparisons between developed and developing countries, it is essential for recycling companies and governmental entities to make profitability data freely accessible. This open access to data empowers future researchers to assess and compare profitability levels, providing valuable insights into the economic aspects of recycling.

By emphasizing practical strategies and considering the economic viability of recycled materials, we can make informed decisions to promote sustainable recycling practices. Recycling companies' and governmental entities' release of

profitability data fosters transparency, collaboration, and knowledge sharing among researchers, policymakers, investors, and entrepreneurs. Together, through these collaborative efforts, we can drive positive changes and advancements in the recycling sector within developing countries and on a global scale.

In order to guarantee the financial viability of recycling in countries such as Brazil, Indonesia, and Ethiopia, it is crucial to take into account important criteria such as the nature of the materials being recycled, the expenses related to operations, the market rates for recovered products, and the progress made in the recycling sector. For instance, Brazil may harness the economic opportunities presented by recycling organic trash derived from its rich biodiversity, while Indonesia could focus on capitalizing on the valuable plastic recycling sector. In Ethiopia, it is essential to synchronize recycling programs with sustainable development objectives. Government incentives, technology developments, and honest sharing of profitability data are crucial elements for promoting a profitable recycling industry in developing countries, which in turn leads to favorable economic, environmental, and social results.

Conclusions

The study we conducted revealed discoveries, namely on the profitability of recycling materials, especially metal. This was determined by doing a comprehensive examination of available literature. Nevertheless, it is crucial to recognize a notable obstacle: the scarcity of data about the recycling sector and its financial potential in poor countries. As a result of this constraint, our findings are mostly based on observations made in industrialized nations, highlighting the need for further data to thoroughly examine and provide treatments within the study.

Also, some similar features were found in developing countries (Brazil, Indonesia, Ethiopia) by means of the PESTEL analysis. Those are the lack of the governmental support, the lack of proper infrastructure for recycling practices and no proper attitude from the locals which would be helpful for recycling practices being promoted more.

There were certain limitations during the research due to the fact that there were no sufficient data about developing countries. Probably it happened due to the fact that recycling practices are not widely used in developing nations and there is not enough governmental support, therefore no data published. Also, there were no sufficient data about developed nations. Since recycling is an important topic and all nations should cooperate to establish the best possible practices in all regions and countries, we think such data should be publicly available for everyone for free and it should not require any financial contributions.

This research showed that recycling can bring environmental, social and economic benefits. It could be beneficial for governments and different businesses which are seeking for profitable business opportunities.

Future researchers can consider the implementation process of recycling technologies and obstacles which this process can entail. Since attitude was a problem in the developing countries which we chose, it would be interesting how the right attitude could be shaped and how the government can play a role in this process.

References

- [1] T. Thorleifsson, “Barriers for private sector companies operating in waste management and recycling in Sub-Saharan Africa,” 2020.
- [2] G. Sabanidze, A. Kivenko, P. Benics, G. Kalkan, and A. Tick, “The importance of SMEs in economic development of developing countries,” in MEB — 19th International Conference on Management, Enterprise, Benchmarking. Proceedings (MEB 2021), Budapest: Óbudai Egyetem, 2021, pp. 91–105.
- [3] W. R. Stahel, *The Circular Economy: A User’s Guide*. London: Routledge, 2019. doi: 10.4324/9780429259203.
- [4] D. Bourguignon, “Circular economy package: Four legislative proposals on waste,” EPRS | European Parliamentary Research Service, Brussels, 2017.
- [5] S. Hossain, H. J. Law, and A. Asfaw, *The waste crisis: roadmap for sustainable waste management in developing countries*, First edition. Hoboken: Wiley, 2022.
- [6] L. Godfrey, Ed., *Waste Management Practices in Developing Countries*. MDPI, 2021. doi: 10.3390/books978-3-0365-0593-0.
- [7] N. Ferronato and V. Torretta, “Waste Mismanagement in Developing Countries: A Review of Global Issues,” *Int J Environ Res Public Health*, vol. 16(6), p. 1060, Mar. 2019, doi: 10.3390/ijerph16061060.
- [8] A.-C. Albertsson and S. J. Huang, Eds., *Degradable polymers, recycling, and plastics waste management*. in *Plastics engineering*, 29. New York: M. Dekker, 1995.
- [9] UNIDO, “Development of recycling industries within the UNIDO circular economy approach,” Vienna International Centre, Vienna, 2019. [Online]. Available: <https://www.unido.org/sites/default/files/files/2019-07/Development%20of%20recycling%20industries%20within%20the%20UNIDO%20circular%20economy%20approach.pdf>
- [10] RSE USA, “Recycling Market Development in the United States – Looking Back and Looking Forward,” RSE USA, USA, Jan. 2019. [Online]. Available: <https://www.oregon.gov/deq/FilterDocs/recMarketDevReport.pdf>

- [11] E. M. Bennett and P. Alexandridis, “Informing the Public and Educating Students on Plastic Recycling,” *Recycling*, 6(4), p. 69, Oct. 2021, doi: 10.3390/recycling6040069.
- [12] T. Hundertmark, C. McNally, T. J. Simons, and H. Vanthournout, “How the chemical industry could expand its activities in plastics waste recycling | McKinsey.” 2018. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.mckinsey.com/industries/chemicals/our-insights/no-time-to-waste-what-plastics-recycling-could-offer>
- [13] Eric and Wendy Schmidt Fund for Strategic Innovation, “Plastics and the circular economy,” <https://emf-digital.shorthandstories.com>. Accessed: Nov. 10, 2023. [Online]. Available: <https://emf-digital.shorthandstories.com/plastics-and-the-circular-economy/>
- [14] R. Geyer, J. R. Jambeck, and K. L. Law, “Production, use, and fate of all plastics ever made,” *Sci. Adv.*, 3(7) p. e1700782, Jul. 2017, doi: 10.1126/sciadv.1700782.
- [15] Z. Ahmed, S. Mahmud, and Dr. H. Acet, “Circular economy model for developing countries: evidence from Bangladesh,” *Heliyon*, 8(5), p. e09530, May 2022, doi: 10.1016/j.heliyon.2022.e09530.
- [16] C. Murphy and J. Rosenfield, Eds., *The circular economy: Moving from theory to practice*. McKinsey & Company, 2016. [Online]. Available: <https://www.mckinsey.com/~media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/The%20circular%20economy%20Moving%20from%20theory%20to%20practice/The%20circular%20economy%20Moving%20from%20theory%20to%20practice.ashx>
- [17] WEF, “Five Big Bets for the Circular Economy in Africa: African Circular Economy Alliance,” World Economic Forum, Geneva: Switzerland, 2021. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.weforum.org/publications/five-big-bets-for-the-circular-economy-in-africa-african-circular-economy-alliance/>
- [18] A. Lemille, “For a true circular economy, we must redefine waste,” World Economic Forum. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.weforum.org/agenda/2019/11/build-circular-economy-stop-recycling/>
- [19] J. M. Allwood, “Squaring the Circular Economy,” in *Handbook of Recycling*, Elsevier, 2014, pp. 445–477. doi: 10.1016/B978-0-12-396459-5.00030-1.
- [20] P. Smith, “Circular economy revenue worldwide 2022-2026.” Nov. 08, 2023. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.statista.com/statistics/1337519/circular-economy-market-revenue/>

- [21] O. US EPA, “National Overview: Facts and Figures on Materials, Wastes and Recycling.” Accessed: Nov. 10, 2023. [Online]. Available: <https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials>
- [22] E. von Koeller, S. Unnikrishnan, A. Meyer zum Felde, E. Millman Hardin, T. Wei, and S. DeFife, “A Circular Future for Glass,” BCG Global. Accessed: Nov. 17, 2023. [Online]. Available: <https://www.bcg.com/publications/2021/environmental-benefits-of-glass-recycling>
- [23] eurostat, “Recycling – secondary material price indicator.” 2023. Accessed: Nov. 10, 2023. [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Recycling_%E2%80%93_secondary_material_price_indicator
- [24] J. Saini, “Scrap Metal Recycling 101 [A Complete Metal Scrapper’s Guide],” Verichek Technical Services. Accessed: Nov. 10, 2023. [Online]. Available: <https://verichek.net/scrap-metal-recycling.html>
- [25] A. Zissu, “Recycled plastic is profitable for first time,” Times Union, Aug. 11, 2021. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.timesunion.com/hudsonvalley/news/article/Pandemic-makes-recycled-plastic-profitable-for-16379524.php>
- [26] L. Lancen, “The Cost Of Recycled Plastic: Is It Cheaper Than Single-Use Plastics? - Climate Of Our Future.” Accessed: Nov. 10, 2023. [Online]. Available: <https://www.climateofourfuture.org/the-cost-of-recycled-plastic-is-it-cheaper-than-single-use-plastics/>
- [27] M. Jacoby, “Why glass recycling in the US is broken,” *Chemistry*, 97(6), 2019, Accessed: Nov. 10, 2023. [Online]. Available: <https://cen.acs.org/materials/inorganic-chemistry/glass-recycling-US-broken/97/i6>
- [28] M. Keller, “The downfall of glass recycling,” *American Recycler* 27/1, Ohio, p. 1;4, Aug. 2018.
- [29] Trash Cans Unlimited, “Scrap Glass Recycling: Is It Profitable & Does It Make Sense? - Trash Cans Unlimited,” *Scrap Glass Recycling: Is It Profitable & Does It Make Sense?* Accessed: Nov. 10, 2023. [Online]. Available: <https://trashcansunlimited.com/blog/scrap-glass-recycling-is-it-profitable-does-it-make-sense/>
- [30] TruiC, “How to Start a Paper Recycling Business,” *HowToStartAnLLC.com*. Accessed: Nov. 10, 2023. [Online]. Available: <https://howtostartanllc.com/business-ideas/paper-recycling>

- [31] P. Walls, "How Much Does It Cost To Start A Paper Recycling Business? (In 2023) - Starter Story," Starter Story. Accessed: Nov. 10, 2023. [Online]. Available: https://www.starterstory.com/stories/start-a-paper-recycling-business-startup_costs-business-ideas
- [32] RecyclingMarkets.net, "Recycled paper prices stay low," Resource Recycling News. Accessed: Nov. 10, 2023. [Online]. Available: <https://resource-recycling.com/recycling/2020/01/14/recycled-paper-prices-stay-low/>
- [33] A. Arendts, "Commercial Plastic Recycling: How Your Company Can Profit by Recycling Scrap Plastic," Mayco International - Automotive tier 1 supplier. Accessed: Nov. 10, 2023. [Online]. Available: <https://maycointernational.com/blog/commercial-plastic-recycling-how-your-company-can-profit-by-recycling-scrap-plastic/>
- [34] R. Patel, "Boost Your Recycling Business Profit Margins with 7 Recyclable Materials." Accessed: Nov. 10, 2023. [Online]. Available: <https://www.upperinc.com/blog/recycling-business-profit-margin/>
- [35] Grand View Research, "Recycled Plastics Market Size & Share Analysis Report, 2030," Bulk Chemicals, GVR-4-68039-043-5, 2022. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.grandviewresearch.com/industry-analysis/recycled-plastics-market>
- [36] Mikeshoots, "Metal Recycling Can Be A Profitable Business For Anyone," SHOUTS. Accessed: Nov. 10, 2023. [Online]. Available: <https://mikeshoots.com/metal-recycling-can-be-a-profitable-business-for-anyone/>
- [37] thesmallrich, "How to Start Paper Recycling Business: A Potential Small-Scale Business with High Market Demand." Accessed: Nov. 17, 2023. [Online]. Available: <https://thesmallrich.com/paper-recycling-business/>
- [38] MIB, "Start Waste Paper Recycling Plant - Business Plan, Profit & Setup Cost | Makeinbusiness.com," Make In Business, Sep. 10, 2023. Accessed: Nov. 10, 2023. [Online]. Available: <https://makeinbusiness.com/starting-waste-paper-recycling-plant-business-plan/>
- [39] C. Ayushi and P. Eswara, "Recycled Glass Market Size, Share and Growth Analysis by 2025 | AMR," AMR, 2019. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.alliedmarketresearch.com/recycled-glass-market>
- [40] Trading Economics, "Indonesia Corruption Index." Accessed: Nov. 10, 2023. [Online]. Available: <https://tradingeconomics.com/indonesia/corruption-index>

- [41] N. Loasana, "Plastic recycling industry needs more govt support to help Indonesia reach lofty goal," *The Jakarta Post*, Dec. 10, 2020. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.thejakartapost.com/news/2020/12/10/plastic-recycling-industry-needs-more-govt-support-to-help-indonesia-reach-lofty-goal.html>
- [42] Trading Economics, "Brazil Corruption Index." Accessed: Nov. 10, 2023. [Online]. Available: <https://tradingeconomics.com/brazil/corruption-index>
- [43] R. De Almeida, R. G. De Souza, and J. C. Campos, "Lessons and challenges for the recycling sector of Brazil from the pandemic outbreak of COVID-19," *Waste Dispos. Sustain. Energy*, 3(2), pp. 145–154, Jun. 2021, doi: 10.1007/s42768-021-00075-y.
- [44] Trading Economics, "Ethiopia Corruption Index | 2000-2020 Data | 2021-2023 Forecast | Historical | Chart." Accessed: Nov. 10, 2023. [Online]. Available: <https://tradingeconomics.com/ethiopia/corruption-index>
- [45] R. H. Khafaga and S. H. Albagoury, "Political Instability and Economic Growth in Ethiopia: An Empirical Analysis," *Jsp*, 5(1), pp. 19–30, Mar. 2022, doi: 10.31014/aior.1991.05.01.332.
- [46] F. B. Teshome, "Municipal solid waste management in Ethiopia; the gaps and ways for improvement," *J Mater Cycles Waste Manag*, 23(1), pp. 18–31, Jan. 2021, doi: 10.1007/s10163-020-01118-y.
- [47] The World Bank, "Support for Investment and Trade Reforms to Improve Indonesia's Competitiveness and Aid the Economic Recovery," Jun. 15, 2021. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.worldbank.org/en/news/press-release/2021/06/15/support-for-investment-and-trade-reforms-to-improve-indonesia-s-competitiveness-and-aid-the-economic-recovery>
- [48] W. Qureshi, "Indonesian plastic recycling project launched to address infrastructure gap," *Packaging News*, Feb. 03, 2022. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.packagingnews.co.uk/news/waste-management/indonesia-plastic-recycling-project-03-02-2022>
- [49] ITA, "Indonesia - Market Challenges." International Trade Administration, Jul. 28, 2022. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.trade.gov/country-commercial-guides/indonesia-market-challenges>
- [50] D. Zahra, "Implementation of a Circular Economy in Indonesia," *FEB UGM*, Jun. 30, 2022. Accessed: Nov. 10, 2023. [Online]. Available: <https://feb.ugm.ac.id/en/news/3694-implementation-of-a-circular-economy-in-indonesia>

- [51] D. Comin and B. Hobijn, “An Exploration of Technology Diffusion,” *The American Economic Review*, 100(5), pp. 2031–2059, 2010.
- [52] N. Piricz, “A review of prosumers’ behaviours in smart grids and importance of smart grid management,” *EV*, 35(2), pp. 483–496, 2022, doi: 10.51680/ev.35.2.18.
- [53] N. Piricz and B. Révész, “Lessons Learned from an Operational Smart Grid Through the Example of a Local Government in Hungary,” *PFQ*, 67(3), pp. 396–412, 2022, doi: 10.35551/PFQ_2022_3_5.
- [54] OECD, *OECD Economic Outlook, Interim Report March 2023: A Fragile Recovery*. in *OECD Economic Outlook*. OECD, 2023. doi: 10.1787/d14d49eb-en.
- [55] E. ABES, “ABES presents trends for the Brazilian software market in 2022,” ABES. Accessed: Nov. 10, 2023. [Online]. Available: <https://abes.com.br/en/abes-apresenta-tendencias-para-o-mercado-brasileiro-de-software-em-2022/>
- [56] GBN, “Partnership Ready Ethiopia: Recycling Sector,” *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*, Eschborn:Germany, 2020. [Online]. Available: https://www.giz.de/en/downloads/GBN_SectorBrief_%C3%84thiopian-Recycling_E_WEB.pdf
- [57] African Business, “The dawn of Ethiopian tech,” *African Business*. Accessed: Nov. 10, 2023. [Online]. Available: <https://african.business/2019/04/economy/the-dawn-of-ethiopian-tech>
- [58] L. S. Conke, “Barriers to waste recycling development: Evidence from Brazil,” *Resources, Conservation and Recycling*, 134, pp. 129–135, Jul. 2018, doi: 10.1016/j.resconrec.2018.03.007.
- [59] E. B. A. V. Pacheco, L. M. Ronchetti, and E. Masanet, “An overview of plastic recycling in Rio de Janeiro,” *Resources, Conservation and Recycling*, 60, pp. 140–146, Mar. 2012, doi: 10.1016/j.resconrec.2011.12.010.
- [60] NaTuRes, “Plastic consumption and recycling in addis ababa, ethiopia. James Njeru. Natural Resources Stewardship Programme. : October 2021. Publication retrieved from:,” *atural Resources Stewardship Programme c/o Deutsche Gesellschaft für internationale Zusammenarbeit (GIZ) GmbH*, Bonn & Eschborn, Germany, 2021. [Online]. Available: <https://nature-stewardship.org/wp-content/uploads/Plastic-Baseline-Study-Ethiopia.pdf>
- [61] H. Kamaruddin, Maskun, F. Patittingi, H. Assidiq, S. N. Bachril, and N. H. Al Mukarramah, “Legal Aspect of Plastic Waste Management in Indonesia and Malaysia: Addressing Marine Plastic Debris,” *Sustainability*, 14(12), p. 6985, Jun. 2022, doi: 10.3390/su14126985.

- [62] EPR Indonesia, “KLHK Regulates Waste Reduction by Producers Through LHK Ministerial Regulation No. 75.” Accessed: Nov. 10, 2023. [Online]. Available: <https://epr-indonesia.id/news/klhk-regulates-waste-reduction-by-producers-through-lhk-ministerial-regulation-no-75>
- [63] Law No.12305 – Brazilian National Policy on Solid Waste. 2017. Accessed: Nov. 10, 2023. [Online]. Available: <https://www.braziliannr.com/brazilian-environmental-legislation/law-no-12305-brazilian-national-policy-solid-waste/>
- [64] M. Cheever, “Chapter 5 Waste Management in Ethiopia,” Colby, 2012. [Online]. Available: https://web.colby.edu/eastafricaupdate/files/2012/02/Environmental-Policy-Review-2011_Chapter-5_color_small.pdf
- [65] D. Knäble, E. de Quevedo Puente, C. Pérez-Cornejo, and T. Baumgärtler, “The impact of the circular economy on sustainable development: A European panel data approach,” *Sustainable Production and Consumption*, 34, pp. 233–243, Nov. 2022, doi: 10.1016/j.spc.2022.09.016.
- [66] M. Yang et al., “Circular economy strategies for combating climate change and other environmental issues,” *Environ Chem Lett*, 21(1), pp. 55–80, Feb. 2023, doi: 10.1007/s10311-022-01499-6.
- [67] O. US EPA, “Recycling in the United States.” Accessed: Nov. 10, 2023. [Online]. Available: <https://www.epa.gov/recycle/recycling-united-states>
- [68] O. US EPA, “Recycling Economic Information (REI) Report.” Accessed: Nov. 10, 2023. [Online]. Available: <https://www.epa.gov/smm/recycling-economic-information-rei-report>
- [69] Y. A. Hajam, R. Kumar, and A. Kumar, “Environmental waste management strategies and vermi transformation for sustainable development,” *Environmental Challenges*, 13, p. 100747, Dec. 2023, doi: 10.1016/j.envc.2023.100747.
- [70] A. Tick, R. Saáry, and J. Kárpáti-Daróczi, “Conscious or Indifferent: Concerns on digitalisation and sustainability among smes in Industry 4.0,” *Serb J Management*, 17(1), pp. 145–160, 2022, doi: 10.5937/sjm17-36412.
- [71] D. C. Wilson, C. Velis, and C. Cheeseman, “Role of informal sector recycling in waste management in developing countries,” *Habitat International*, 30(4), pp. 797–808, Dec. 2006, doi: 10.1016/j.habitatint.2005.09.005.

How is Innovation Changing Healthcare Supply Chains? – Review of Innovation Models and Their Impact

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Abstract: Innovation and Artificial Intelligence (AI) technologies frequently appear together in discussions, as AI is considered a tool for driving innovation. While many sectors pursue innovation primarily for competitive advantages, the healthcare sector embraces it from an ethical perspective. The commitment to innovation in healthcare is not just about competition; it's fundamentally about improving quality of life, effectively curing patients, and introducing new medications to the market. The prevalence of AI-driven applications is increasing within the Healthcare sector. In this systematic literature review, we explore various innovation models employed and examine how these relate to AI solutions in the healthcare sector. Additionally, we offer a comprehensive overview of the theoretical foundations behind these models and their practical significance and utility within healthcare supply chain context.

Keywords: Innovation model, Healthcare Supply Chain, Health care, Artificial Intelligence, Literature review

1 Introduction

Supply chain responsiveness and innovation are indisputably essential to build a resilient Healthcare Supply Chain (HSC) to fight unexpected challenges when the demand uncertainties are extremely high [1]. The increasing number of patients, population growth, increasing prevalence of chronic diseases and rising healthcare costs are not only significant challenges for healthcare systems but also motivating key factors to boost innovation [2].

The healthcare industry continuously prioritizes the development of innovative medicines and treatments to enhance human life quality and longevity. However, the development of these innovations alone is not sufficient; ensuring their accessibility to the end-user is critical, with Healthcare Supply Chain (HSC) playing a crucial role [3]. This underscores the importance of managing Healthcare Supply Chains, as medical and pharmaceutical equipment can be vital for human lives.

So our research question is: What role does AI play in driving innovation within healthcare supply chains, and how does it contribute to improving overall healthcare delivery and patient outcomes?

To answer our question, we used a systematic literature review to examine the current and future role of AI in Healthcare Supply Chains.

2 Review of the relevant literature

The authors decided to use a systematic approach to provide a clear and comprehensive overview of the available literature in this field. The selection of papers was finalized using the Scopus database, chosen for its extensive coverage and advanced search features. The selected papers, dated from 2020 to 2024, were all written in English and covered the following subject areas: Business, Management and Accounting, Engineering, Computer Science, Medicine, Decision Sciences, Environmental Sciences, Social Sciences.

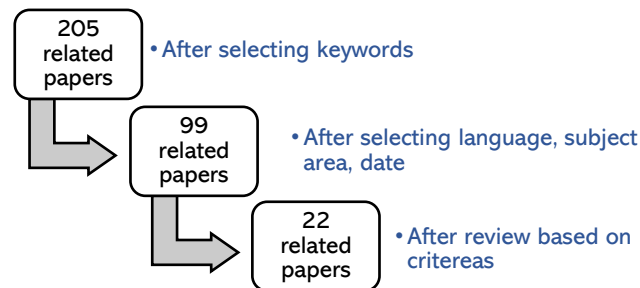


Fig. 1.
Systematic literature review steps

Keywords and why: The keywords of this study included: (TITLE-ABS-KEY ("innovation") OR TITLE-ABS-KEY ("innovative") AND TITLE-ABS-KEY ("Healthcare supply chain") OR TITLE-ABS-KEY ("Health care supply chain")).

The authors reviewed the articles and selected those that met the following criteria:

- Articles introducing new technological tools in healthcare supply chains, whether evaluated or not.

- Any articles examining AI technologies in healthcare and healthcare supply chains.
- Any paper pertinent to any research methods such as empirical, case study, modelling, or analytical.

Based on the exclusion criteria, we excluded all articles that did not affect the health sector, and those that did not focus on innovative solutions in the healthcare sector (the latter could include new technology or AI introduction). Finally, we recognized 22 relevant papers in Scopus database. The relatively fewer research articles on AI in Healthcare in Europe compared to other regions like Asia or North America can be explained by various reasons including regulatory challenges, funding issues, data privacy concerns. More investigations are needed within Europe to obtain a more relevant picture of the potential innovation opportunities and enrich our understanding of the dynamic landscape of this region.

3 Innovation and exploring some innovation models

The standard ISO 56000:2020 defines innovation as "a new or changed entity realizing or redistributing value". But nowadays we talk about business model innovation [4], or business relationships/networks can also be a source of innovation [5]. And innovative business networks pose specific challenges for the actors [6]. The innovation must bring economic and financial results, since innovation means a new, higher quality way of satisfying consumer needs. Innovation is usually classified into three groups: incremental (means constant progress, continuous improvement, e.g. the company is wants to get the most out of its existing products and services without, without making significant changes or investing large amounts of money), radical (is the result of a non-continuous development and brings radical change to the market and/or the industry), and disruptive (is replacing old products, "disrupting" the market, this innovation may even lead to a new market). AI clearly falls into this last category [7].

3.1 Healthcare Supply Chain (HSC)

The supply chain process plays an essential role in facilitating healthcare services. It is a crucial factor to ensure the delivery of services and goods to the ultimate recipient - the patient. The HSC stands apart from others; unlike many other sectors, where innovation is driven mainly by competitive reasons, the healthcare industry embraces innovation more from an ethical perspective. To ensure a more resilient HSC, healthcare supply chains should receive more operational support through diverse software applications, facilitating both data processing and data making processes. AI technologies can potentially help to make HSCs more resilient to disruptions like the worldwide pandemic in 2019. [8][9][10]

Under the current model of value-based care, health systems are required to improve patient outcomes while reducing costs [11]. Specifically, in the healthcare industry, managing the supply chain is indispensable. Given that the products within the HSC have critical relevance as they are directly linked to the well-being of patients, the timely and accurate delivery of healthcare products is crucial for patient care and outcomes [12]. The general purpose of Supply Chains is to ensure the right product in the right quantity is available at the right place at the right times. The healthcare supply chain is more complex due to its diverse and specialized products, such as pharmaceuticals and medical devices, which might require special handling and storage. [13] The HSC operates within an extremely regulated framework to ensure the safety of patients, as well as efficacy and quality of the healthcare products. It encompasses the movement of various product types and involves multiple stakeholders. Its primary objective is to ensure the timely delivery of products to meet the demands of healthcare providers. The most important business stakeholders in the HSC are categorized into three principal groups based on their roles: producers, purchasers, and providers [14].

Unquestionably, the final element of the supply chain is the patient, but we have enumerated the other elements that appear along the product or service's journey. So, there are many members in the HSC. The first is the manufacturer; the availability of medicines and healthcare products depends on them. The second members are the distributors, including wholesale distributors, logistic partners, and third-party logistics. Their key role is to obtain the products from the manufacturing facilities and focus on delivering the goods to the providers. The providers receive the medicines and products from the distributors and their role is to deliver these various healthcare products to the end-users - the patients. [15] The management of the healthcare supply chain presents challenges, particularly as healthcare systems are more complex and unpredictable. Uncertainty and risks are inherent in every stage of the healthcare decision-making process. Inefficiencies in managing the HSCs can lead to adverse effects on the overall healthcare system. [16] [17]

4 Importance of innovation models (based on selected papers)

In the following discussion, we aim to highlight the importance of defining the innovation model. In the absence of a clearly defined innovation model and strategy, alongside a defined characterization of the necessary innovation portfolio, employees may encounter challenges in executing tasks effectively [18]. In Table 1 we have compiled all pertinent innovation models and innovation related theories utilized in the reviewed articles.

Innovation models and theories	The rationale behind their use	Authors
SIAP model	Examine relations between BDA, SCI, RSC, and SCR. According to the SIAP model, the firms adjust in the business environment by following 3 theoretical basic steps, which are: scanning, interpreting, and responding.	[1] Bag et al.
Adoption of AI in the Healthcare Industry Model	Contextualizes the factors influencing adoption of AI in the healthcare industry.	[2] Roppelt et al.
Service innovation model	Customer is considered as a source of innovation. Innovation concept: innovation as process.	[5] Hara et al.
Disruptive innovation	The specialized literature uses disruptive innovation as a synonym for disruptive technology, and it refers to the disruptive effects of new technologies within a domain. The most common disruptive technologies were examined in the article's database n=97.	[7] Páváloia et al.
Technological innovation	The most prominent technological innovations in the healthcare supply chain were identified in this SLR.	[10] Arji et al.
A business model of innovation	The model used in the paper presents a useful approach to describe the relationships behind an innovation model and creates a framework (Input, Process, Output, and Outcome) to describe innovation at the business unit level.	[18] Davila et al.
Technology Innovation model	The technology innovation model emphasizes radical innovation driven by a company's technology group, and this article reflects on the importance of keeping these people focused and motivated.	[18] Davila et al.
Disruptive innovation	Disruptive innovation is a broader term that addresses both technology and business model changes. Disruptive innovations include technology-driven innovation.	[18] Davila et al.
Technological innovation	R&D in HCSC will lead to innovation and improved decision support systems. Implementing big data and predictive analytics (HCSCI&T 2) Implementing big data analytics is needed to optimize HCSC activities through forecasting and decision-making.	[19] Hossain et al.
Sustainable Oriented Innovation (SOI)	This research aim is to propose a sustainability-oriented innovation (SOI)-driven assessment guide and decision-making framework for health care managers to enhance sustainability.	[30] Elabed et al.

Table 1
Innovation models and theories used in the reviewed papers

Upon examination of the table, it became apparent that the predominant findings revolve around “technology innovation” and “technological innovation”. This trend is not coincidental, as it can largely be attributed to the widespread and rapidly growing adoption of AI. The wording "technological innovation" and "technology innovation" are offer used interchangeably, but they may represent distinct nuances in certain contexts. In the reviewed literature, both "technological innovation" and "technology innovation" were employed within the same contextual framework. To ensure clarity we summarize as follows: introduction or advancement of novel technologies, processes, and resulting notable enhancements in products, services, or systems [10][18][19].

Technological innovation, within the realm of information system theory, examines how users adopt and use technology. According to this model, various factors shape users' decisions regarding the adoption and timing of new technologies. A series of studies on technological innovation has laid the groundwork for disruptive innovation, as elucidated by Christensen and other co-authors. [20][21] AI and technological innovation are closely linked, as they symbiotically advance together. AI technology can enable new possibilities in various technological domains, and vice versa. This synergy between AI and technological innovation contributes significantly to the rapid evolution and adoption of cutting-edge technologies. [22] How AI stimulates technological innovation? Based on reviewed papers we see that AI fosters technological innovation via three primary mechanisms:

1. accelerates knowledge creation and creates technology spillover,
2. enhancing firms' abilities to learn and integrate new advancements,
3. increasing investments in research and development as well as nurturing human talent.

While the significance of AI is widely acknowledged and its usage is growing, scholarly research examining its influence on technological innovation is still rare. A cursory review of existing literature reveals that studies investigating the impact of AI on technological innovation are still in their early stages, primarily concentrating on defining these concepts. [23] The research conducted by Davila (2006) underscores the significance of both business model innovation and technology innovation for successful innovation outcomes. It suggests that companies need to understand and prioritize both types of innovation to achieve industry-changing advancements.

5 AI and HSC based on systemized literature review

5.1 AI's current involvement in Healthcare

AI has been present in healthcare for a long time, continuously and increasingly. AI technologies are able to diagnose diseases, create personalized treatment strategies, and aid clinicians in decision-making. The primary goal is to advance these AI technologies that can elevate patient care. In the following figure, we have listed the main healthcare areas where AI-based technologies are present and most commonly used.

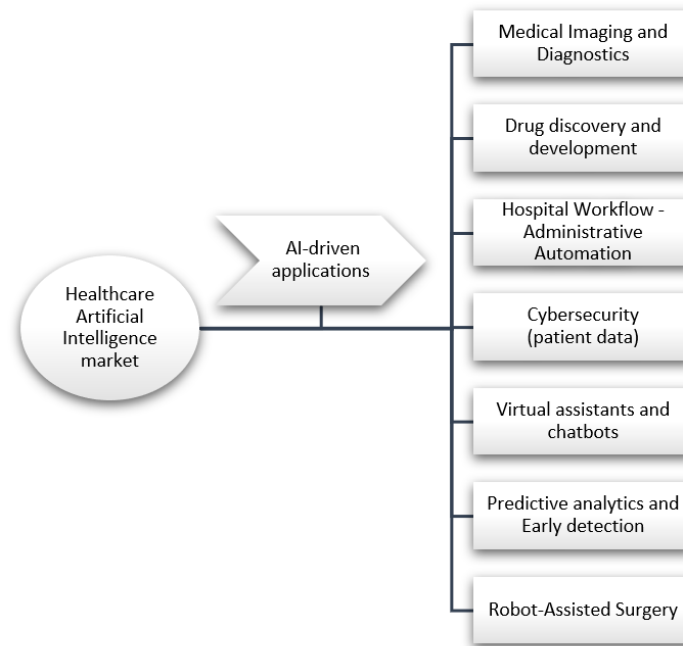


Fig. 2. Artificial Intelligence in Healthcare Market by Application Area based on literature [24][25]

Based on [24, 25] we have listed the distribution of AI-based application areas in Healthcare market on Figure 2. Many articles attempt to quantify how they are distributed in terms of proportion, for instance, on websites like Statista.com. Estimated forecasts can be found, for example, on the Statista.com website.

Conclusions

Concerning the future directions of AI in HSC, the Healthcare Supply Chain stands as a crucial operation, necessitating high levels of integrity, agility, resilience, and cost-efficiency. Traditional supply chains fall short in addressing contemporary challenges such as counterfeiting, geopolitical tensions, disruptions caused by global health crises, and the scarcity of skilled personnel essential for delivering products and services to end-users [26][27]. Emerging technologies like AI, Deep Learning, Human-Machine Interface, Machine Learning, block chain, robotics, cloud computing, Big Data Analytics, Digital Twins, Industry 4.0, IoT, and control towers are pivotal in developing end-to-end intelligent, integrated and data-driven supply chains [28].

Implementing innovations associated with logistics and supply chain management activities could assist the health-care industry in deriving effective agile lean practices. This could reduce annual costs, improve the quality of care, and limit treatment health cycle time [29][30][31]. Based on the 22 papers from the systematic literature review, we have identified the most important trends expected to reshape the future of Healthcare Supply Chains:

1. Lessons learned from the COVID-19 pandemic highlight the need for resilience, including contingency planning and disruption management. Enhanced resilience is crucial for optimizing performance, reducing disruptions, and staying competitive [32][33][34].

2. Increased integration of AI technologies will enhance efficiency, traceability, and transparency in chain management. For instance, Block chain technology improves security and transparency, ensuring accountability in healthcare and supply chains [35][36].
3. Automation, driven by AI, reduces errors, releases manual tasks, and promotes smoother collaboration among chain members. Industry 4.0, built on IoT, cloud computing, and big data analytics, streamlines value chain optimization and supply chain efficiency [37].
4. Predictive analysis using historical and big data aids in forecasting medical supply demand, reducing shortages, and improving patient care. However, risks associated with AI applications require careful consideration [38][39].
5. Ensuring high-quality care involves timely delivery and enhanced patient care. AI applications in the US continue to rise, surpassing 500 approvals in patient care by 2023 [39].

Integrating innovative solutions, especially AI-powered ones, can transform and empower Supply Chains. The Healthcare sector must capitalize on innovative opportunities to enhance its development and efficiency, as people's lives and quality of life depends on it. One of the biggest challenges will be the integration of these new, innovative technologies and the accelerated adoption of telemedicine.

References

- [1] S. Bag, S. Gupta, T. -M. Choi and A. Kumar: "Roles of Innovation Leadership on Using Big Data Analytics to Establish Resilient Healthcare Supply Chains to Combat the COVID-19 Pandemic: A Multimethodological Study," in IEEE Transactions on Engineering Management, doi: <http://doi.org/10.1109/TEM.2021.3101590> , 2021
- [2] J. Stefanie Roppelt, D. K. Kanbach, S. Kraus: "Artificial intelligence in healthcare institutions: A systematic literature review on influencing factors" Technology in 76, 2024
- [3] C. Kalaria, S. Singh, B. Prajapati: "Intelligent Healthcare Supply Chain" DOI: <http://doi.org/10.1002/9781394200344.ch17> , 2023
- [4] G. Hamel, "Leading the Revolution: "How to Thrive in Turbulent Times by Making Innovation a Way of Life" Harvard Business Review Press, 2002
- [5] Y. Hara, H. Kenichi, L. Grzegorz, Z. Marek: "Relationships as source of innovations in advertising industry: comparative study of Polish and Japanese approaches", IMP Conference, Combining the social and technological aspects of innovation: Relationships and Network, Rome, Italy, Volume: 28, DOI: <http://doi.org/10.13140/2.1.3985.6646> , September 2012

- [6] D. Corsaro, C. Cantù, A. Tunisini: “Actors' Heterogeneity in Innovation Networks”, *Industrial Marketing Management*, 41, Issue 5, Pages 780-789, 2012
- [7] V.-D. Păvăloaia, S.-C. Necula: “Artificial Intelligence as a Disruptive Technology—A Systematic Literature Review”, *Electronics* 2023, 12, 2012
- [8] H. M. Alaka, s and T. Eren: “Health 4.0 and Medical Supply Chain” 2023, *Accounting, Finance, Sustainability, Governance & Fraud: Theory and Application*, ISBN 978-981-99-1818-8 (eBook) <https://doi.org/10.1007/978-981-99-1818-8>
- [9] M. Waqas, Z. Yu, S.A.R. Khan; M. Tanveer; AR. Ahmad: “ Promoting Healthcare Technologies Through Ssustainable Supply chain operations: An empirical analysis of key success factors using the ISM-MICMAC approach, 2023, DOI: <http://doi.org/10.17270/J.LOG.2023.722>
- [10] Arji G.; Ahmadi H.; Avazpoor P.; Hemmat M.: “Identifying resilience strategies for disruption management in the healthcare supply chain during COVID-19 by digital innovations: A systematic literature review”, *Informatics in Medicine Unlocked*, 38, 2023, DOI: <http://doi.org/10.1016/j.imu.2023.101199>
- [11] F. Cañizares Galarza, B. Neto Mullo, M. R. Argilagos: “Information Fusion from Multimodal Clinical Sensors for Effective Supplier Decision-Making in Healthcare” *Fusion: Practice and Applications*, 14(1) ,2024, pp. 149-157, <https://doi.org/10.54216/FPA.140113>
- [12] West: “What is Healthcare Supply Chain Management?” <https://www.pathstonepartners.com/blog/healthcare-supply-chain-management/> , (Accessed: 11th January 2024)
- [13] S. Ashtab, W. Anderson: “Differences in manufacturing and healthcare supply chain management: an overview” *International Journal of Healthcare Technology and Management* 20(3), pp 232-248, 2023
- [14] J. Mathew, J. John, Dr. S. Kumar, “New Trends in Healthcare Supply chain”
- [15] R. Dadmun, “What is the Healthcare Supply Chain?” *Healthcare Distribution Alliance, 89th Edition HAD Factbook: The Facts, Figures and Trends in Healthcare* (2018)
- [16] Lau YY, Dulebenets MA, Yip HT, Tang YM: “Healthcare Supply Chain Management under COVID-19 Settings: The Existing Practices in Hong Kong and the United States” *Healthcare (Basel)* ;10(8):1549. doi: <http://doi.org/10.3390/healthcare10081549> , 2022
- [17] Ayakwah, I. S. Damoah: “Transferring AI technology in medical supply chain: a disruptive approach at addressing political, socioeconomic, and environmental dilemma in developing economies”, *International Journal of Technology, Policy and Management* 22(4), pp 325-347, 2022

- [18] T. Davila; Epstein, Marc J.; R. Shelton: “Making Innovation Work: How to Manage It, Measure It, and Profit From It.” Pearson Education, Inc., 2006
- [19] M.K. Hossain, V. Thakur: “Benchmarking health-care supply chain by implementing Industry 4.0: a fuzzy-AHP-DEMATEL approach”, 2023, DOI: <http://doi.org/10.1108/BIJ-05-2020-0268>
- [20] Omar Ali, Jeffrey Soar: “Technology Innovation Adoption Theories” 2016 DOI: <http://doi.org/10.4018/978-1-5225-0135-0.ch001>
- [21] Jennifer P. Wisdom, corresponding author Ka Ho Brian Chor, Kimberly E. Hoagwood, and Sarah M. Horwitz “Innovation Adoption: A Review of Theories and Constructs Adm Policy Ment Health. 2014 Jul; 41(4) pp. 480–502.
- [22] Sivaram Ponnusamy - Synergies-of-Digital-Twin-Technology-and-AI - Future-Focused-Innovations-in-Business DOI: <http://doi.org/10.4018/979-8-3693-1818-8.ch015> In book: Digital Twin Technology and AI Implementations in Future-Focused Businesses pp. 217–230
- [23] Forrest, Jeffrey (et al.) : How Artificial Intelligence Affects Technological Innovations , Value in Business, 2022, pp 379 – 399
- [24] Artificial Intelligence (AI) in Healthcare Market (By Component: Software, Hardware, Services; By Application: Virtual Assistants, Diagnosis, Robot Assisted Surgery, Clinical Trials, Wearable, Others; By Technology: Machine Learning, Natural Language Processing, Context-aware Computing, Computer Vision; By End User) - Global Industry Analysis, Size, Share, Growth, Trends, Regional Outlook, and Forecast 2022 – 2030, <https://www.precedenceresearch.com/artificial-intelligence-in-healthcare-market> (Accessed: on 5th January 2024)
- [25] IoT in Healthcare Market by Component, Application and End user and Region-Global Forecast to 2028, <https://www.marketsandmarkets.com/Market-Reports/iot-healthcare-market-160082804.html> , (Accessed: on 5th January 2024)
- [26] Aarti E, “A review of blockchain technology” Smart City Infrastructure: The Blockchain Perspective, Chapter 9, DOI: <http://doi.org/10.1002/9781119785569.ch9> , 2022
- [27] G. Naga Nithin , A.K. Pradhan; G. Swain, “zkHealthChain - Blockchain Enabled Supply Chain in Healthcare Using Zero Knowledge” Internet of Things. Advances in Information and Communication Technology pp.133-148, 2023
- [28] R. Saxena; E. Gayathri; L. Surya Kumari, “Semantic analysis of blockchain intelligence with proposed agenda for future issues” International Journal of System Assurance Engineering and Management 14 (Suppl 1), pp. 34–54, 2023

- [29] D. Elmuti, G. Khoury, O. Omran, A. Abou-Zaid, A, “Challenges and opportunities of healthcare supply chain management in the United States”, *Health Marketing Quarterly*, 30(2), pp. 128-143., 2014
- [30] Elabed, A. Shamayleh, A. Daghfous, “Sustainability-oriented innovation in the health care supply chain”, *Computers & Industrial Engineering*, Volume 160, 2021, 107564, doi: <https://doi.org/10.1016/j.cie.2021.107564>
- [31] J.O. Onyango, “Supply chain solutions for essential medicine availability during COVID-19 pandemic” *Journal of Humanitarian Logistics and Supply Chain Management* 14(7/8) DOI: <https://doi.org/10.1108/JHLSCM-05-2022-0056>
- [32] Q. Xiao, M.S. Khan, “Exploring factors influencing supply chain performance: Role of supply chain resilience with mixed method approach empirical evidence from the Chinese healthcare Sector “, 2024, DOI: <https://doi.org/10.1080/23311975.2023.2287785>
- [33] P. Maheshwari; S. Kamble, A. Belhadi, S. Gupta, S.K. Mangla, “Resilient healthcare network for simultaneous product allocations during supply chain disruptions”, 2023, DOI: <https://doi.org/10.1080/16258312.2023.2238669>
- [34] Atinga RA, Dery S, Katongole SP, Aikins M., “Capacity for optimal performance of healthcare supply chain functions: competency, structural and resource gaps in the Northern Region of Ghana.”, *Journal of Health Organizations Manag.* 2020 Oct 12; ahead-of-print (ahead-of-print). doi: <https://doi.org/10.1108/JHOM-09-2019-0283>. PMID: 33029993.
- [35] Alhasan S.J.; Hamdan A.: “Human Safety and Security Tracing Blockchain”, *Emerging Trends and Innovation in Business and Finance* pp 747–756, 2023
- [36] Fiore M.; Capodici A.; Rucci P.; Bianconi A.; Longo G.; Ricci M.; Sanmarchi F.; Golinelli D: “Blockchain for the Healthcare Supply Chain: A Systematic Literature Review”, 2023, DOI: <https://doi.org/10.3390/app13020686>
- [37] Adhikari; R. Joshi; S. Basu: “Collaboration and coordination strategies for a multi-level AI-enabled healthcare supply chain under disaster”, 2023, DOI: <https://doi.org/10.1080/00207543.2023.2252933>
- [38] S. Bag; P. Dhamija; R.K. Singh, M.S. Rahman; V.R. Sreedharan: “Big data analytics and artificial intelligence technologies based collaborative platform empowering absorptive capacity in health care supply chain: An empirical study”, 2023, *Journal of Business Research*, 154, DOI: <https://doi.org/10.1016/j.jbusres.2022.113315>
- [39] K. Wehkamp, M. Krawczak, S. Schreiber: “The Quality and Utility of Artificial Intelligence in Patient Care” *Dtsch Arztebl Int.*, 2023, 120(27-28)pp. 463-469. doi: <https://doi.org/10.3238/arztebl.m2023.0124.v>

Navigating Finance: Exploring Student Financial Literacy and Decision-Making in 2023

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Abstract: Financial literacy has emerged as a critical skill for students in the modern world. This study investigates the financial knowledge, behavior, and attitudes of students across various countries in 2023. The research employs a quantitative approach to analyze students' financial awareness, attitudes, and knowledge regardless of the source of their financial resources. Additionally, demographic information like social status and academic achievements is considered. The findings reveal a positive association between financial literacy and active financial behavior and decision-making. Students who acknowledge their

limitations in financial knowledge (e.g. lack of confidence in managing their finances) demonstrate a willingness to seek guidance from financial advisors or pursue financial education opportunities. Furthermore, students with access to financial assistance exhibit higher levels of financial literacy, as evidenced by their proclivity towards saving, emergency fund creation, and retirement planning. This study highlights the need to address identified weaknesses in students' financial literacy. The results underscore the significance of both general financial literacy and personal financial education, particularly in higher education settings. Ultimately, the research emphasizes the importance of implementing initiatives to enhance financial literacy education for students globally.

Keywords: Financial literacy, Finance, Financial Awareness, Financial education

1 Introduction

Financial literacy is an important component of personal financial management, and it is critical that individuals understand financial concepts in order to make informed financial decisions. As young adults, college students are at the stage of making important financial decisions that will affect their future [1]. Therefore, it is essential that they have good financial literacy in order to effectively manage their finances. The research contributes to existing knowledge by building upon previous findings, such as those presented in the PISA 2022 Results report [2] and the OECD/INFE 2023 international survey [3], which highlight the global importance of financial literacy education.

This study examines the level of financial literacy among students in different countries.

To make wise financial decisions and protect their financial future, students need to be financially literate. As society and technology develop, financial issues are becoming more complex, making financial literacy more important than ever. Rising debt levels, stagnant earnings, and declining savings rates are all signs of lack of financial literacy among students [4]. According to this theory, financial literacy is essential for students to graduate with a solid understanding of finance and be able to cope with any future financial challenges. Students can secure a secure financial future by making financial education a priority and learning the knowledge and skills necessary to manage their money wisely, make wise financial decisions, and prepare for long-term investments. Previous studies have shown that students are not as financially literate as they should be. For example, Chen and Volpe [5] found that college students had a limited understanding of basic financial concepts such as interest rate, inflation, and savings.

Financial literacy has been found to have a significant impact on financial behavior and decision-making. Ciszárik-Kocsir and Varga [6] have found that those students who participated in financial studies and gained financial knowledge had more

decisive financial plans in their savings and financial matters an achieved higher level of financial literacy. Fernandes, Jr., and Netemeyer [7] discovered that individuals with high financial literacy were more likely to engage in positive financial behaviors, such as saving money and investing in retirement accounts. However, as found by Csiszárík and Varga [6] around 50% of students in higher education do not have basic financial knowledge. To improve financial literacy among students, efforts have been made through financial education programs.

The purpose of this study is to extend prior research by examining university students' levels of financial literacy, identifying gaps in their knowledge, and exploring how financial literacy affects financial behavior and decision making. Understanding the impact of financial knowledge on financial behavior will contribute to the development of effective financial education programs for young adults [8]. The structure of this paper is as follows: after a literature review, the research design and data collection methods are presented, followed by the research hypotheses, findings and results. The paper closes with a discussion and conclusion section.

2 Literature review

According to a study by Ahumada-Maldonado and Sanchez-Lujan [9], students in higher education exclude money management, even if they are majoring in finances, business administration or accountancy. It also found that they spend more than what they earn and are not accustomed to budgeting for themselves.

When it comes to investments among Millennials and Generation Z, a recent survey [10] found that time deposits, savings accounts, and insurance are popular, with about 40% of respondents investing in shares and mutual funds. The findings indicate that the Internet and television are the most effective sources of financial literacy for Millennials and Generation Z.

Through in survey conducted in 2019, Aydin [11] found that financial knowledge, attitude, and behavior scores were low but increased significantly each year from freshman year to master's program. Additionally, students who were financially influenced by their parents had higher financial knowledge, attitude, and behavior scores [6]. Finally, students with higher financial knowledge also had higher financial attitude and behavior scores.

Baseline data collected prior to financial invention [12] revealed that parental financial socialization had a positive impact on adolescent financial behavior, mediated by financial learning outcomes and psychological transformation, in sequence.

Data from a recent study [13] on the financial skills and the economic strength of students in different regions shows, that there is a considerable association between

employment and study. with an average of 39% of students working across the participant countries. Furthermore, the study found that working and studying together helps young people develop the skills they need for their current jobs and makes the transition from school to work easier and faster. The study also found that the association between employment and schooling varied by educational background and major. One study [14] that examined gender differences in personal finance knowledge found that, on average, women were less knowledgeable about personal finance than men.

A recent study [15] reveals the interrelationships among the dimensions of financial literacy, money ethics, and time preference in an emerging economy with relatively little experience with the formal financial system and unstable macroeconomic conditions.

Furthermore, according to a recent study conducted by Lisardi [16], financial literacy affects everything from day-to-day financial dimensions to long-term financial decisions, which affects both individuals and society. Low levels of financial literacy in countries correlate with ineffective spending and financial planning, high borrowing and debt management, especially among student groups. As Maslov states [17], financially literate individuals are no longer dependent on external factors or the decisions of others. They have the freedom to independently choose their life path and build a financially successful future.

However, Norvilities et al. [18], who investigated student debt behavior, found that lack of financial knowledge, age, number of credit cards, delay of satisfaction, and attitude toward credit card use were associated with debt. Sensation seeking, materialism, Student Attitude toward Debt scale, gender, and grade point average were not unique predictors of debt. Students in the European region who reported greater debt reported greater stress and lower financial well-being. A study on student financial literacy [19] also found the likelihood of male and female students working was on average about the same and the same in most countries. Students whose fields of study are health and social work, teacher training and educational sciences, and humanities, languages, and arts are most likely to be employed. One of the papers by Sherbakova [20] discusses interactive teaching strategies that increase the content and delivery options of the discipline of "financial literacy" and enhance the effectiveness of the educational process. The study by Zhu [21] explores the relationship between school financial education and parental financial socialization among adolescents in Hong Kong. The research findings suggest that both school financial education and parental financial socialization are positively associated with financial literacy and financial behavior among Hong Kong adolescents. The study also highlights the importance of school-parent collaboration in providing effective financial education to young people.

Mataeva et al. [22] analyzed the financial literacy of students at Chechen State Pedagogical University. Suggestions were made regarding how to divide time to

help students become financially literate. They also advised the use of various management types when assessing learning outcomes.

While much of the previous research focused on the importance of financial education and the role of schools and the families, few studies examined personal characteristics such as self-confidence or the role of outside financial consultant when examining students' financial literacy and financially awareness behavior. As a result of our literature review, we were able to identify the research gaps described above, develop a research design, and formulate research questions and hypotheses, which will be presented in the Research method section.

3 Research Design and Methods

The present study aims to examine the level of financial literacy among university students, identify knowledge gaps, and examine the relationship between financial awareness, financial behavior, and decision-making. Since financial literacy has been found to significantly influence financial behavior and decision-making, it is important to develop effective financial education programs for young people. Based on previous research results the present study aims to explore the following research questions:

- 1) What is the level of financial literacy among university students?
- 2) What are the gaps in their financial knowledge?
- 3) How does financial awareness affect financial behavior and decision-making among university students?

This research aims to contribute to the development of effective financial education programs for young people by gaining insight into college students' financial awareness levels and identifying knowledge gaps. In addition, the study examines the impact of financial awareness on college students' financial behavior and decision-making, which may influence the development of tailored financial education programs. The study may have limitations, such as the use of convenient sampling methods, which may affect the generalizability of the results. Additionally, the study will rely on self-reported data, which may be subject to response bias. Finally, the study focused on university undergraduates, which limits the generalizability of the results to other settings.

Based on the literature review and the research questions, the following research model on financial literacy and behavior was developed (Figure 1).

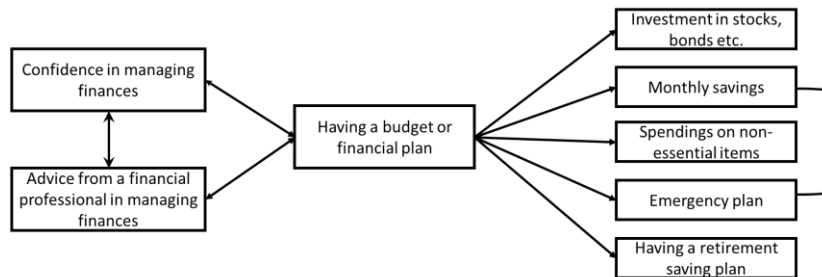


Figure 1.

Research design on financial literacy and financial behavior

Apart from the factors included in the above research model (Figure 1), the influence of credit card ownership, or the fact of having received a large sum as a gift from a family member on having a loan was also examined (Figure 2).

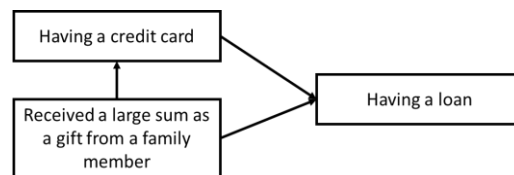


Figure 2.

Relationship between having the existence of a credit card, reception of gift money and having a loan.

Furthermore, the influence of some demographic characteristics was analyzed in the case of various statements related to financial awareness and literacy, as for example in the case of having a budget or financial plan, or having some savings, retirement plan etc. [23]. To address the research objectives, the following hypotheses are tested:

- H1₁ As students get older, they start to save more money.
- H2₁ Students with higher degrees of education save more money (monthly savings, emergency fund and retirement savings plan).
- H3₁ Having a financial budget or financial help among students, i.e. being financial literate, has a significant impact on financial behavior, that is having investment in stocks, bonds, having monthly savings, emergency plan and retirement plan.
- H4₁ Regular savings lead to the existence of an emergency fund.
- H5₁ Financially literate students (having a financial budget or plan) tend not to spend on non-essential items.
- H6₁ Students with less confidence in managing their finances seek advice from a financial professional while they do not have a financial budget or financial plan.
- H7₁ Student who turn to financial professionals tend to have a financial budget.

- H8₁ Credit card ownership increases the probability of taking loans.
H9₁ Gift money from a family member to pay off debts reduces the probability of taking loan and having a credit card.

This research adopts survey research design and quantitative analysis method. Data was collected via a self-developed, self-administered, two-part questionnaire: demographic information and questions about financial literacy, behavior and decision-making. All participants were informed about the study prior to participation and received an online informed consent form. Due to the online distribution of the questionnaire, convenient type sample was employed. Based on the topic of the research quantitative type research was conducted which included voluntary anonymous convenient sampling method to select students aged 16 and over. To ensure confidentiality, all data collected are treated confidentially, and participants' identities are kept anonymous throughout the study.

In the survey, financial knowledge was measured by a series of questions covering basic financial concepts. To measure financial behavior and decision-making, participants were asked to respond to statements related to their financial habits and attitudes. The questionnaire consisted of two parts: the first part gathered some demographic information, while the second part included questions related to financial knowledge, behavior, and decision-making. Likert scale type questions and statement were mostly used, next to Yes/No questions. Statistical analyses were used to analyze the data collected from the questionnaires, including a descriptive approach to the sample's demographic characteristics and financial literacy levels. Correlation analysis and independence testing (Chi², Cramer's V and Fisher's Exact test) were conducted using MS Excel and SPSSv25. All the data are treated confidentially, ensuring participants' anonymity throughout the study.

3.1 Demographic profile

The study collected a total of 95 responses from various countries. Table 1 displays the demographic profile of the respondents.

	Column n %	Country	n
Gender		Russia	29
Female	67.4%	Kyrgyzstan	26
Male	32.6%	Mexico	13
Total	100.0%	Hungary	7
Age groups		Kazakhstan	5
17-21	31.6%	Brazil	2
22-26	48.4%	Jordan	2
27-31	12.6%	Laos	2
32-36	7.4%	Belarus	1
Total	100.0%	China	1
Education level		Ecuador	1
Bachelor	38.9%	Indonesia	1
Master	33.7%	Nigeria	1
PHD	2.1%	Serbia	1
Undergraduate	25.3%	South Africa	1
Total	100.0%	Turkmenistan	1
		United States of America (USA)	1
		Total	95

Table 1.
Demographic profile of the respondents

Russia had the highest representation with 30.53%, followed by Kyrgyzstan accounting for 27.37% of the respondents, and Mexico representing 13.68%. While Hungary accounted for 7.37% of the respondents, Kazakhstan comprised 5.26%, and Ecuador, Brazil, South Africa, Laos, Turkmenistan, China, Nigeria, Jordan, and the United States, each constituted 1.05% of the sample.

More than two thirds (67.24%) of the respondents identified as female and 32.76% as male. The sample population consisted of individuals within the age range of 22–26, comprising the largest proportion at 48.69%. The age group of 27–31 accounted for 12.57% of the participants, while those aged 32–36 represented 8.38% of the total sample. These demographic findings demonstrate the gender distribution and age composition of the participants involved in the research on financial awareness among students.

The study encompassed a diverse group of participants, providing a comprehensive perspective on financial literacy in relation to different demographics. Regarding the participants' educational background, the majority of the respondents held a Bachelor's degree, representing 38.94% of the total sample. Those with a Master's degree accounted for 33.68% of the participants, while individuals with a Ph.D. comprised 2.11%. Respondents who were currently pursuing an undergraduate degree represented 25.26% of the sample. These percentages indicate the

distribution of educational levels among the participants, providing insights into the academic qualifications of the respondents involved in the study.

4 Results

In the following sections the results on financial awareness, financial behavior and financial literacy of students are analyzed and presented. The responses on the above-mentioned aspects are related to various demographic factors as age, gender and education level, then the interrelationship between the various aspects of financial literacy is analyzed and presented. Finally, it is explored whether the possession of a credit card or some gift money would have an impact on having a loan.

4.1 Financial awareness of young adults

In terms of financial awareness students were asked about their financial budgeting, plans and savings for the future. Figure 3 below shows the existence or non-existence of financial plans of the respondents by age.

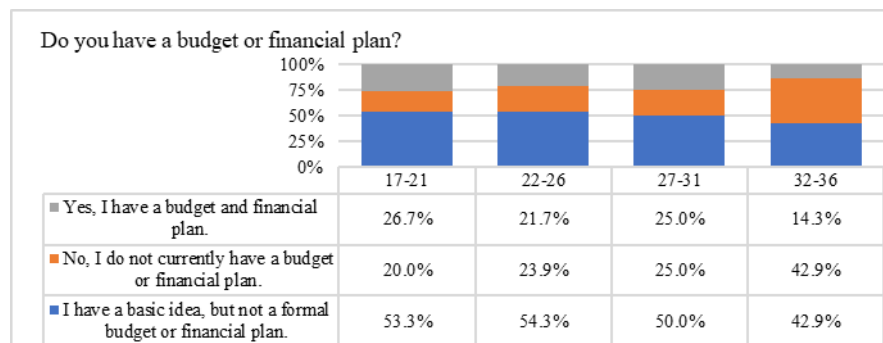


Figure 3.

Distribution of the existence of financial plan by age groups.

Based on the results, in general regardless of age the respondents only have “a basic idea of their monthly expenses and have saving goals”, however, they do not have a formal budget or financial plan”. The small proportion of the respondents has a fixed budget. No statistically significance could be detected between the age groups ($p=0.937$), which assumes that despite aging financial literacy does not really improve. Despite the existence of conscious budgeting or financial plan, respondents are assumed to save a portion of their income. Figure 4 displays the frequency of savings from regular income by age.

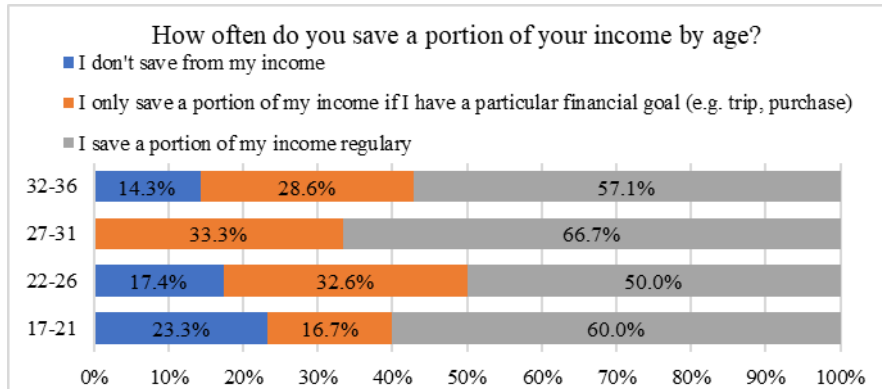


Figure 4.

Distribution of monthly savings from income by age

According to the findings, around three quarters of the respondents of all ages save from their income. Moreover, half of those polled said they save on a regular basis. In particular, across all age categories, at least 50% of respondents regularly save a portion of their income. The biggest number (67%) of respondents aged 27–31 reported steady savings, whereas the rest respondents save when they have specified financial goals. 60% of participants in the age group of 17–21 indicated regular income savings. The results do not show statistically significant differences by age groups ($p=0.465$), however, the existence of regular savings means that the respondents care about their financial possibilities and strive to accumulate a lump sum for their future spending. Similarly, no statistically significant differences could be detected by education level ($p=0.480$) either, despite the positive results that savings are made on a regular basis, they are independent from the educational level, thus not supporting the part of the H2 hypothesis stating that there is a relationship between education level and regular savings (Table 2).

How often do you save a portion of your income?	What is your current educational level? (%)				
	Under-graduate	Bachelor	Master	PhD	Total (%)
I don't save from my income	25.0	13.5	12.5	50	16.8
I only save a portion of my income if I have a particular financial goal (e.g. trip, purchase)	20.8	29.7	28.1	50	27.4
I save a portion of my income regularly	54.2	56.8	59.4		55.8
Total	100%	100	100	100	100

Table 2

Distribution of responses about regular savings by education level

Despite that the age group with the largest proportion of stable savings falls within the older age range, the results do not support the first hypothesis ($H1_1$) that older

students tend to save more money, because no significant differences could be detected. The remaining respondents only save when they have clear financial objectives. This suggests a proactive approach to financial planning and goal-setting since some people, regardless of age, save with specific goals in mind.

Analyzing further the financially conscious behavior of the respondents a significant relationship was detected between having a financial plan and saving a certain amount monthly ($p=0.000$ based on Fisher's exact test and Cramer's $V=0.307$) thus supporting the part of H4 referring to the relationship between a financial budget or plan and regular savings.

When students were asked about some emergency fund set aside for unexpected expenses, 43.2% of the respondents agreed that they had an emergency fund and that they add some money to it regularly. 18.9% of them said that they used to have an emergency fund but they had to use it for unexpected expenses and 37.9% of the respondents do not have an emergency fund. The results correspond with the previous question as 55.8% of the respondents save a portion of their income regularly, 27.4% save some money for a particular goal and 16.8% do not save any from their income. The correspondence is statistically significant between regular savings and the existence of an emergency fund with $p=0.000$ using the Fisher's exact test, and the Cramer's V shows also a significant relationship ($V=0.373$). The relationship supports H4₁.

In the 17–21 age group, 40% of people reported having an emergency reserve for unforeseen expenses. 47.6% of the females and 22.2% of the males in this age group. Moving on to the 22–26 age group, 43.50% of people said they had an emergency reserve for unforeseen expenses. The percentage is higher in the 27–31 age range, equaling 58.3%, while a lower 28.6% of those aged 32–36 reported having an emergency fund set up for unforeseen expenses.

When education levels were considered, respondents with a bachelor's or master's degree had an emergency fund set up at a rate of 43.2% and 53.1%, respectively. Undergraduates have an emergency fund in 29.2% being the smallest group compared to those not having an emergency fund (54.2%) or have already used it for unexpected expenses (16.7%). This shows that students with lower level of education rather not have an emergency fund, which could be linked to age categories as well. Furthermore, no significant relationship could be detected between the existence of an emergency fund and either age ($p=0.264$), gender ($p=0.154$) or education level ($p=0.313$), thus the part of H2₁ related to the relationship between having an emergency fund and education level could not be supported.

Additionally, when it comes to having a retirement saving plan, both bachelor and master degree holders report a similar proportion (32.4% and 34.4% respectively). Undergraduate degree holders have a retirement plan in 16.7%, which also means that 83.3% of the respondents in this group does not have a retirement plan. Looking at the relationship with age, females rather not have a retirement plan (78.1%) while

the corresponding proportion is 54.8% within males, resulting in a significant difference between males and females concerning the retirement plan ($p=0,02$). The results do not support the relevant part of $H2_1$ hypothesis, as the relationships did not prove to be significant between having a retirement plan and the education level ($p=0,347$). Furthermore, no significant difference was detected in relation to age ($p=0,274$).

Apart from asking about financial plans and saving, respondents were asked about their investment habits and plans. On average, respondents stated that they didn't invest and are not interested in investing in to the stock market. Meanwhile, comparing genders, on average, male bachelors at the age of 17–26, and male masters at the age of 22–31 seem to have interest in the stock market, while in the case of female undergraduates in the age of 17–26, and masters in the age of 22–26 on average have investments in the stock market. The response gives the hint that the younger generation is more interested in the stock market. Significant differences could not be tracked, the p values were higher than 5% in each case of comparison.

The results on the respondents' interest in investments can be justified by their individual confidence in handling their own finance. Figure 5 displays that the majority of respondents are not confident or indecisive in this question since 41.1% of the respondents responded with the option of 'not at all confident' or 'somewhat not confident' and almost one third of the respondents could not decide whether they were confident or not.

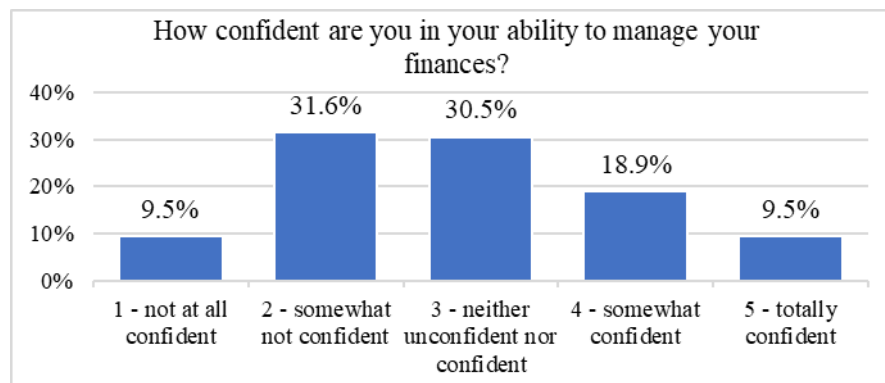


Figure 5

Distribution of responses regarding confidence in managing own finances.

Consequently, half of the respondents are not confident ($Me=3$), that is, a sizable proportion of respondents is confident in their abilities to handle their finances. At the same time the most frequent response was "somewhat not confident" ($Mo=2$), i.e. a sizable proportion of respondents had a low level of trust in their financial management abilities. The stander deviation equaled 1.1227, which suggests a

relatively low degree of diversity in the respondents' level of confidence. The responses are generally close to the mean (2.87), indicating that there is some agreement on individuals' confidence in handling their finances.

According to the findings, while a large percentage of respondents expressed moderate trust in their money management abilities, a significant proportion also showed poor confidence. The median and mode values both suggest a degree of uncertainty or lack of confidence, although the standard deviation indicates a very small amount of variation in the responses.

Despite the fact that respondent feel relatively low trust in managing their own finances they tend not to ask financial advice from a professional. Figure 6 shows that over 50% of the respondents have never asked advice, however, they consider doing so in the future. The 12.6% of respondents who are not even interested in asking advice could give a good starting point for financial literacy education. One fifth of the respondents have asked advise so far, however, there is still 12.7% of them who have not completed the deal with the financial professional.

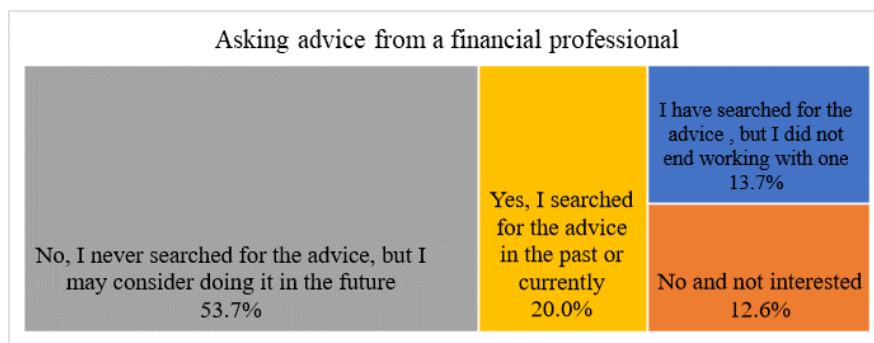


Figure 6.

Distribution of responses related to asking financial advice from a professional.

In the group of 17–21, only the females in masters have never searched for the advice of a professional in this field, however, they may consider it in the future. It is also the group of females aged 27-31 in Bachelors' and Masters studies who have not looked for financial advice. Only males with masters aged 22–26 have not searched for financial advice within the male group. Similarly to previous results no significant differences could be detected by gender, age group or educational level as the p values came higher than 5% in each comparison. In summary, young people up to the age of 36 are either not familiar with the possibility of asking financial consultancy or are not interested in conscious financial behavior. Both behavior type could be improved by increasing financial literacy.

Despite of assuming that people who are not confident in managing their finances would ask for some consultancy, no significant relationship was detected as p equaled 0.940 using the Fisher's exact test, which does not support the part of H6₁

related to the relationship between lack of confidence and turning to a financial advisor. As Table 3 shows in the group of people who are not confident or are indecisive, the largest proportion are considering to ask for financial consultancy.

	How confident are you in your ability to manage your finances?			Total
	Not confident	Neither confident nor unconfident	Confident	
Have you ever searched the advice of a financial professional, such as a financial advisor or accountant?				
I have searched for the advice, but I did not end working with one	7	4	2	13
No and not interested	5	3	4	12
No, I never searched for the advice, but I may consider doing it in the future	19	16	16	51
Yes, I searched for the advice in the past or currently	8	6	5	19
Total	39	29	27	95

Response options for financial confidence were recoded to three groups due to a small number of responses for certain combination of responses.

Table 3.

Relationship between confidence in financial management and financial consultancy

As a long-term consequence of lower financial literacy people might spend extra on non-essential goods. Figure 7 provides information regarding the amounts spent on non-essential items.

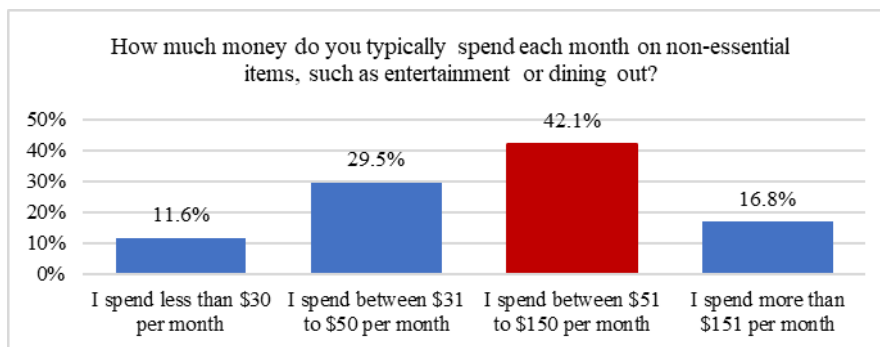


Figure 7.

The amount spent on non-essential goods per month.

On average, respondents spend between \$51–\$151 per month, which means that a substantial percentage of people spend this amount of money on non-essential products. These results, however, are not representative, since the respondents did not give information about their monthly income.

Financial literacy and conscious behavior includes the existence of a retirement plan as well. Figure 8 displays the distribution of people by age showing whether they have a retirement. As expected younger generation have a retirement plan in a smaller percentage (24-26%), while older generations start saving for retirement.

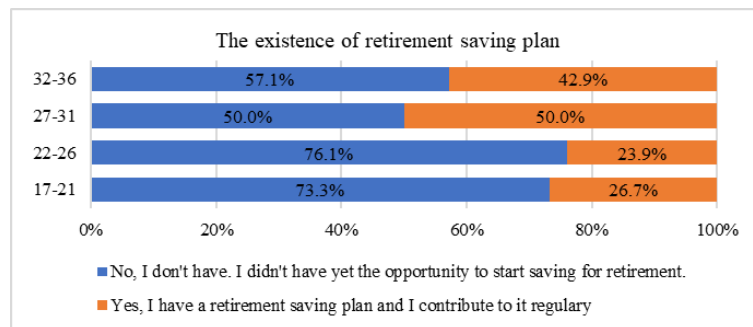


Figure 8.

Distribution of respondents with and without a retirement plan by age.

In order to reveal financial literacy and some conscious behavior in personal financial matters the relations in the research model 1 was checked. Figure 9. display the interrelationships between the included aspects of financial behavior and financial literacy.

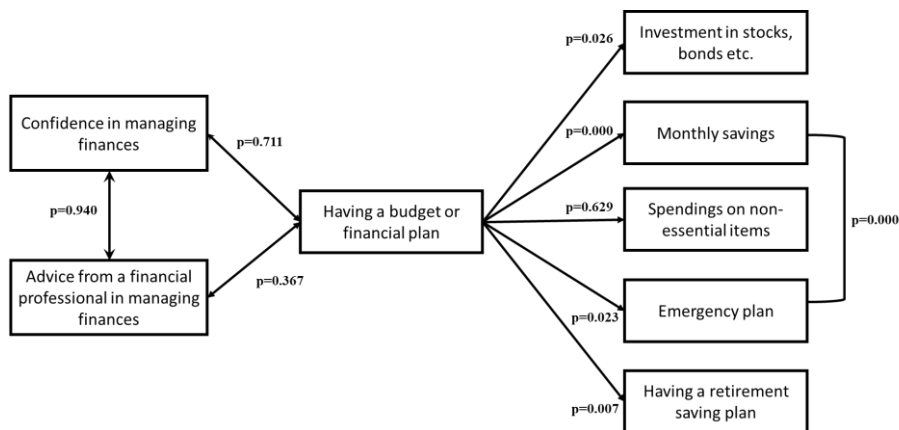


Figure 9.

Evaluation of the research model financial literacy

Despite the assumptions that confidence in managing finances is relation with seeking financial advice from a professional and with the existence of financial budget, the model reveals these factors have no significant relationship with each other, since the Chi2 and the Fisher's exact test could not detect significant relation between them ($p > 0,005$ in each case). This shows that an individual's confidence in

their money management ability has no effect on the presence of a budget or financial plan. It indicates that people may adopt budgeting strategies regardless of their perceived financial confidence. Therefore, H6₁ and H7₁ could not be supported which assumed relationship between these factors.

However, the existence of a financial budget or financial plan proved to be significant in the financial literacy and financial behavior of students, as except the case on spending on non-essential items ($p=0.629$), significant relationships were detected between the existence of budget and financial help and investments in stocks and bonds, regular savings, existence of an emergency fund, and a retirement saving plan.

Furthermore, a significant relationship could be detected between monthly savings and the existence of an emergency fund. The results support H3₁, H4₁. The H5₁ cannot be unambiguously supported since the non-significant relationship only state that there is no relationship between these two statements, spending on non-essential items might be influenced by impulse shopping or by commercial, marketing tools. In addition, significant relationship could be detected directly between confidence in personal financial management and monthly savings ($p=0.007$), and there was a significant relationship between the advice of a financial professional and investments in stocks and bonds ($p=0.003$) and the existence of emergency plan ($p=0.002$). This implies that those who are more confident in their money management skills are more likely to engage in investing activities.

Financial literacy includes handling credits and loans as well. The findings reveal that credit card ownership differs by age, gender, and degree of education. While 49.5% of the respondents who not have a credit card with the group credit card owners the age group 27–31 owns a credit card in the largest percentage (58%), while females (58.1%) have a higher ownership compared to males (41.9%). Credit card ownership is similarly influenced by education level, with a larger proportion among those with bachelor's degrees (44.2%) and master degree (30.2%). Figure 10 below shows the ownership rates of credit card per age.

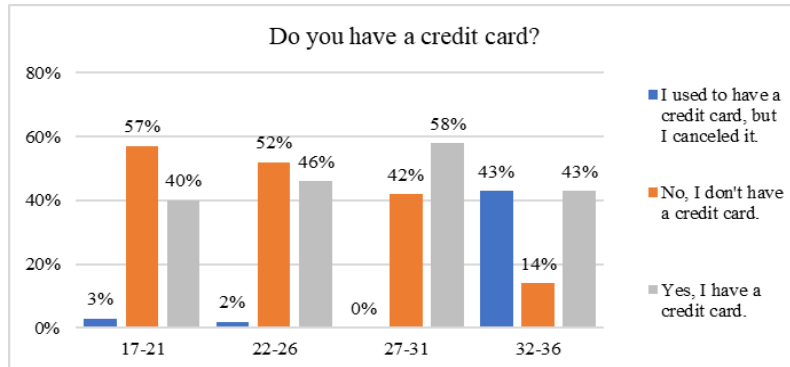


Figure 10.
Percentage of credit card owner by age.

A very small percentage of the respondents have a loan (14.7%) and almost two thirds of the respondents (64.2%) are not interested in taking some loan, loan taking. No significant relationship could be detected between credit card ownership and possessing a loan ($p=0.057$) using the Fisher's exact test, however, a larger sample size could detect a significant relationship since both the Cramer's V (0.266) and the Chi2 test showed significant relationship ($p=0.036$). Concerning this sample $H8_1$ could not be supported.

Responses show that people who have credit cards use them "very frequently (more than 10 times per month)" (41.9%), however, the second largest group uses it rarely (1-2 times per month) (20.9%). We can imply from these results that, individuals are relying on their credit cards as a primary payment method for a wide range of purchases. On the other hand, people who are not currently holding a credit card are not considering getting one in the future (71.2%).

As expected responses on the probability to pay off debts using gift money from a family member is high. As Figure 11 shows the largest group of respondents would use the money to pay off debts (42.1%) and only one person responded that they would use it for something else. Based on the distribution of the responses we can accept one part of $H9_1$ stating that students who receive a large sum of money from family member would rather use it for paying off their debts.

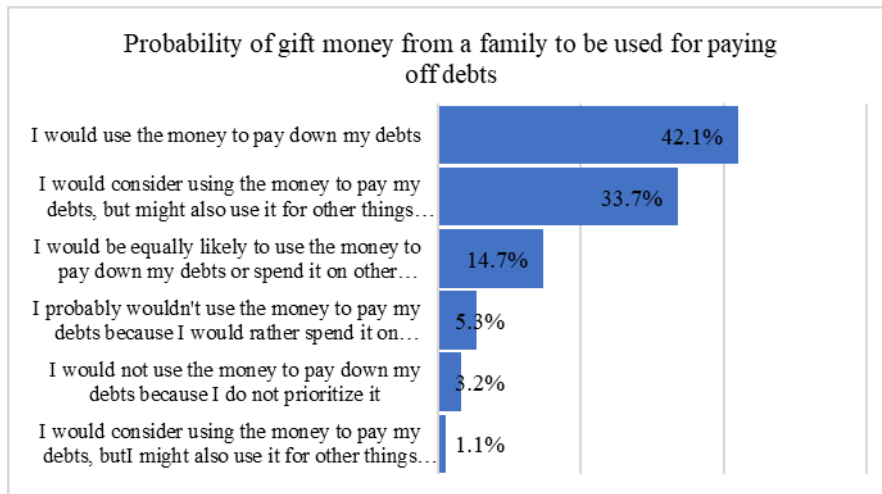


Figure 11.

Likelihood of gift money used for paying off debts by the respondents.

Furthermore, as assumed gift money received from a family member to pay off debts would not lead to taking out loans ($p=0.192$ using Fisher's exact test) and would not likely to have a credit card ($p=0.226$ using the Fisher's exact test) as no significant relationship was detected thus $H9_1$ cannot be fully supported. Regardless of having or not having a credit card or loan, students would rather use the gift money to pay off their debts and no significant relationship could be detected.

According to the findings, a significant number of respondents are likely to use a substantial sum of money received as a present from a family member to pay off any obligations they may have. The median (3.36) and mode (4) values both imply a modest likelihood, however, the standard deviation (1.688) indicates the degree of variation in the replies.

In summary the relationships between these three aspects (credit card, having a loan and gift money) was also evaluated. As Figure 12 shows no direct and significant relationships could be detected between these aspects. However, as mentioned as the p value is very close to 0.05 in finding a relationship between credit card ownership and having a loan, a larger sample could change the significance of the relationship.

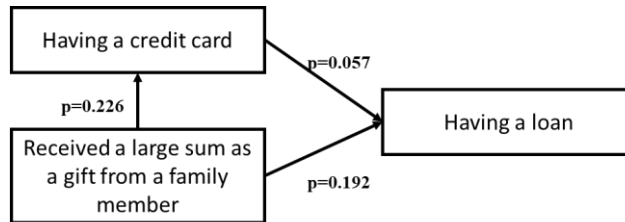


Figure 12.

Model evaluation on credit card ownership, having a loan and some gift money received

5 Discussion

According to data found in the study, financial knowledge, attitude, and behavior ratings among students are initially poor but considerably improve with time. It is worth emphasizing that young people who receive financial assistance from their parents have greater levels of financial knowledge, attitude, and behavior. This data lends support to the idea that parental financial socialization has a significant impact on young people's financial ability [24].

The results showed that a significant proportion of respondents, regardless of their age and educational level, had a basic understanding of their monthly expenses and savings goals but lacked a formal budget or financial plan. This suggests that individuals may engage in budgeting practices regardless of their perceived financial confidence. This research result is consistent with earlier research, which indicates that young people frequently mismanage their funds [25]. The results of this study have the potential to inform the creation of focused interventions and educational initiatives aimed at improving financial literacy and fostering positive financial habits among students and young adults.

The presence of a retirement saving plan was also analyzed. The results demonstrated a significant relationship with gender however, age and educational level did not show differences with the presence of a retirement savings plan, however older people with higher education level had higher retirement savings. The results align with previous research findings on retirement planning and financial behavior as a study conducted by Johnson and Johnson [26] found similar results regarding age and retirement savings plans. They discovered that older individuals were more likely to have retirement savings plans in place compared to younger individuals. This suggests that as individuals progress through their careers and approach retirement age, they become more aware of the need to save for their post-work years.

Regarding educational level, a study by Adams et al. [27] demonstrated that higher educational qualifications were positively associated with the presence of

retirement savings plans. The researchers hypothesized that individuals with higher education may possess greater financial knowledge and awareness, leading to increased retirement planning and savings behaviors.

By linking the results of the current study to existing research, we can draw stronger conclusions and reinforce the understanding that demographic factors such as age, gender, and educational level might play crucial roles in shaping individuals' retirement planning behaviors. These findings have implications for financial educators, policymakers, and employers who can target interventions and initiatives to improve retirement preparedness among specific demographic groups.

The significant relationships between the existence of the financial plan and budget and the actual financial activities proves that, on the one hand, students with higher financial literacy behave more consciously in their personal financial management, even the non-significant relationship with spending on non-essential items might indicate financial awareness. On the other hand, the significant relationships detected support that students with less financial literacy are not highly conscious in their financial matters. Individuals who feel more adept of managing their finances may be more prepared to take risks and investigate investment possibilities to increase their wealth.

However, the research also revealed students are not prepared for conscious financial behavior, and their financial literacy needs to be improved – through education and training – since confidence and trust as well as seeking financial advice had no significant relationship with the existence of financial budget and plan. Student need to financially literate in order to increase their confidence in personal financial matters and need to recognize that financial advice from a professional could help them increase their personal financial matters.

The significant relationship between confidence and regular monthly savings shows that those who are more confident in their money management abilities are more likely to save on a regular basis. It suggests that confidence has a role in encouraging positive saving behavior, as people who feel more capable of managing their finances are more likely to prioritize saving and commit a percentage of their income to future financial objectives.

The current study aimed to explore the debt behavior of students, taking into account factors such as financial knowledge, age, number of credit cards, delay of gratification, and attitudes toward credit-card use. While Norvilitis et al. [18] found associations between these variables and debt, it is important to acknowledge the limitations of our study that prevent us from making definitive conclusions. Despite observing an increased frequency of credit card usage among students in our findings, the available information is insufficient to fully support or refute the statement made by Norvilitis et al. [18]. Therefore, caution should be exercised in generalizing our results and further research is needed to obtain a comprehensive understanding of the complex relationship between these factors and student debt behavior. Further research is needed to explore the long-term impact of financial

education, parental influence, budgeting practices, and factors influencing retirement planning and student debt behavior.

Conclusions

The significance of financial literacy among students and its influence on their financial actions and outcomes have been highlighted by this research. The results repeatedly emphasize the need for better financial literacy instruction and interventions aimed at this particular group. The findings show that a sizeable percentage of college students lack fundamental financial knowledge, which has an adverse effect on their ability to make sound financial decisions and adds to problems with money management and debt accumulation. The findings reveal specific weaknesses, emphasizing the need for targeted interventions, as supported by initiatives like Global Money Week [28].

The study also highlights the impact of a number of variables on financial literacy, such as gender, socioeconomic status, and past exposure to financial education. There are differences between genders in financial attitudes and understanding. These results highlight the significance of creating customized financial literacy programs that cater to the unique requirements and difficulties faced by various groups of students.

The study also emphasizes the beneficial relationship between financial literacy and responsible financial practices including saving, investing, and creating a budget. Higher financial literacy among students is associated with better financial behavior, which may have long-term effects on their present and future financial security. Therefore, efforts should be made to improve the teaching of financial literacy and give students the materials and tools they need to make wise financial decisions.

The research had its limitations as convenient sampling could not provide a representative sample so the conclusion can rather be applied to the sample, the country distribution results in bias, which both mean that further data collection is required in the future. With larger sample size and a more diverse country distribution a more thorough examination of the financial literacy can be conducted in the future.

Overall, this study highlights the value of financial literacy in providing students with the skills and knowledge required to effectively navigate the complex financial landscape. Educational institutions, policymakers, and other stakeholders can enable students to make educated financial decisions and improve their general financial well-being by addressing the gaps in financial knowledge and supporting healthy financial habits. To create financial literacy programs and treatments that effectively address the requirements of college students and position them for financial success in both their personal and professional life, it is crucial to do ongoing research and collaborate with other researchers.

References

- [1] A. Baranyi, J. Csernák and Á. Csiszárík-Kocsir, "Methods for Developing Financial Literacy," ON-LINE JOURNAL MODELLING THE NEW EUROPE, 2(39), pp. 174-195, 2022.
- [2] OECD, "PISA 2022 Results: Volume I: The State of Learning and Equity in Education," OECD Publishing, Pisa, 2022.
- [3] OECD, "OECD/INFE 2023 International Survey of Adult Financial Literacy," OECD Business and Finance Policy Papers, 39, 2023.
- [4] Á. Csiszárík-Kocsir, "The Purposes and Motivations of Savings Accumulation based on Generational Affiliation, Financial Education and Financial Literacy," ACTA POLYTECHNICA HUNGARICA, 20(3), pp. 195-210, 2023.
- [5] H. Chen and R. P. Volpe, "An Analysis of Personal Financial Literacy among College Students," Financial Services Review, vol. 7, pp. 107-128, 1998.
- [6] Á. Csiszárík-Kocsir and J. Varga, "Financial Awareness in everyday life dure to the pandemic, basedon the results of a Hungarian questionnaire survey," PEOPLE: INTERNATIONAL JOURNAL OF SOCIAL SCIENCES, 8(3), pp. 54-66, 2022.
- [7] D. Fernandes, J. G. Lynch Jr. and R. G. Netemeyer, "Financial Literacy, Financial Education, and Downstream Financial Behaviors," Management Science, 60(8), p. 1861–1883, 2014.
- [8] M. Garai-Fodor, J. Varga and Á. Csiszárík-Kocsir, "Generation-specific perceptions of financial literacy and digital solutions," Poprad, 2022.
- [9] B. Ahumada-Maldonado and B. Sanchez-Lujan, "Higher Level Students and Money Management," Educational Science Magazine, 3(9), pp. 25-34, 09 2019.
- [10] Y. Akash, "A Study of Financial Literacy and Financial Behavior among Millenials and Generation Z," Journal of the Asiatic Society of Mumbai, 95(21) pp. 25-34, 05 2022.
- [11] A. S. E. Aydin, "An investigation of financial literacy, money ethics and time preferences among colledge students: A structural equation model," International journal of Bank Marketing, 37, pp. 35-48, 2019.
- [12] F. Khagundokova, "Forming financial literacy of students outside of the classes," Bulletin of the RMAT, 3(3), pp. 76-78, 2019.

- [13] V. P. A. G. V. Carangui, "Personal finance: the influence of age on financial decision making," *Social Writing Journal*, 1(3), pp. 81-88, 12 2017.
- [14] H. Chen and R. Volpe, "Gender differences in personal financial literacy among college students," *Financial services review*, 11(3), pp. 289-307, 2002.
- [15] B. Jorgensen, "Financial literacy of college students: Parental and peer influences," *Virginia Tech*, pp. 89-100, 2007.
- [16] A. Lisardi, "Financial literacy and the need for financial education: evidence and implications," *Swiss Journal of Economics and Statistics*, 155(1), pp. 28-35, January 2019.
- [17] Y. M. S. Maslov, "Factors influencing financial literacy of students," *International Journal of humanities and Natural Sciences*, 4(4), pp. 92-94, 2022.
- [18] J. M. Norvilitis, M. M. Merwin, T. M. Osberg, P. V. Roehling, P. Young and M. M. Kamas, "Personality Factors, Money Attitudes, Financial Knowledge, and Credit-Card Debt in College Students," *Journal Of Applied Social Psychology*, 36(3), pp. 1395-1413, 2006.
- [19] OECD, *PISA 2015 Results: Students' Financial Literacy*, vol. 4, Paris: OECD Publishing, 2017.
- [20] I. L. Y. Sherbakova, "Financial Literacy of Students and its Improvement through the Use of Interactive Teaching methods," *Journal of Udmurt University*, 6(32), pp. 1042-1047, 2022.
- [21] A. Zhu, "School financial education and parental financial socialization: findings from a sample of Hong Kong adolescents," *Children and Youth Services Review*, 107, pp. 57-60, December 2019.
- [22] R. Mataeva, Z. Musayeva and M. Alkhastova, "Criteria and Indicators for Assessing the Formation of Financial Literacy of University Students," *Journal of Applied Research*, 11(3), pp. 243-248, 2022.
- [23] A. Marouani and A. Tick, "Predictive Modeling to Investigate and Forecast Customer Behaviour in the Banking Sector," in *IEEE 21st World Symposium on Applied Machine Intelligence and Informatics SAMI (2023) : Proceedings*, Herlany, 2023.
- [24] L. Mandell and L. S. Klein, "The impact of financial literacy education on subsequent financial behavior," *Journal of Financial Counseling and Planning*, 20(1), pp. 15-24, 2009.

- [25] D. Johnson, R. Johnson and K. Smith, "Cooperative Learning: Improving University Instruction By Basing Practice On Validated Theory," *Journal on Excellence in College Teaching*, 25(3-4) pp. 85-118, 2014.
- [26] D. Johnson and R. Johnson, "Cooperative Learning: The Foundation for Active Learning," 5 November 2018. [Online]. Available: <https://www.semanticscholar.org/paper/Cooperative-Learning%3A-The-Foundation-for-Active-Johnson-Johnson/838704c00552d887b065778d5499207fc8c954e0>.
- [27] B. Adams, M. Meyers and L. Sekaja, "Positive Leadership: Relationships with Employee Inclusion, Discrimination, and Well-Being," *Applied Psychology*, 69(4), pp. 1145-1173, 2020.
- [28] Allianz, "Playing with a squared ball: the financial literacy gender gap," Allianz SE, 2023.

The Loyalty Ladder: A Quantitative Exploration of Satisfaction and Commitment in Building Brand Loyalty

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Abstract: Understanding the factors influencing customer loyalty is crucial for businesses to thrive in today's competitive landscape. This study investigates the impact of brand personality and satisfaction on customer commitment and loyalty. Highlighting the crucial role of customers, the research emphasizes the importance of quality products, service, and brand policies in fostering positive brand perception. While existing research suggests a link between a strong brand and customer loyalty, this study examines the specific influence of brand personality and satisfaction on commitment, acting as a mediator between these factors and loyalty. Through a quantitative study, the research explores the relationships between brand satisfaction, personality, relationship commitment, and loyalty. The findings reveal a moderate positive association between brand satisfaction and loyalty, signifying that satisfied customers are more likely to be loyal. However, brand personality did not exhibit a significant relationship with either satisfaction or commitment. These findings suggest that

building strong customer relationships through satisfaction is a key driver of loyalty, while brand personality may require further investigation to understand its specific role in this context.

Keywords: Brand personality; Brand satisfaction; Brand relationship commitment; Brand loyalty

1 Introduction

If people believe they share values with a company, they stay loyal to the brand. Brand loyalty (BL) is a marketing concept, everybody wants to look unique and more attractive, which is the reason why customers buy branded clothes. This is a vast concept but brand loyalty plays an important role in the market because of the numerous brands existing on the market. Brand loyalty and customers are believed to be the bread and butter that keeps a business valuable. It should be the top priority of every business to keep their customers happy and satisfied [1], [2], [3]. Customer satisfaction can be achieved through brand satisfaction.

Brand satisfaction (BS) is the most effective concept in the marketing world. Brand satisfaction means product name, sign, symbol, and other features that fully satisfy the customer, customer by a product and feel pleased with these productions. After brand satisfaction, the customer and product build relationship with strong commitment, this commitment helps brand loyalty. Brand commitment is an indication of brand loyalty. Brand commitment plays a mediating role between brand satisfaction and brand loyalty.

The present research strives to explore whether brand satisfaction (BS) and brand relationship commitment (BRC) could improve brand loyalty (BL), these two factors being variables that help customers develop brand loyalty. A third aspect, the brand personality (BP) construct is seen to be a brand image component consisting of the human characteristics people associate with brands [4]. Brand personality can serve as a basis for meaningful and sustainable emotional differentiation [5]. The concept enables customers to attribute an identity to a brand and therefore supports their identification with the brand [6]. This, in turn, increases the personal meaning of a brand.

Considering the interrelationship of the above four concepts brand satisfaction (BS) and brand personality (BP) can be considered as an independent variable while brand loyalty (BL) is a dependent variable and brand commitment (BRC) might play a mediating role in this model.

Mostly global and local content are available according to brand loyalty but in this research paper we fill the gap with the help of brand relationship commitment and brand satisfaction. This research paper helps to enhance customer brand loyalty.

The research is based on a model developed by the authors and is independent of any specific brand. The research focuses on brand satisfaction, loyalty, personality and relationship commitment in general.

Therefore, this paper is to give an evaluation of how brand satisfaction and customer relationship commitment can boost brand loyalty, to see what role brand personality can play in increasing brand relationship commitment and brand loyalty. A large number of brands are available to be evaluated and still the market is developing with high level of performance by giving high services in return of low prices.

Customer loyalty is the most important factor to keep business alive. The customer is the important asset of any business, that is why this paper is focusing on the brand loyalty. A customer plays an essential role in every business. In Pakistan there are couples of brands that are providing services to customers at a potential level [7]. The only way to maintain the customer brand is to provide possible services to customers. The main problems businesses seek answer are e.g. why customers change their brand, and who controls and grabs the attention of new customers. This research focuses on identifying the significant factors that might make customers loyal towards the brand. This loyalty can occur by giving them satisfying services. Brand and customer bonding help make strong customer commitment relationship.

The paper is organized as follows: after literature review, the research methods are presented, then the research data are analyzed and the findings are evaluated. The paper closes with a conclusion section.

2 Literature Review

2.1 Brand Satisfaction

Many studies have been performed on brand satisfaction [8]. According to [9], among some of the known preceding of satisfaction extant literature gives functional, symbolic, and experiential benefits. It is disputed in several literature that brand attributes are influenced via mediating, brand satisfaction attested by past consumption experience [8]. Brand attributes at the same time have activated as a result of brand satisfaction by empirical studies [5]. According to He et al. [6], when the performance of a brand fulfils the belief of a purchaser, satisfaction occurs. If brands fail to fulfil the expectations of the purchaser, negative effects occur on brand reputation that is the cause of dissatisfaction of products or a brand [4]. Brand satisfaction describes as valuing summary of direct consumption experience based on superior expectations and actual expectation analysis after consumption, However, customer positive or negative comments are based on brand services and overall consumers' total purchasing and experience after using brand products or services. It is vital for every brand and business to serve their customers' loyalty to

make customers brand loyal. If brands or businesses do not serve their customers, then customers switch to other brands.

Brand satisfaction is the most essential variable of this article. Every company brand product finds a way through which the company can enhance brand satisfaction because brand satisfaction is a first step to increase brand loyalty for the customer. Without satisfaction, the customer cannot be loyal to a brand, therefore a hypothesis stating that brand satisfaction has a significant relationship with brand loyalty can be stated.

2.2 Brand Personality

The set of human features related to a brand has been described as brand personality [10]. In contrast to earlier psychologists who described personality in terms of traits, Chen [10] defined it in terms of attributes. The demographic characteristics fall under the concept of brand personality, which includes factors like socioeconomic class, gender, and age. These factors are influenced by how brand users, product spokespersons, and staff are perceived, as well as by product features indirectly [11]. Based on the compatibility between their own self-concept and the brand personality, consumers frequently give products higher ratings [12]. As an illustration, the cigarette brand Marlboro is often associated with men who are "macho cowboys" and is a representation of the brand image that a company creates.

Similar to how BMWs are perceived as being used by upper classes due to their image of exceptional quality and performance. Customers typically choose brands that reflect their personalities and those of the individuals they interact with. As a result, they develop associations with brands like those they have with people [13]. In this study, brand personality was defined as the collection of human personality traits that are relevant to describing the brand as a reciprocal partner in the consumer-brand interaction and those that relate to the interpersonal domain of human personality [14]. In summary the hypothesis stating that brand personality has a significant relationship with brand satisfaction can be formulated.

2.3 Brand loyalty

Dislike the wide number of studies on brand loyalty most of the research in recent past 3 decades analyzed consumers from two positions, attitudinal loyalty and behavioral loyalty [11], [14]. If a consumer repeatedly purchases products from the same brand, it is known as behavioral loyalty. If consumers make psychological commitment in the purchases act, it is called attitudinal loyalty. Such as purpose to buy and aim to purchase without need is fully based on previous satisfaction and loyalty. [12]. In the field of GSM business, relationship marketing was analyzed to reveal brand royalty [15]. Factor analysis and regression analysis were applied to explore how relationship marketing practices can influence brand loyalty. In tourism, Gue at al. [16] powerfully point out the behavioral studies and present that

the attitudinal studies are much suitable to study travelers' loyalty because tourists can be loyal to a direction even if they do not travel to the spot.

Brand loyalty is an independent variable in the research model designed by the authors and the focus is on how to increase brand loyalty through different products of the company, so this problem is solved through brand satisfaction. Brand satisfaction is when a person feels pleased and happy with using the product. Satisfaction is the most important factor when it comes to loyalty. Based on the literature the hypothesis stating that brand relationship commitment has a significant relationship with brand loyalty can be formulated.

2.4 Brand relationship commitment

Consumers may engage with brands in ways that resemble human relationships as they give companies human qualities and treat them as human-like partners. Additionally, these brand interactions may be influenced by the standards that regulate human relationships [17]. It appears that there are some differences between consumers' relationships with brands and their relationships with other people. While consumers can establish and maintain relationships with numerous brands at the same time, certain interpersonal interactions—particularly romantic ones—represent exclusive dynamic partnerships. However, given that consumers view brands as potential partners in relationships, it is possible to assume that the bonds they establish and uphold with these entities are comparable to those in human relationships [18]. Reported by Morgan and Hunt [19] as well as Gundlach et al. [20] trust and commitment are rational variables in which the separate individual relationship is motivated to protect the relationship to avoid separation. Commitment has been investigated as a key concept in social exchange literature for a number of decades. According to Rusbult [21] and Rusbult & Buunk [22], commitment is a psychological state that encompasses the sensation of being dependent on a relationship and indicates a long-term orientation, including a desire to keep a relationship going and a sense of connection to a relational partner.

It has been demonstrated that a relationship's commitment may accurately predict whether it will be voluntarily maintained. In other words, relationship commitment is linked to a variety of so-called relationship maintenance acts, such as disparaging alternative partners by drawing them away or disparaging them [23]; being willing to make a sacrifice by giving up desired behavioural options for the sake of a relationship [24]; and having a propensity to accommodate bad behaviour from a partner rather than take offence [22]. In conformation with an extensive literature review conducted by Gundlach et al [20], 26 brand commitment is defined as an ordinary consumer's long-term, behavioral and attitudinal rapport towards relational brands. The impressive commitment can often be a trigger to further use the brand's switching motivation [4]. Many authors believe that commitment differentiate faithful brand loyalty from other repetitive purchase behavior that have confirmed habit, a real loyalty [14].

Brand relationship commitment is a mediating variable to produce a link between brand satisfaction and brand loyalty. Brand relationship commitment means interaction between the brand and how customers think of ideas about brands, feel about brands, and also if they are committed to buy the branded products. Without brand relationship commitment customers cannot be loyal. Brand satisfaction helps in building a relationship commitment which improves brand loyalty of customers. Therefore, a hypothesis stating that BRC has a significant mediating role in the relationship between BS and BL, as well as between BP and BL can be formulated.

3 Methods

The research applies the positivist approach to research methodology. Positivism comes up with the research questions which are quantitative in nature and certain hypotheses are tested. It helps researchers to explain the phenomenon. This research philosophy leads to have the quantitative analysis for the authentic outcome. In this research paper, a research model is designed and several hypotheses are formulated and tested to reveal whether customers of any brand are loyal towards their brand based on their brand satisfaction, brand personality, and brand relationship commitment. The research uses a deductive approach where the researchers aim to find answers to the posed research questions, which is done through testing pre-existing hypothesis.

Quantitative method was applied. The data were collected through a questionnaire. The questions included statements that belong to the four components and were surveyed on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). Anonymity was ensured and participants gave their consent by filling in the questionnaire. The survey applied convenient type sampling as the questionnaire was distributed online via internet and was targeted to people who have good or bad image about their brands, are currently customers of any brand.

The collected responses were analysed with the help of the Partial Least Squares Method – Structural Equation Modeling (PLS-SEM) in the Smart PLS software while further analyses were conducted in MS Excel and SPSS v25. The PLS-SEM modelling is a method of structural equation modelling and it allows the estimation of complex cause-effect relationship in path models with the selected latent variables. The procedure fits a composite model and maximized the amount of variance explained [25], [26].

Based on the research questions and the hypotheses the research model displayed in Figure 1 was developed to conduct a path analysis in order to reveal how Brand Satisfaction (BS) and Brand Personality (BP) influence Brand Loyalty (BL) through Brand relationship Commitment (BRC) as a mediator. Meanwhile, the influence of Brand Personality on Brand Satisfaction was also tested.

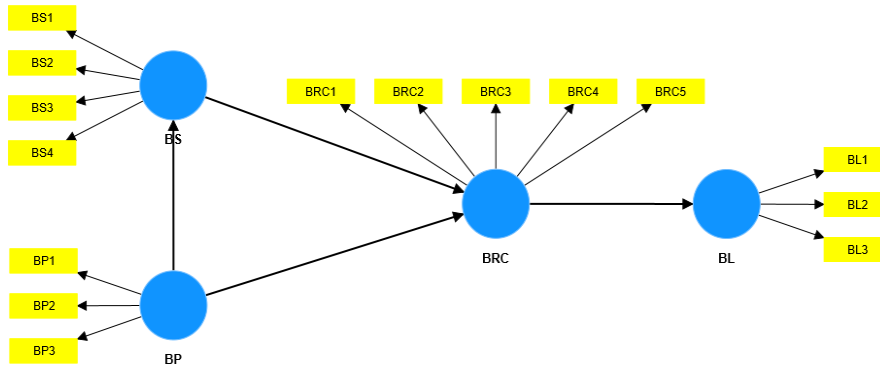


Figure 1.
The research Model (developed by authors)

The following hypotheses were formulated based on the research model:

- H1₁. BP has an impact on BS.
- H2₁. BP has an impact on BRC.
- B3₁. BS has an impact on BRC.
- H4₁. BRC mediates between BP and BL, and BS and BL.
- H5₁. BRC has an impact on BL.

The following sections will present the evaluation of the model using path analysis and give the conclusion on the findings and results.

4 Results

The results section is divided into subsection, first a demographic profile of the respondents is presented, then the reliability of the building blocks of the research model is tested, then the research model is evaluated and finally the hypotheses are tested and either supported or not supported.

4.1 Demographic Profile

A total of 118 responses were collected, all of which could be included in the analysis. Table 1 displays that the gender distribution of the responses is well balanced, 44.9% of the participants are males and 55.1% of them are females.

Gender	Percent
Male	44.9
Female	55.1
Total	100

Table 1.
Gender distribution (developed by authors)

As age is concerned, 33.9% of the respondents are between 16 and 25, 49.2% of them are between 26 and 35, 11% of them are between 36 and 50, while 5.9% of them are over 50 (Figure 2). It shows that the focus is on the age group between 26 and 35, the economically active younger generation, who are expected to have built commitments and loyalty to brand or job etc.

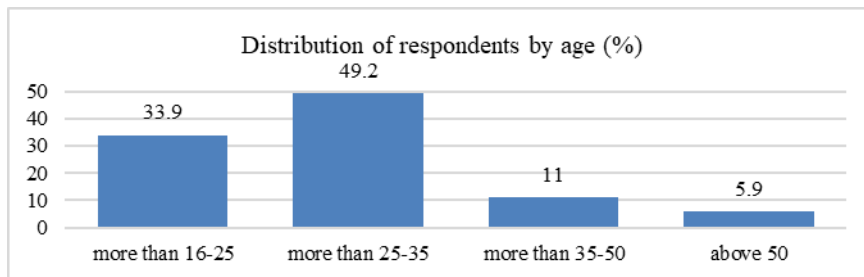


Figure 2.
Age distribution (developed by authors)

If education level is taken, over 40% of the respondents have a bachelor degree (which corresponds with the age group), while 30% have a master degree and 28.21% of the participants finished secondary education.

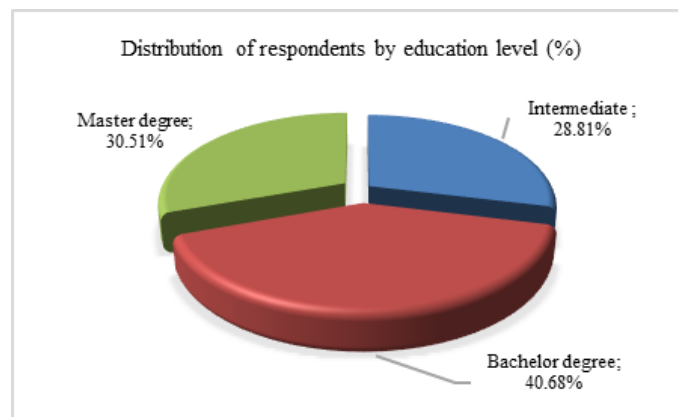


Figure 3.
Distribution of participants by education level (developed by authors)

4.2 Analysis of Brand Commitment components

Before the research model is built and evaluated, the individual statements are analyzed. Figure 4 presents the distribution of responses given by the respondents.

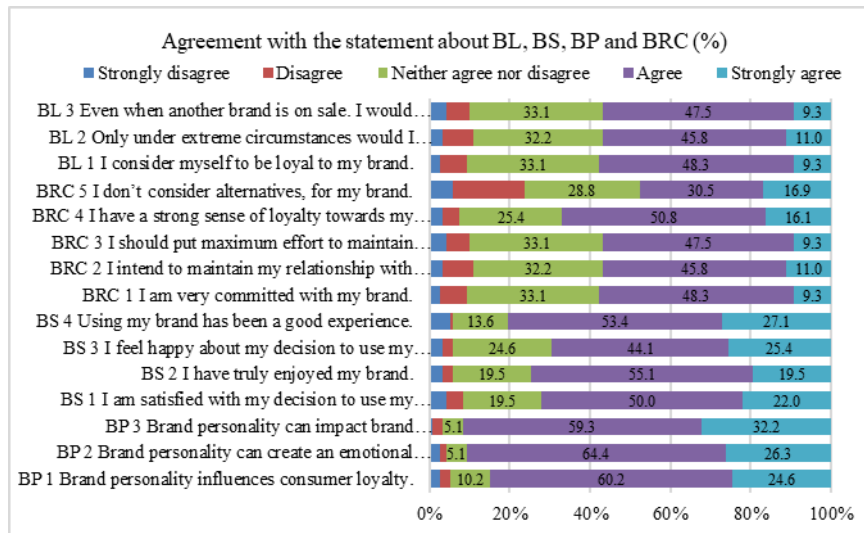


Figure 4.

Distribution of responses given by the participants (%) (developed by authors)

It is sticking out that respondents agreed with the statement in the highest percentage (between 30.5% and 64.4%) and they either strongly agreed with a statement or they were indecisive in the second highest percentage. Disagreement was not frequently chosen as response option.

4.3 Dimension reduction and Reliability analysis

The designed model has four components, each component comprised a couple of statements. Before the PLS-SEM and factor analysis the reliability of the components was tested using Cronbach's alpha. The Cronbach's alpha value shows good reliability between 0.5-0.6 satisfactory reliability between 0.6 and 0.8 and if Cronbach's alpha is higher than 0.8 then the reliability of the component is high [10]. The first row of Table 2 shows the Cronbach's alpha value.

Outer loadings	BL	BP	BRC	BS	VIF
Cronbach's α	0.823	0.617	0.834	0.878	
BL1	0.83				1.672
BL2	0.88				2.078
BL3	0.867				1.948
BP1		0.800			1.3
BP2		0.793			1.252
BP3		0.655			1.162
BRC1			0.804		1.769
BRC2			0.838		2.107
BRC3			0.847		2.146
BRC4			0.690		1.539
BRC5			0.680		1.501
BS1				0.862	2.372
BS2				0.867	2.308
BS3				0.797	1.893
BS4				0.893	2.605

Table 2

Research model components factor loadings and VIF values (developed by authors)

Table 2 also shows the factor loadings and the variance inflation factor (VIF) values of the components received in the course of PLS-SEM analysis. The factor loadings received are all greater than 0.593, which means high factor loadings, implying that the statements well determine the corresponding factor. The VIF measures collinearity in the multiple regression and checks the existence of model overfitting. In this model the VIF measures for the predictors are all smaller than 3, which indicates low correlation among the variables so all statements can be used for model evaluation [25], [27].

The composite reliability (CR) and the Average Variance Extracted (AVE) of the model have also been checked for the variable. Table 3 includes the value of CR and AVE. Dash and Paul [25] state CR should be over 0.6 and AVE over 0.5 for each construct in order to keep reliability and validity. These requirements are fulfilled, implying high reliability of the items.

	CR (ρ_a)	CR (ρ_c)	AVE
BL	0.824	0.895	0.739
BP	0.635	0.795	0.566
BRC	0.860	0.882	0.601
BS	0.892	0.916	0.732

Table 3

CR and AVE testing of the mediator and the output variable (developed by authors)

The Fornell-Larcker Criterion, which measures the square root of the AVE values with the latent variable correlations are presented in Table 4. The criterion is fulfilled as in each case the correlation measures are smaller than the square root of AVE. (diagonal).

	BL	BP	BRC	BS
BL	0.860			
BP	-0.172	0.752		
BRC	0.966	-0.184	0.775	
BS	0.557	-0.101	0.558	0.855

Table 4

The Fornell-Larcker criterion results (developed by authors)

As the conditions defined in Hair [28] does not hold for the BRC-BL path (<1), the discriminant validity of the model is not established, further items need to be included in the model in the future.

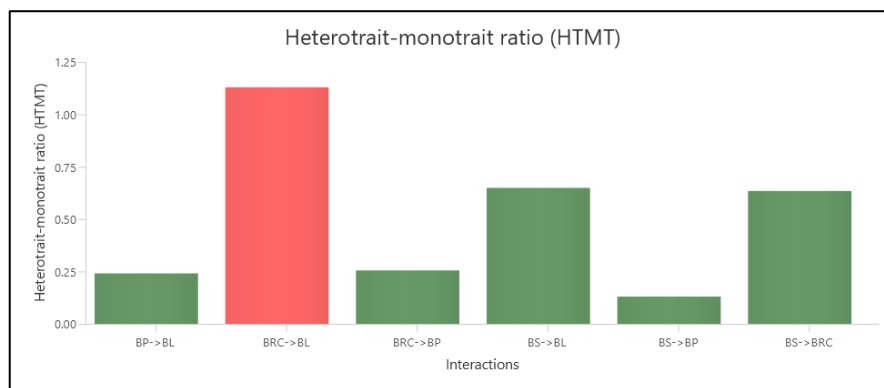


Figure 5.

Heterotrait-monotrait ratio (HTMT) results (developed by authors in Smart-PLS)

4.4 Evaluation of Brand Loyalty through Brand Relationship Commitment

First the correlation of the elements was analyzed to detect some positive and negative influences. Table 5 shows that BL and BRC are in very strong positive correlation, BS has a moderate positive correlation with BL and with BRC while BP and BL are in weak negative correlation. Furthermore, the input variables in the model, BP and BRC are in weak negative correlation. The results imply that BP has a negative effect on BL while the other constructs, BP and BRC will have a positive and presumably significant influence on BL.

Correlations	BL	BP	BRC	BS
BL	1			
BP	-0.172	1		
BRC	0.966	-0.184	1	
BS	0.557	-0.101	0.558	1

Table 5

Correlation of model constructs (developed by authors)

Figure 6 presents the PLS-SEM path analysis and evaluation. The R-square values show that BRC determines BL by 93.2% (Adjusted R²=93.2%), BRC is determined by 32.8% by BS and BP (Adjusted R²=31.6%) while BS is explained by a mere 1% by BS (Adjusted R²=0.002%).

The path coefficients show weak negative impact from BP to BS (-0.129) and BRC (-0.101) while BS→BRC path coefficient equals 0.545, showing moderately strong influence and the BRC→BL path coefficient equaling 0.966 shows a highly strong positive determination.

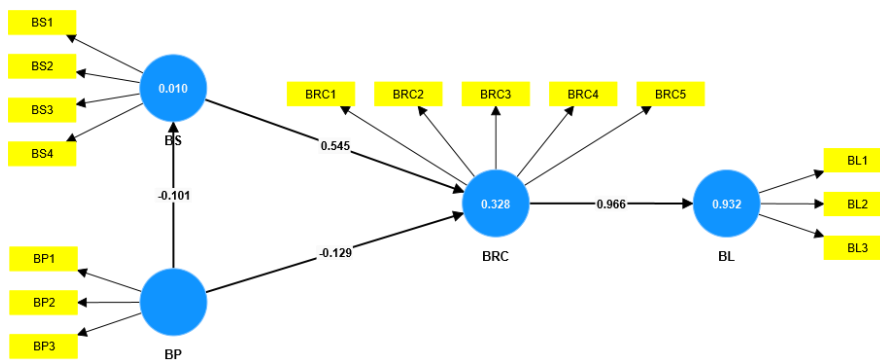


Figure 6

PLS-SEM model path analysis with factor loadings (developed by authors)

Bootstrapping was applied to test the robustness of the model and the coefficients were tested in order to justify the formulated hypotheses. Figure 7 presents the path coefficients and the significance levels, which allow us to draw conclusions and find the significant relationships and influences in the model. The figure displays the R² values, the path coefficients and the p values (in brackets).

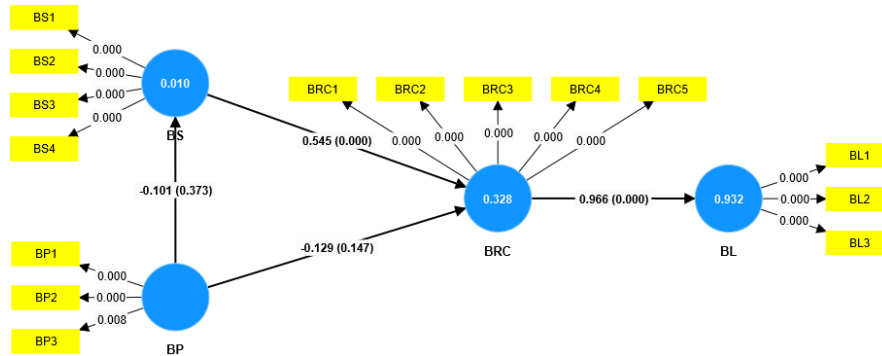


Figure 7

PLS-SEM model significant testing of the constructs and paths (developed by authors)

During the evaluation of the model Brand Personality (BP) has proved to be insignificant ($p=0.147$ and $p=0.373$), while BS is significant with $p=0.000$ and BRC has proved to be a significant mediator in the model ($p=0.000$). Considering the constructs similar results could be detected. Each item is significant in each construct of the model ($p<0.05$). Despite the fact that BP does not have a significant impact on BS and BRC. BS influences BRC significantly.

The effect sizes (f-square) in the model is presented in Table 6. While BP f-square is small (f-square <0.02), it has no effect on the model, however, the f-square values for $BRC \rightarrow BL$ and $BS \rightarrow BRC$ are larger than 0.35, they have a large effect on the dependent variables in the model [28].

	f-square
BP \rightarrow BRC	0.025
BP \rightarrow BS	0.010
BRC \rightarrow BL	13.784
BS \rightarrow BRC	0.437

Table 6

f-square values in the model (developed by authors)

Next to the path coefficients and the total effects, indirect effects were also analyzed (bootstrapping results). Table 6 includes the significant and non-significant total indirect and specific indirect effects. Two total indirect effect was found significant ($BS \rightarrow BL$), i.e. Brand Satisfaction has a significant effect on Brand Loyalty, and interestingly BP would have a negative impact on BL (the link was not explored in the original model). One specific indirect effect was significant ($BS \rightarrow BRC \rightarrow BL$) i.e. Brand Satisfaction – Brand Relationship Commitment – Brand Loyalty, and extra significant effects were found between Brand Satisfaction and Brand Loyalty, in each case $p=0.000$.

Total indirect effects	Original sample (O)	T statistics (O/STDEV)	P values
BP → BL	-0.178	2.029	0.043
BP → BRC	-0.055	0.875	0.382
BS → BL	0.526	5.613	0.000
Specific indirect effects			
BS → BRC → BL	0.526	5.613	0.000
BP → BRC → BL	-0.125	1.450	0.147
BP → BS → BRC	-0.053	0.873	0.382
BP → BS → BRC → BL	-0.055	0.875	0.382
Total effects			
BP → BL	-0.178	2.029	0.043
BP → BRC	-0.184	2.032	0.042
BP → BS	-0.101	0.891	0.373
BRC → BL	0.966	203.322	0.000
BS → BL	0.526	5.613	0.000
BS → BRC	0.545	5.653	0.000

Table 7

Direct and Indirect effects on the research model (developed by authors)

Conclusions

Brand personality is the collection of human qualities and features that a company displays to appeal to customers and create emotional bonds with them. It covers the values, tone, and overall look of the company. Companies can set themselves apart from rivals and establish a solid brand identity by creating a distinctive brand personality. A clearly defined brand personality elicits feelings and impressions, enabling customers to grow their trust, loyalty, and affinity for the product [11], [29].

Several studies proved that brand satisfaction is based on services and products which brands offer to their customers in different potential ways, and which products and services make customers satisfied [6]. Branded products and services that make customers satisfied is hypothesized to make them committed to specific brand. The research justified the above statement, i.e. H3₁ is supported, as well as an extra relation was found significant between BS and BL, stating that Brand satisfaction has a strong positive impact on Brand Loyalty. If customers are satisfied with branded product and services then customers wish to buy the used brand, otherwise they tend to turn away from the used brand.

However, H1₁ and H2₁ could not be justified, brand personality had no impact on brand satisfaction, brand relationship commitment and on brand loyalty, despite that for example Alikhani & Mokhtarian found significant relationship between these characteristics [30].

Customer relationship commitment, on the other hand, is based on customers satisfaction. Customer satisfaction makes strong bounding between customers and brand, which might lead to brand loyalty. Brand relationship commitment means customers shows great favor towards their brand and make purchases of used goods and services from their favorite brand. The research proved and justified the strong bound between brand relation commitment and brand loyalty, therefore, H5₁ is supported. At the same time, since BRC had no relation with BP but there was a significant effect on BL with the moderating effect of BRC (BS → BRC → BL) it can be said that brand personality does not influence customers in decision making as much brand satisfaction or brand relation commitment. Therefore, H4₁ is partly supported as BRC does not mediates between BP and BL, but mediates between BS and BL. When customers show great commitment towards their favorable brand, they become brand loyal.

The research has its limitations as a larger sample size would have better supported the research model and as some items in the constructs proved to be non-significant, more statements should be included in the future. However, the present adds value to the field of brand marketing and it might give advice to brand and marketing policy makers that brand satisfaction and brand relation commitment play a more significant role in decision making than brand personality.

This paper developed a research model to explore the path analysis with the help of PLS–SEM on customer loyalty towards their brand. The impact of brand satisfaction and brand personality was analyzed with brand relation commitment as mediator on brand loyalty. The authors believe that the findings might help managers to enhance their performance by making customers more satisfied through or by offering high quality products and services.

References

- [1] M. Mohammad and O. Szigeti, “Relationship Between Attitude and Online Purchase Intention of Dairy Functional Foods in Hungary: An Extended TAM Approach,” *ERSJ*, 26(1), pp. 545–559, Feb. 2023, doi: 10.35808/ersj/3128.
- [2] A. Popovics and M. Garai-Fodor, “Hungarian food purchasing behaviour and promotion opportunities in the light of primary data,” in 2023 IEEE 17th International Symposium on Applied Computational Intelligence and Informatics (SACI), Timisoara, Romania: IEEE, May 2023, pp. 000287–000290. doi: 10.1109/SACI58269.2023.10158568.
- [3] K. R. Szűcs, A. Tick, and R. Z. Reicher, “Applying Attitude Theory to Determine User Security Approaches,” *Serbian Journal of Management*, vol. 19(1), 2024.
- [4] L. A. Bettencourt and S. W. Brown, “Contact employees: Relationships among workplace fairness, job satisfaction and prosocial service behaviors,”

- Journal of Retailing, 73(1), pp. 39–61, Mar. 1997, doi: 10.1016/S0022-4359(97)90014-2.
- [5] B. Cooil, T. L. Keiningham, L. Aksoy, and M. Hsu, “A Longitudinal Analysis of Customer Satisfaction and Share of Wallet: Investigating the Moderating Effect of Customer Characteristics,” *Journal of Marketing*, 71(1), pp. 67–83, Jan. 2007, doi: 10.1509/jmkg.71.1.067.
- [6] H. He, Y. Li, and L. Harris, “Social identity perspective on brand loyalty,” *Journal of Business Research*, 65(5), pp. 648–657, May 2012, doi: 10.1016/j.jbusres.2011.03.007.
- [7] Google, “pakistan popular brands - Google Search.” Accessed: Feb. 14, 2024. [Online]. Available: <http://tinyurl.com/3m97k7bm>
- [8] S. Kuenzel and S. Vaux Halliday, “Investigating antecedents and consequences of brand identification,” *Journal of Product & Brand Management*, 17(5), pp. 293–304, Aug. 2008, doi: 10.1108/10610420810896059.
- [9] K.-M. Wong, C. Yen-Nee Ng, M. V. Valerian, and M. giovanni Battistotti, “Satisfaction of Heritage Hotels’ Patrons in Penang Island: A Research Note,” *International Journal of Business and Society*, vol. 15, no. 2, pp. 255–266, 2014.
- [10] Y.-S. Chen, “The Drivers of Green Brand Equity: Green Brand Image, Green Satisfaction, and Green Trust,” *Journal of Business Ethics*, 93(2), pp. 307–319, 2010, doi: 10.1007/s10551-009-0223-9.
- [11] S. Bandyopadhyay and M. Martell, “Does attitudinal loyalty influence behavioral loyalty? A theoretical and empirical study,” *Journal of Retailing and Consumer Services*, 14(1), pp. 35–44, Jan. 2007, doi: 10.1016/j.jretconser.2006.03.002.
- [12] Y. Odin, N. Odin, and P. Valette-Florence, “Conceptual and operational aspects of brand loyalty: an empirical investigation,” *Journal of Business Research*, 53(2), pp. 75–84, Aug. 2001, doi: 10.1016/S0148-2963(99)00076-4.
- [13] S. Magin, R. Algesheimer, F. Huber, and A. Herrmann, “The Impact of Brand Personality and Customer Satisfaction on Customer’s Loyalty: Theoretical Approach and Findings of a Causal Analytical Study in the Sector of Internet Service Providers,” *Electronic Markets*, 13(4), pp. 294–308, Nov. 2003, doi: 10.1080/1019678032000135572.
- [14] A. S. Dick and K. Basu, “Customer Loyalty: Toward an Integrated Conceptual Framework,” *Journal of the Academy of Marketing Science*, vol. 22, no. 2, pp. 99–113, Mar. 1994, doi: 10.1177/0092070394222001.

- [15] T. YeğİN, “Brand Loyalty in creating relationship marketing practices: A study on GSM operators,” *Elektronik Sosyal Bilimler Dergisi*, vol. 20, no. 77, pp. 201–216, Jan. 2021, doi: 10.17755/esosder.661291.
- [16] X. Guo, V. Scuott, and W. Xue, “Exploring the Use of Social Networking Sites in Banking Services: Evidence from China,” presented at the The 2015 WEI International Academic Conference Proceedings, Harvard, 2015, p. 228. [Online]. Available: <https://www.westeasinstitute.com/wp-content/uploads/2015/07/Xin-Guo-Veronica-Scuotto-Wanxin-Xue.pdf>
- [17] P. Aggarwal, “The Effects of Brand Relationship Norms on Consumer Attitudes and Behavior,” *J Consum Res*, vol. 31, no. 1, pp. 87–101, Jun. 2004, doi: 10.1086/383426.
- [18] S. Fournier, “Consumers and Their Brands: Developing Relationship Theory in Consumer Research,” *J CONSUM RES*, vol. 24, no. 4, pp. 343–353, Mar. 1998, doi: 10.1086/209515.
- [19] R. M. Morgan and S. D. Hunt, “The Commitment-Trust Theory of Relationship Marketing,” *Journal of Marketing*, vol. 58, no. 3, pp. 20–38, 1994, doi: 10.2307/1252308.
- [20] G. T. Gundlach, R. S. Achrol, and J. T. Mentzer, “The Structure of Commitment in Exchange,” *Journal of Marketing*, vol. 59, no. 1, pp. 78–92, Jan. 1995, doi: 10.1177/002224299505900107.
- [21] C. E. Rusbult, “A longitudinal test of the investment model: The development (and deterioration) of satisfaction and commitment in heterosexual involvements.,” *Journal of Personality and Social Psychology*, vol. 45, no. 1, pp. 101–117, Jul. 1983, doi: 10.1037/0022-3514.45.1.101.
- [22] C. E. Rusbult and B. P. Buunk, “Commitment Processes in Close Relationships: An Interdependence Analysis,” *Journal of Social and Personal Relationships*, vol. 10, no. 2, pp. 175–204, May 1993, doi: 10.1177/026540759301000202.
- [23] D. J. Johnson and C. E. Rusbult, “Resisting temptation: Devaluation of alternative partners as a means of maintaining commitment in close relationships.,” *Journal of Personality and Social Psychology*, vol. 57, no. 6, pp. 967–980, Dec. 1989, doi: 10.1037/0022-3514.57.6.967.
- [24] P. A. M. Van Lange, E. M. N. De Bruin, W. Otten, and J. A. Joireman, “Development of prosocial, individualistic, and competitive orientations: Theory and preliminary evidence.,” *Journal of Personality and Social Psychology*, vol. 73, no. 4, pp. 733–746, 1997, doi: 10.1037/0022-3514.73.4.733.
- [25] G. Dash and J. Paul, “CB-SEM vs PLS-SEM methods for research in social sciences and technology forecasting,” *Technological Forecasting and Social*

- Change, vol. 173, p. 121092, Dec. 2021, doi: 10.1016/j.techfore.2021.121092.
- [26] A. Tick, A. Toktosunova, H. Fallah, Z. Toutouchi, and Z. Tadzhibaeva, “The Impact of ChatGPT on Learning in Higher Education – Results of a Pilot Study,” *Practice and Theory in Systems of Education*, vol. 18, no. 1, Art. no. 1, Dec. 2023.
- [27] J. F. Hair, G. T. M. Hult, C. M. Ringle, M. Sarstedt, N. P. Danks, and S. Ray, *Partial Least Squares Structural Equation Modeling (PLS-SEM) Using R: A Workbook*. in *Classroom Companion: Business*. Cham: Springer International Publishing, 2021. doi: 10.1007/978-3-030-80519-7.
- [28] J. F. Hair, Ed., *A primer on partial least squares structural equation modeling (PLS-SEM)*, Second edition. Los Angeles: Sage, 2017.
- [29] M. Garai-Fodor and A. Popovics, “Analysing the Role of Responsible Consumer Behaviour and Social Responsibility from a Generation-Specific Perspective in the Light of Primary,” *ACTA POLYTECH HUNG*, vol. 20, no. 3, pp. 121–134, 2023, doi: 10.12700/APH.20.3.2023.3.8.
- [30] A. Alikhani and P. Mokhtarian, “Impact of brand personality traits on customer’s brand commitment (case study: NIVEA hygienic products),” *Journal of Global Scholars of Marketing Science*, vol. 31, no. 4, pp. 543–562, Oct. 2021, doi: 10.1080/21639159.2020.1808808.

Issues Relating To Waste Management: Construction Industry

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Abstract: This study aims to explore and draw attention to the issue of sustainability, with an emphasis on Waste Management, the possibility of applying Environmental Management Accounting (EMA) and its impact on Financial and Environmental performance, through examinations in a business, in the industry of construction in Albania. Environmental Accounting techniques vary in conception, perception and development, from one business to another, from sector to sector, in order to accurately identify environmental costs and provide the appropriate decision-making orientation for the economic entity. Meanwhile, the construction industry, especially in the last decade, inevitably connected with the environment, has great importance for the economy of our country.

Accounting is a key element in financial and managerial planning, therefore, as such, it must be reorganized and updated to include the effect of environmental considerations in relation to company performance. Accountants must work in relation to raw material, its treatment, capital, financial indicators and at the same time they must observe, recognize, measure, receive, control and report emissions and losses from traditional business activity. Environmental Accounting, which consists of the financial reporting of environmental costs in quantitative parameters, is closely related to Environmental Management Accounting, as well as to Financial and Cost Accounting and is referred to in various manuals and directives, depending on local and global policies, such as manuals of the European Commission, the United Nations or the European Union.

The research work in this paper, focused on the International Federation of Accountants approach and financial/accounting standards, is carried out through primary sources, which consists of a case study, undertaken in a business operating in the construction industry, in a building under reconstruction. Information is selected through the triangulation method. It includes financial information from construction estimates/construction assessment and periodic reports of work situations, management information obtained through site inspections and interviews with the facility engineer and CFO respectively.

The results of the study show that adapting the Environmental Management Accounting system can increase business reliability, financial information quality and management efficiency. Moreover, it can influence the decision-making process regarding investments related to the improvement of the production process. It can be a starting point for the complex total value chain should be re-organized in Albanian businesses.

Keywords: Environmental Accounting, Environmental Management Accounting, Environmental Impact, Construction and demolition waste.

1 Introduction

Waste management is a crucial aspect of any industry, including construction. When it comes to construction companies, effective waste management is essential for various reasons. It not only helps in reducing environmental impact but also contributes to cost savings and regulatory compliance. Construction projects generate a significant amount of waste, including materials, debris, and hazardous substances. Proper waste management practices ensure that these wastes are handled, treated, and disposed of responsibly and sustainably. By implementing efficient waste management strategies, construction companies can minimize their ecological footprint and promote a cleaner and healthier environment for everyone.

One of the key benefits of effective waste management in construction is the reduction of environmental impact. Construction activities can have a significant impact on land, air, and water quality. By implementing waste management practices such as recycling, reusing, and proper disposal, construction companies can minimize the amount of waste that ends up in landfills or gets released into the environment. This helps in conserving natural resources, reducing pollution, and preserving ecosystems.

In addition to environmental benefits, proper waste management can also result in cost savings for construction companies. By implementing recycling programs and reusing materials, companies can reduce their procurement costs. Instead of purchasing new materials, they can utilize recycled or reclaimed materials, which are often more cost-effective. Moreover, by properly managing hazardous waste, construction companies can avoid potential fines and penalties associated with non-compliance with environmental regulations.

Efficient waste management also plays a crucial role in ensuring the health and safety of workers and the general public. Construction sites can be hazardous environments, and improper waste management can increase the risk of accidents, injuries, and exposure to harmful substances. By implementing proper waste handling and disposal procedures, construction companies can minimize these risks and create a safer working environment for their employees. This includes providing appropriate training and personal protective equipment to workers involved in waste management activities.

Furthermore, effective waste management practices can enhance the reputation and credibility of construction companies. In today's environmentally conscious world, customers, investors, and stakeholders are increasingly concerned about sustainability and responsible business practices. By demonstrating a commitment to proper waste management, construction companies can improve their brand image, attract environmentally conscious clients, and gain a competitive edge in the

market. Additionally, construction companies can leverage their waste management efforts to showcase their social and environmental responsibility through marketing and public relations initiatives.

This study aims to explore and draw attention to the issue of sustainability, with an emphasis on Waste Management, the possibility of applying Environmental Management Accounting (EMA) and its impact on Financial and Environmental performance, through examinations in a business, in the industry of construction in Albania. Referring to the Fig.1, gross fixed capital formation due to construction knew an increase during the last decade. The data refer to residential buildings, non-residential buildings and public engineering projects from 1996-2021. The pandemic COVID-19 decreased the trend slightly, which is recuperated after it till nowadays. This shows that in Albania construction industry contributes not only in the GDP of the country but at the same time generates high amount of waste.

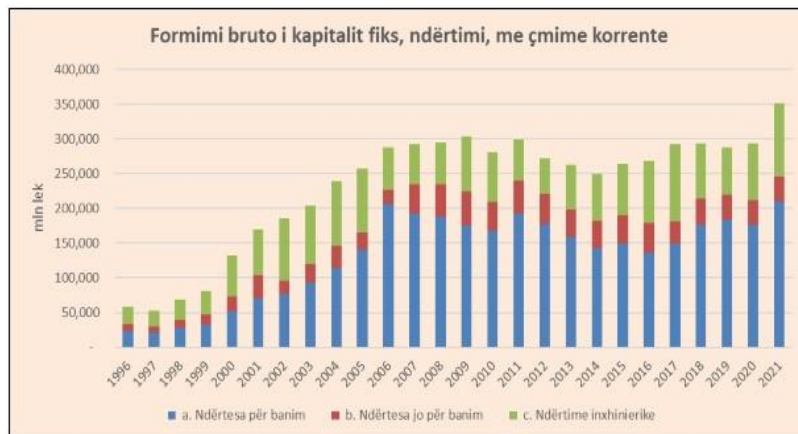


Figure 1. Gross fixed capital formation, construction (INSTAT, 2021)

If we compare the building permits issued by authorities, compared to the EU, Italy, Croatia, or even other Western Balkan Countries, we can see that for Albania there is an exponential increase. So, if we consider, construction and reconstruction's effect on the environment, it's more than an immediate issue to investigate to what extent Albanian Companies deal with waste management.



Figure 2.
Building permits- m² Useful Floor Area (Index 2015=100) (UNDP, 2022)

To reinforce the extent to which construction is an immediate issue relating to waste in Albania, let's have a look at EUROSTAT data referring to production in construction for a large number of countries, EU member states and non-member states. These data refer to 2023, and it shows clearly that Albania has an increase in construction sites and projects.

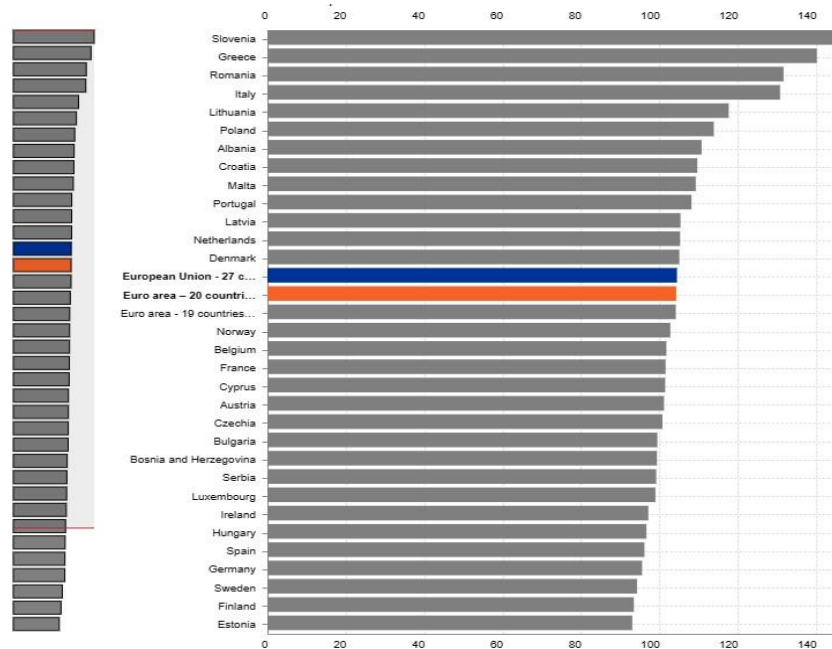


Figure. 3
Production in construction, annual data, (2021=100) (EUROSTAT, 2024)

Due to the above analysis and background, we aim to explore to what extent waste management is implemented through Environmental Management Accounting in the construction enterprise.

Furthermore, can waste management be inducted into accounting in the construction industry in our environment and what is its impact on a business?

The following paper is organized as follows: a literature review of waste management, methodology, and results and conclusions.

2 Literature Review

Effective waste management in construction requires a proactive approach throughout the project lifecycle. This includes careful planning, efficient procurement and inventory management, accurate estimation of materials, and effective communication among project stakeholders. By implementing waste management strategies, construction companies can reduce costs, improve project timelines, and enhance overall project performance.

(Baloi, 2003) The issues relating to developing countries are more complex compared to developed countries. Since the signing of the Paris Agreement in 2015, greenhouse gas emissions from the buildings and construction sector have peaked

(in 2019) and subsequently fallen to 2007 levels. This current decline is due mostly to the COVID-19 pandemic, whereas transformative, long-term progress in sector decarbonizing remains limited.(Environment, 2021).

Built environment has a significant impact on resources where it accounts for one-sixth of the world's freshwater withdrawals, one-quarter of its wood, and two-fifths of its material and energy flows. (Hussin et al., 2013)

Excessive resource and energy use and a growing demand for raw materials are largely responsible for the depletion of natural resources worldwide and the acceleration of global warming. About 40% of the world's resource and energy used is lined to the construction and maintenance of buildings (Global Green, USA).

In this context the industry should be revised, had to be taken in consideration what impact it has on overall sustainability. The entire process of a product, from the beginning to the end should be assessed from a cost point of view and by end it is eant when it is discarded and has to be disposed of.(Kartam et al., 2004).

To address waste in construction, various strategies can be employed.

To achieve effective waste management in construction, companies can implement several strategies. These include:

- Lean Construction which is a philosophy that aims to minimize waste and maximize value in construction processes. It focuses on eliminating activities that don't add value, optimizing workflows, and improving overall efficiency.
- Prefabrication and Modular Construction techniques can help reduce waste by allowing for more precise material planning, minimizing on-site construction waste, and improving overall productivity.
- Proper material planning and inventory management can help minimize waste by ensuring that materials are ordered in the right quantities, reducing excess inventory, and preventing material spoilage or damage.
- Recycling and Reusing Materials: Construction projects generate a significant amount of waste, but many materials can be recycled or reused. Implementing recycling programs and finding opportunities to reuse materials can help reduce waste and save costs.
- Waste Segregation and On-Site Sorting: Implementing proper waste segregation practices on construction sites can make it easier to recycle and dispose of different types of waste appropriately. On-site sorting stations can help ensure that waste is properly categorized and disposed of.
- Collaboration and Communication: Effective waste management in construction requires collaboration and communication among all stakeholders, including contractors, suppliers, and waste management companies. Clear communication channels and regular coordination can help optimize waste management efforts.

Furthermore, waste management in construction can be enhanced through the use of digital technologies. Building Information Modeling (BIM) and construction

management software can improve project planning, resource allocation, and waste tracking. These technologies enable real-time monitoring and analysis, allowing for timely interventions to minimize waste.

One key aspect of waste management is the identification and categorization of waste types. This helps in understanding the sources and causes of waste, allowing for targeted interventions. Common waste categories in construction include material waste, time waste, energy waste, and waste generated from inefficient processes.

In conclusion, waste management is a critical aspect of construction projects. By implementing effective waste management strategies, construction companies can reduce costs, improve project efficiency, and minimize their environmental footprint. Emphasizing waste management in construction can lead to more sustainable and successful projects.

As environmental management has evolved, interest has grown in developing a better understanding of environment-related financial costs and benefits as an input to conventional management accounting. (Bartolomeo et al., 2000).

3 Methodology

The study was pursued through a multimethod qualitative and quantitative case study approach conducted in a construction company that operates in different geographical areas of the country with a large scale of construction sites.

Case study methodologies encourage the triangulation of sources of information to increase the internal validity of data and the accuracy of observations. The main sources of information and data are as follows;

- Observations on construction sites through regular visits,
- Documentation of operational reports,
- In-depth interviews with engineers, workers, contractors, managers, accountants and CFO.

The research work is carried out through primary sources, which consists of a case study, undertaken in a business operating in the construction industry, in a building under reconstruction. Information is provided through the triangulation method.

We considered the framework of Houvila and Leinonen (2000) approach in preparing the questions for interviews and estimation of documentation and data available.

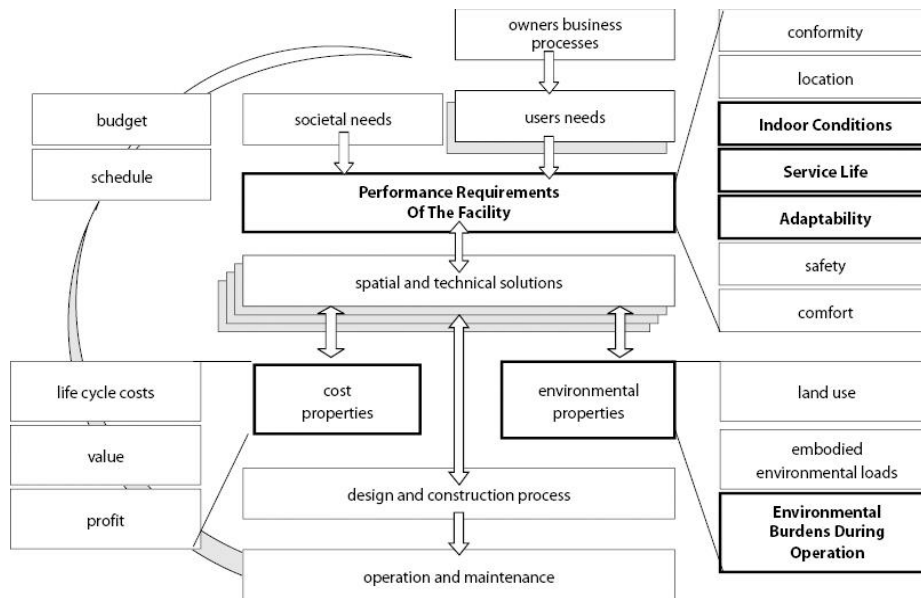


Figure 4.

Approach for Environmental Management in Construction , *Huovila, P. & Leinonen, J. (2000)*

The evaluation is done with a focus on the Deposition of Construction and Demolition Waste, in processes such as:

- Complete demolition of the non-load-bearing exterior cladding.
- Complete demolition of the internal non-load-bearing partition walls.
- Complete demolition of internal stairs and lift shafts.
- Increasing the depth of the foundation slab because of the installation of new lift shafts and escalators.
- Demolition of a part of the roof because of the construction of a new roof structure.
- Reduction of the wooden roof truss overlap around the perimeter of the building.
- Drilling holes in slabs because of the new communication system.

4 Results and Discussion

For the case study, recycling and waste management can be less expensive than landfilling.

The main findings referring to the construction case study are:

- Misrecognition of the concept of Environmental Accounting in practice by the sector.

- Inefficiency of accurate measurement of services and operations in relation to environmental impact.
- Unavailable software program for statistical data processing.
- Lack of protocol documentation.

Despite this, the most important conclusions from this research work, applying an Environmental Accounting method in business, treated as a case study, are as follows:

- Technological and environmental waste are very important in the production process.
- Their cost tends to increase proportionally with the purchase of materials and processing, resulting in rather inefficient production.
- The adopted technology of financial information processing is an important concern for the environmental accounting system.

Adapting Environmental Accounting and Environmental Management Accounting, as well as finding the appropriate cost measurement method, can increase business reliability, financial information quality and management efficiency.

The results of the study show that adapting the Environmental Management Accounting system can lead the business to operations that avoid high production costs. Moreover, it can influence the decision-making process regarding investments related to the improvement of the production process. It can be a starting point of the long study of the implementation of Environmental Management Accounting, by accountants, managers and environmental regulatory institutions.

At the end of the research, it could be said that the concept of Environmental Accounting is not known and adopted by local businesses.

Conclusion

It is well recognized that construction waste has residual value and its generation can be avoided.

The environmentally suitable recommended solution for the case study was more cost-effective than landfilling, even though the landfill was closer than the recycling facility, anyway as the methodology is a case study, the result cannot be generalized.

The general conclusion anytime is that Environmental Costs increase when more materials are purchased, processed, and produced as non-products (Cost of loss)

Environmental Management Accounting can get implemented in a business, if:

- The production stages get well-examined and measured
- The costs are well identified and allocated.

Environmental Management Accounting can lead the business through operations that avoid the high costs of production.

Environmental Management Accounting can influence the decision-making process related to investments linked to the improvement of production.

The total value chain should be re-organized in Albanian businesses.

This study can be a starting point for the long study of the implementation of Environmental Management Accounting, by accountants, managers, and environmental regulative institutions

References

- [1] Baloi, D. (2003.). Sustainable construction: challenges and opportunities. *Sustainable Construction*.
- [2] Bartolomeo, M., Bennett, M., Bouma, J., Heydkamp, P., James, P., & Wolters, T. (2000). Environmental Management Accounting in Europe: Current Practice and Future Potential. *European Accounting Review*, 9, pp. 31–52. <https://doi.org/10.1080/096381800407932>
- [3] Cheremisinoff, N. P. (2003). *Handbook of Solid Waste Management and Waste Minimization Technologies*. Butterworth-Heinemann.
- [4] Colangelo, F., Gómez, T., Farina, I., & Petrillo, A. (n.d.). Comparative LCA of concrete with recycled aggregates: A circular economy mindset in Europe. *Int J Life Cycle Assess.*
- [5] Environment, U. N. (2021, October 19). 2021 Global Status Report for Buildings and Construction. UNEP - UN Environment Programme. <http://www.unep.org/resources/report/2021-global-status-report-buildings-and-construction>
- [6] Gálvez-Martos, J.-L., Styles, D., Schoenberger, H., & Zeschmar-Lahl, B. (2018). Construction and demolition waste best management practice in Europe. *Resources, Conservation and Recycling*, 136, pp. 166–178. <https://doi.org/10.1016/j.resconrec.2018.04.016>
- [7] Hussin, J., Abdul Rahman, I., & Memon, A. (2013). The Way Forward in Sustainable Construction: Issues and Challenges. *International Journal of Advances in Applied Sciences (IJAAS)*, 2, pp. 31–42. <https://doi.org/10.11591/ijaas.v2i1.1321>
- [8] Kartam, N., Al-Mutairi, N., Al-Ghusain, I., & Al-Humoud, J. (2004). Environmental management of construction and demolition waste in Kuwait. *Waste Management (New York, N.Y.)*, 24, pp. 1049–1059. <https://doi.org/10.1016/j.wasman.2004.06.003>
- [9] Latan, H., Chiappetta Jabbour, C. J., Lopes De Sousa Jabbour, A. B., Wamba, S. F., & Shahbaz, M. (2018). Effects of environmental strategy, environmental uncertainty and top management’s commitment on corporate environmental performance: The role of environmental management

- accounting. *Journal of Cleaner Production*, 180, pp. 297–306.
<https://doi.org/10.1016/j.jclepro.2018.01.106>
- [10] Pongrácz, E., Phillips, P., & Keiski, R. (2004). Evolving the Theory of Waste Management-Implications to waste minimization.
- [11] Raghu, S. J., & Rodrigues, L. L. R. (2020). Behavioral aspects of solid waste management: A systematic review. *Journal of the Air & Waste Management Association*, 70(12), pp. 1268–1302.
<https://doi.org/10.1080/10962247.2020.1823524>
- [12] Rose, C. M., & Stegemann, J. A. (2018). From Waste Management to Component Management in the Construction Industry. *Sustainability*, 10(1), Article 1. <https://doi.org/10.3390/su10010229>
- [13] Spišáková, M., Mésároš, P., & Mandičák, T. (2021). Construction Waste Audit in the Framework of Sustainable Waste Management in Construction Projects—Case Study. *Buildings*, 11(2), Article 2. <https://doi.org/10.3390/buildings11020061>
- [14] Yeheyis, M., Hewage, K., Alam, M. S., Eskicioglu, C., & Sadiq, R. (2012). An overview of construction and demolition waste management in Canada: A lifecycle analysis approach to sustainability. *Clean Technologies and Environmental Policy*, 15. <https://doi.org/10.1007/s10098-012-0481-6>
- [15] Zhang, C., Hu, M., Di Maio, F., Sprecher, B., Yang, X., & Tukker, A. (2022). An overview of the waste hierarchy framework for analyzing the circularity in construction and demolition waste management in Europe. *Science of The Total Environment*, 803, 149892.
<https://doi.org/10.1016/j.scitotenv.2021.149892>

Developing SME personnel competence in strategic business sustainability

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Abstract: The importance of social and economic responsibility for SMEs' strategic business has increased since the EU CSRD (Corporate Sustainability Reporting Directive) entered into force in 2023. Due to the stakeholders' demand, SMEs are forced to react and strengthen personnel sustainability competence as a part of their strategic and economic management. This paper aims to grasp how Universities of Applied Sciences can support SMEs' need to increase their personnel sustainability competence to apply stakeholders' demands by distance learning ability. This paper is based on findings in the project Green Responsibility and response to the conclusions of the project Strengthening Responsibility and Business Competence for the Personnel of SMEs and Startups. Consequently, we present the importance of strategic business responsibility for SME personnel, which can be strengthened by distance learning and, e.g., gaining a competitive advantage.

Keywords: competence, human resources, SME, strategic management, sustainability

1 Introduction

The SME sector plays a crucial role due to its diversity to strengthen and achieve global sustainable development goals (SDGs) and responsibility. Many of the SME firms belong to the value chains of larger firms that require sustainability actions from their SME partners. The impact of SMEs globally and nationally is significant due to the large number of SMEs and their impact on employment. [1] For this

reason, actions aimed at the sustainability and responsibility of SMEs have a wide-ranging impact both nationally and globally. The sustainable and responsible operations of SMEs depend heavily on the level of competence of their personnel and their commitment to development to achieve the company's strategic goals. When a company anticipates and reacts to stakeholder requirements related to sustainable development and responsibility, it can strengthen its competitiveness and profitability in the long run. The competence of the personnel is a crucial factor in the implementation of strategic responsibility factors, underlining the importance of their role in maintaining profitability and competitiveness. [2] [3]

In addition to stakeholders, the requirements for responsibility and sustainable development are defined in the EU by, among other things, directives guiding more detailed national legislation and, globally, the United Nations' 2030 Agenda Sustainable Development (SDG) goals. Of the EU directives, the CSRD (Corporate Responsibility Reporting Directive) and CSD (Corporate Responsibility Due Diligence Directive), for example, are tightened on corporate responsibility, thereby promoting sustainable development to mitigate climate change in the EU green finance taxonomy. The results of the Green Responsibility project (2021-2023) showed that, from an SME perspective, there is a need for more precise and transparent strengthening of social and economic responsibility, both as part of business operations and among the personnel who carry them out. For example, the MEB 2023 conference highlighted shortcomings in the responsibility competence of SME personnel. In more detail, Laurea and LAB Universities of Applied Sciences identified this in the Green Responsibility Project 2021–2023 to promote the company's strategic factors. [4]. Based on this observation, the new and ongoing VALIOT project by Laurea and LAB University of Applied Sciences focused on increasing and strengthening SMEs' strategic responsibility competence and understanding by developing three sustainability courses for SME personnel in Finland. VALIOT project (2023-2025) was designed as a continuing project of Green Responsibility. [5]

Corporate responsibility scholars have mainly focused on companies' strategic vision of sustainability and, in some respects, on the impact of CSRD on a company's strategy, e.g., Manfred (2010) and Haski-Leventhal (2018). However, less attention has been paid to implementing responsible, operational, strategic, and social responsibility measures for sustainable development, which the companies' personnel implement based on their competence. For example, researchers should find answers to strengthening strategic and social responsibility measures as part of a company's practical strategic business operations.

In addition, Palthe (2013) has argued that aspects of social responsibility have been less ignored in the education programs of business schools. However, social and human sustainability form the critical components of SDGs. In their strategic vision and practical strategic operations, SMEs must consider their personnel's level of sustainability and responsibility competence to meet the requirements of, for example, sustainability reporting and corporate responsibility in listed companies'

value chains. The design of competence development studies in the VALIOT project by Laurea and LAB University of Applied Sciences focused on the perspectives of responsible strategic business and recruitment, marketing, and commercialization. These choices were made, for example, based on observations made in the Green Responsibility project [6]. In addition, it has been commonly claimed that when responsibility is included in the strategy, a responsible corporate image and reputation attract skilled recruiters to companies. Moreover, sustainability issues (e.g., equality and execution of human rights) in the context of recruitment have received less scholarly attention. Therefore, increasing and strengthening skills in these areas is strategically crucial for maintaining the competitiveness of companies.

This study aims to understand how SMEs can respond to stakeholder challenges and maintain competitiveness by increasing and strengthening their personnel's responsibility competence. More specifically, in this article, we will focus on strategically significant aspects of responsible business and recruitment competence development, as they enable and benefit companies in maintaining competitiveness, recruiting skilled personnel, and shaping their corporate image. To ensure a more comprehensive understanding and essential information related to the topic, the principles related to corporate responsibility and corporate responsibility reporting and practical groundwork from the perspective of double materiality analysis were considered in the design and design, as well as the impact of responsible strategic operations on responsible sales and commercialization measures. The main targets of the project behind this study are strategic strengthening responsibility and business competence for the personnel of SMEs and Startups, as well as the importance of strategic business responsibility for SME personnel, e.g., gaining a competitive advantage.

2 Theoretical background

In today's fast-paced business environment, Small and Medium Enterprises (SMEs) play a crucial role in economic development. This article explores the concept of economic responsibility and how it integrates into the strategic business practices of SMEs, focusing on ensuring the continuity of customer services and warranty issues, etc. Economic responsibility should be a significant part of an SME's systematic strategic planning process (SPP) [7]. This integration begins with incorporating economic responsibility into the company's mission and vision, reflecting a long-term commitment to sustainable practices. Defining concrete, measurable objectives (KPIs) related to financial sustainability and responsibility helps guide strategic planning. Building solid relationships with customers based on economic responsibility can lead to greater loyalty and retention. Transparent communication about business practices and economic impacts fosters trust. Offering products or services that deliver genuine value and positively contribute to

the economy reinforces this trust, ensuring that customers feel secure about the continuity of the services they receive [8].

SMEs often face unique challenges when implementing economic responsibility, such as limited financial and personnel resources, lack of expertise, competitive environment, and market turbulence [9]. These constraints can make it difficult to implement economic responsibility strategies. However, there are ways to overcome these challenges by investing in training programs that inform employees about financial responsibility. Cooperation with other companies, industry groups, and administrative bodies also enables sharing of resources and information, facilitating the adoption of responsible practices. According to Sirkiä [10], the company's management and supervisors must ensure investment in personnel training and competence. By adopting responsible economic practices, SMEs can create a stable financial foundation, enabling the company's long-term continuous service and product support and the preservation of jobs, thus working for the benefit of customers. This stability guarantees customers that the services they need will not be interrupted or completely stopped due to economic instability. By building a reputation for reliability and trustworthiness, SMEs can attract and retain a loyal customer base, further strengthening their financial stability and the continuity of their services [11].

2.1 Social responsibility for SMEs' strategic business

According to Palthe [12], the full scope of sustainability has yet to become embedded in mainstream business education and human rights, and the social aspect of sustainability has been given less attention than economic and environmental issues. However, in a time of global crises, there is a specific need for education on the social dimension of sustainability. Human rights are the basic standards to secure dignity and equality for all [13].

The social dimension of sustainability includes human rights to fair treatment, adequate health care, safety, equity, advancement, education, and equal representation [12]. Moreover, social sustainability covers issues such as the implementation of human rights and is linked to labour, women's empowerment, and gender equality [13].

Good stakeholder relationships are also a critical aspect of social sustainability. [13]. Good stakeholder relationships and implementation of social sustainability issues also create trust and social capital [14], creating a competitive advantage for firms. Noteworthy, the social dimension of sustainability needs to be more integrated into the education and academic programs of business schools and universities of applied sciences. For example, education is necessary in the context of socially responsible HR and recruitment policies and practices. According to Palthe [12 p. 123], *“Business leaders of the future need to be taught how to integrate human*

rights into business decision making and recognize that prudent strategic decision making incorporates economic, environmental, and social sustainability elements.”

2.2 Sustainability competence frame

The competence needs for strategic economic and social responsibility are based on the EU's Green Deal Industrial Plan. It aims to improve the competitiveness of net-zero industry and the transition to climate neutrality, strengthening the achievement of the EU's climate objectives. [16] From the business point of view, rules will be simplified, procedures will be speeded up, and know-how will be harnessed in the mass production of innovations as funding improves and the growth of clean technologies accelerates. [16]. The Action Lines of the Green Deal's Industrial Plan consider a proactive and simplified regulatory environment, faster access to finance, open trade to support resilient supply chains, and the need to raise skills levels. This study focuses on practical actions for a proactive and simplified regulatory environment and upskilling SMEs. [16]

For example, when SMEs are part of the value chain of a large company operating in the EU, they must act according to the obligations of the company responsible for the value chain, the EU Corporate Responsibility Reporting Directive, and corporate responsibility due diligence. [17] To comply with the regulations in force in the EU, the awareness, understanding, and competence of companies' personnel in these matters must be increased and tied to the company's practical business operations.

3 Empirical case-study

The research team defined the first feasibility research methods at the beginning of the project in autumn 2023 to formulate responsibility studies that serve the needs of SMEs to develop sustainable development and its competence. As a result of the specification, it was decided to utilize qualitative and applied design science research methods. The analysis of this article focuses on the development of economic and social responsibility in small and medium-sized enterprises (SMEs) through the upskilling of their staff. By utilizing Design Science research methods [19], we aim to study the significance and impact of competence in economic and social responsibility factors on SMEs' current strategic operations and profitability. This article aims to understand and describe the sustainability competence needs of SMEs in authentic conditions.

To embody an authentic theory, a case study is suitable for a crucial situation so that the theory can be challenged and expanded. When studying everyday situations and practices, previously undiscovered phenomena may emerge, and a case study helps analyze possible deviations from the norm. [18.] The applied design science research method is proper when researching practical solutions to real-world

problems by testing theories and considering the research object's culture. It includes an explanatory part that outlines the study's framework, objectives, process, and legitimacy. [19.] Schedules, processes, locations, and participants are appropriately selected according to research constraints when using a qualitative research method. When collecting data, the researcher highlights subjective thinking as part of the research. [18.] The analysis of the collected data is based on everyday experiences, views, and goals. In qualitative research, data collection is holistic, with the researcher interpreting phenomena and filtering them for practical experiences and views, creating information for context. [20.] When information is context-specific, there may be several realities related to this depending on the interpreter, i.e., the same information may appear different to different researchers, and, for example, the topic may change based on the answers to open questions. [18][21][22]. Contextualism poses a challenge of impartiality for researchers in collecting qualitative research data, based on which a foundation for accurate and reliable information must be laid. [22]. In the interviews, open-ended questions are primarily asked, and the theme can be discussed, in which case the interpretation is divided into a timeline for conducting the research. [23]. The contextualization of qualitative research means considering unexpected events and comprehensive descriptions of reality. In this case, various variables, meanings, processes, and relationships are considered, focusing on identifying regularities and generalizable observations. Things are observable but not measurable, emphasizing the design and implementation of theoretical models and proposals. [22] [28.]

This study used group and semi-structured interviews to collect data to understand SMEs' perspectives on practical sustainability measures and the level of sustainability competence and needs. The research team and authors planned and defined the first phase of the research question set in the fall of 2023. The aim was to gain an up-to-date view of how the SME strategy considers and responds to stakeholder responsibility requirements by developing the personnel's responsibility competence. The data from the interviews and surveys were further compared and analyzed to iterate on the practical development needs of companies' responsibility. Based on analyses and comparisons, different approaches were selected considering the target group. First, the topic was approached with a thematic interview targeted at SMEs, after which an unstructured survey was directed to the interviewees. The preliminary study charted how companies have considered the requirements of sustainable development and responsibility in a strategic approach to practical business and how the competence of personnel supports strategic, practical operations. Based on group and semi-structured interviews, the research group developed a study module on strategic responsibility for SMEs, focusing on strategic business responsibility, responsible recruitment from the perspective of corporate image, and responsible commercialization and marketing.

3.1 Authentic company cases supported by team learning

In our project teaching, we implement team learning methods based on the principles of a Knowledge-Creating Company [24] and the concept of a Learning Organization [25]. According to Senge [25], teams can learn more than individuals. Learning organizations should implement the processes of expanding knowledge into their structures and enhance the quality of this knowledge by using special tools or mechanisms [26].

In the process of creating learning organizations, five key areas are essential: 1) systematic thinking, 2) personal mastery, 3) thought models, 4) shared vision, and 5) grouped learning. Learning from one's own mistakes, availing of experience, and constant learning should be composite parts of a learning organization. [26]. According to Halmaghi [27], the critical factors of learning organizations are as follows (pp. 99–102):

- creation of systems supporting the learning process
- appreciation and perception of values arising from the organization-environment relation
- encouragement of sharing knowledge
- awakening cooperation and dialogue
- constant creation of conditions that are favourable for employees wanting to learn
- learning based on experience, elimination of current mistakes
- emphasizing and advocating relations based on the individual employee and the organization
- creation of an atmosphere and organizational culture that are favourable for learning

In our project, we implemented several team learning methods and the concepts of Learning Organizations [25]. First, students work in their company teams, and together, they analyze their current sustainability issues based on their analysis, define their company's key development areas of sustainability, and make a long-term plan for developing their sustainability goals. Secondly, we implement peer-learning methods in the three sustainability courses of the project as students also learn from other teams and individuals in the course through online meetings. In those online “team meetings,” they can share their practices, concerns, and notifications with students from other firms and increase their knowledge of sustainability issues.

In our project courses, teachers' roles are seen as “mentors” supporting and encouraging learning. Teachers' role is also to create a psychologically safe learning

environment for students, encouraging them to express their concerns and make mistakes. Team learning methods require motivation from students as students are seen as active creators of knowledge – not just passive information acquirers.

4 Results

This research indicates that SMEs must take responsibility guidelines into account strategically, and the personnel's responsibility competence must be more comprehensive. The daily work of businesses and personnel around responsibility and sustainable development must meet the responsibility requirements of different stakeholders. This maintains the company's competitiveness in the long run. To develop the responsibility competence of SME personnel, our study proposes three study modules focusing on responsibility, the by-product of which is an analysis of the current state of responsibility and a development plan for the company. With these, the company can develop responsibility and sustainability functions, considering the perspectives of double materiality analysis.

The GAP analysis was conducted at the beginning of 2024 based on semi-structured (n19) and group interviews (n 4-13), which revealed recurring themes in SMEs' views on promoting and considering sustainable development and responsibility. SMEs' views on responsible business operations focused on compliance with regulations, such as directives, responsibility, legislation, and transparency. In this context, SME representatives highlighted transparency, doing the right thing, fairness, integrity, and ethical and moral principles. The importance of preventing harmful activities was highlighted in the immediate business environment and as part of the value chain. The respondents focused on the profitability and strategic starting points of business operations and their positive relationship to sustainable development and responsibility in the long term. During the semi-structured and group interviews, some respondents woke up to the comprehensiveness and significance of the dimensions of responsibility as part of competitiveness and when meeting stakeholder requirements. The areas of social responsibility, such as increasing the personnel's responsibility competence to ensure competitiveness, were considered significant. In this context, the importance of the personnel's responsibility competence as part of corporate image, marketing, and commercialization was highlighted, for example, to avoid greenwashing. The long-term view of SMEs is to consider that having different recycling options and using renewable, responsibly produced natural resources is essential. All in all, responsibility was felt to support the business's strategic goals.

The responses to the semi-structured interview show that some companies have taken some sustainability and responsibility into account as part of their practical business. Responsibility and the company's views on sustainable development are communicated, for example, on the website. In addition, it is stated that responsible matters must be implemented as required by regulations and legislation. From the

perspective of social responsibility and corporate identity, in addition to communication, interaction is based on openness and trust, as well as in a customer-oriented manner. A few companies have invested in responsible product innovations, recycled materials, and the use of responsibly produced products. A couple of the respondent companies have gone further and calculated their carbon footprint, carried out sustainability-related certificates and a life cycle analysis, or joined the One Global Contact initiative, for example, and taken equality and non-discrimination into account.

4.1 Responsibility Competence in SMEs'

The research team analyzed and planned how the Universities of Applied Sciences could support SMEs in increasing their personnel sustainability competence to meet stakeholders' demands.

Most company representatives said they had not attended any training to increase their competence in responsibility. The research group had already made a similar observation during the Green Responsibility project, and the previous observation was confirmed in the survey. To formulate sustainability studies targeted at SME personnel members in a needs-based manner, the research group's representatives were asked what issues they thought were related to responsible business operations, human resources management, and recruitment.

Responsible business was requested to include content and closer examinations with practical examples of responsible communication, forming a responsible corporate image, and regional impacts. The challenge was implementing the responsibility strategy in the company's everyday operations. In decision-making in procurement and value chains. The comprehensiveness of responsibility and sustainable development and its strategic and long-term significance for ensuring the company's profitability and existence were discussed.

Social responsibility should be considered in practical decisions, for example, from the perspective of multiculturalism. The survey section on responsible human resource management and recruitment revealed that the respondents wanted clarification on what responsible recruitment is, what is included in the equality plan, and what its significance is for the corporate image. Regarding responsible recruitment, the responses considered what the applicant can ask about the company's values and how to reliably verify the level of competence in recruitment. A few people left this point unanswered or said the question was irrelevant. In this context, the research group considered the respondents' needs. It raised awareness through planned studies to provide all participants with a clear picture of the impacts and significance of responsible human resource management and recruitment.

Conclusions

Consequently, we present the importance of strategic business responsibility for SME personnel, which can be strengthened, e.g., by distance learning and gaining a competitive advantage.

Based on the research team's GAP analysis, thematic and group interviews, and a survey, it was decided to focus on strategically responsible business, recruitment, commercialization, and sales competence in the responsibility studies offered to SME personnel members. This resulted from research data showing the importance of responsibility and sustainable development in the future operations of SMEs and stakeholder demands. For SMEs to meet the responsibility requirements of all stakeholders, their personnel must master and know the most relevant issues affecting responsibility and sustainable development for the company's business. Responsibility competence and its level become concrete in everyday practical business. Responsible and sustainable implementations affect companies' capabilities and profitability in the long term.

By participating in the responsibility studies designed and formulated by the research team based on the data, companies can draw up a current state and development plan for responsibility related to their own business, which will increase SMEs' strategic competence and thinking about responsibility. The study participants learn to understand the team learning method's peer learning and problem-solving skills by utilizing current responsibility requirements in practice. In this way, they can further develop the competence areas of responsibility and sustainable development, which are central to the company's future.

References

- [1] Chowdhury P., Shumon. R.: Sustainability Minimizing the Gap between Expectation and Ability: Strategies for SMEs to Implement Social Sustainability Practices, *Sustainability* 2020, 12 (16), 6408; <https://doi.org/10.3390/su12166408>
- [2] Jansson J., Nilsson J., Modig F., and Hed Vall, G.: Commitment to Sustainability in Small and Medium-Sized Enterprises: The Influence of Strategic Orientations and Management Values *Bus. Strat. Env.*, 2017, 26, pp. 69–83. DOI: 10.1002/bse.1901.
- [3] Laasch O., Moosmayer D.C., Antonacopoulou E.P.: The Interdisciplinary Responsible Management Competence Framework: An Integrative Review of Ethics, Responsibility, and Sustainability Competencies. *J Bus Ethics* 2023, 187, pp. 733–757, <https://doi.org/10.1007/s10551-022-05261-4>
- [4] Green responsibility, 2023, <https://vihreävastuu.fi/in-english/>
- [5] Increasing responsibility and business competence, 2024, Vastuullisuus ja tulevaisuuden kuluttaja brändin keskiössä 9.4.2024 <https://www.valiot.fi>

- [6] Sivén S., Tuominen T., Sirkiä J., Isola T.: Social and Economic Sustainability from the Perspective of SMEs, in Proceedings of MEB 2023, Keleti Faculty of Business and Management Óbuda University, Hungary, 2023, https://kgk.uni-obuda.hu/wp-content/uploads/2023/12/MEB2023_Proceedings_1202.pdf
- [7] Dwikat S.Y., Arshad D., Mohd Shariff M.N: The Influence of Systematic Strategic Planning and Strategic Business Innovation on the Sustainable Performance of Manufacturing SMEs: The Case of Palestine, Sustainability 2022, 14, 13388. <https://doi.org/10.3390/su142013388>
- [8] Kang J., Hustvedt G.: Building Trust Between Consumers and Corporations: The Role of Consumer Perceptions of Transparency and Social Responsibility. Journal of Business Ethics, 2014, 125(2), pp. 253–265. <http://www.jstor.org/stable/24033230>
- [9] Sundström A., Hyder A.S., Chowdhury E.H.: Market-oriented CSR implementation in SMEs with sustainable innovations: an action research approach, Baltic Journal of Management, 2020, 15(5), pp. 775-795. <https://doi.org/10.1108/BJM-03-2020-0091>
- [10] Sirkiä J.: Leveraging digitalization opportunities to improve the business model, Väitöskirja, 2020, Lappeenranta-Lahti University of Technology LUT, LUTPub. <http://urn.fi/URN:ISBN:978-952-335-560-6>
- [11] Jančiauskaitė L., Lasickaitė K., Ripkauskaitė A.: Corporate sustainability impact on reputation and customer behavior, Vilnius University Open Series 2019, pp. 19-26, 10.15388/OpenSeries.2019.18399.
- [12] Palthe J.: Integrating Human Rights in Business Education: Embracing the Social Dimension of Sustainability, Journal of Education for Business, 2013, 88, pp. 117–124.
- [13] United Nations Global Compact (UNGC), Human rights, 2024, <https://unglobalcompact.org/what-is-gc/our-work/social/human-rights>
- [14] Nahapiet N., Ghoshal S.: Social Capital, Intellectual Capital, and the Organizational Advantage. Academy of Management Review. 1988, 23(2), pp. 242-266
- [15] Putnam R. D.: Bowling alone: The collapse and revival of American community, New York, NY: Simon & Schuster, 2000
- [16] Official website of the European Union. Strategy and policy. Priorities. European Green Deal. The Green Deal Industrial Plan - European Commission (europa.eu)

- [17] Official website of the European Union. Financing. Company reporting and auditing. Company reporting. Corporate sustainability reporting. Corporate sustainability reporting - European Commission (europa.eu)
- [18] Gupta RK., Awasthy R.: *Qualitative Research in Management: Methods And Experiences*. New Delhi: SAGE Publications India Pvt, Ltd.; 2021.
- [19] Peffers K., Tuunanen T., Rothenberger M., Chatterjee S.: "A Design Science Research Methodology for Information Systems Research, *Journal of Management Information Systems* 24(3), 2007, pp. 45–77. doi:10.2753/MIS0742-1222240302.
- [20] Cassell C., Buehrins A., Symon G. Editors: *Qualitative methods in management research*, Emerald Publishing Limited, 2006, ProQuest Ebook Central, <https://ebookcentral.proquest.com/lib/laurea/detail.action?docID=258136>.
- [21] Cassell C. et al.: *The SAGE Handbook of Qualitative Business and Management Research Methods: History and Traditions*, 55 City Road, London: SAGE Publications Ltd, 2018, Sage Research Methods, DOI <https://doi.org/10.4135/9781526430212>.
- [22] Cassell C. et al.: *The SAGE Handbook of Qualitative Business and Management Research Methods: Methods and Challenges*, 0 vols. 55 City Road, London: SAGE Publications Ltd, 2018, Sage Research Methods, DOI <https://doi.org/10.4135/9781526430236>.
- [23] Taylor, S.J.: *Introduction to Qualitative Research Methods: A Guidebook and Resource*, John Wiley & Sons, Incorporated, 2015, ProQuest Ebook Central, <https://ebookcentral.proquest.com/lib/laurea/detail.action?docID=7104054>.
- [24] Nonaka: *The Knowledge-Creating Company: How Japanese companies create the dynamics of innovation*, New York: Oxford University Press, 1995
- [25] Senge P.: *The fifth discipline, The art and practice of the learning organization*. USA: Doubleday/Currency, 1990
- [26] Madej M.: Using the concept of learning organization to build a third-generation university. Case study of the Jagiellonian University. *International Journal of Contemporary Management*. 19(4), 2020. pp. 65–89
- [27] Halmaghi E.: From the traditional organization to the learning organization. *Journal of Defense Resources Management* (9) 1, 2018
- [28] Durdella N.: Working as a Qualitative Methodologist in Dissertation Contexts, In *Qualitative Dissertation Methodology: A Guide for Research Design and Methods*, 3-32. Thousand Oaks, CA: SAGE Publications, Inc, 2019, <https://doi.org/10.4135/9781506345147>.

Importance of Integrating HR Analytics to Measure Employee Learning and Development: A Descriptive Study towards Human Return on Investment

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Abstract: In the strategic management of Human Resources (HR), the portrayal of employees as human assets has significant inferences as it highlights the human investment perspective in firms. It necessitates an appropriate and integrated approach to managing the workforce with the organization's strategy. However, it needs the best HR practices and metrics to identify the effectiveness of productivity, profit, growth, and innovation. This involves dilemmas related to the investment in the workforce. Accordingly, this study helps to identify the significance of integrating HR analytics to measure employee learning and development in a selected University in the United Arab Emirates. A questionnaire was developed based on the intensive literature review. The primary data was collected by interviewing employees from different strata. The collected data was analyzed by descriptive statistics and tested the crafted hypotheses through a Confirmatory Factor analysis (CFA). The results prove the significance of HR analytics in employee development toward organizational effectiveness. Organizations that invest in their talent force are more attractive to prospective employees and can retain the best talents for firms' future growth and stability. Well-trained employees increase a competitive advantage to firms in the marketplace and ensure a Return On Investment (ROI). Hence, this study can be a roadmap to determine the actual "value" of each employee. Valuation of human assets has a high impact on performance, compensation, career development, and retention strategies in firms. Future studies can be concentrated on these areas.

Keywords: Human Resource Analytics, Learning and Development, Employee Development, Human Value, Return On Investment.

1 Introduction

An organization that invests in its employees will be more attractive to prospective employees and will have less difficulty in retaining current employees; this leads to efficiency and gaining the organization's competitive position.

1.1 Purpose and aim of the study

Firstly, the study tries to examine the importance of HR analytics in general and how it links to employee performance. Though the performance is based on a lot of parameters, here it focuses only on learning and development (L&D) activities. It then identifies and confirms the latent variables for learning, employee development & human Return on Investment (ROI) through reliable measurements. The outcome of the study recommends that the firm incorporate HR metrics to measure the effectiveness of employee development. This can minimize firms' operation costs and increase revenue per employee. This proposed business model can not only upgrade employee knowledge, skills, and abilities to make better decisions but also ensure ROI.

1.2 Objectives of the study

1. To understand the significance of HR analytics in L&D.
2. To understand the significance of HR analytics in employee development.
3. To identify the relationship between HR analytics and human Return on Investment (ROI).

2 Literature Review

Human Resource Management International Digest (2017) defines HR analytics as the systematic identification and quantification of personnel practices to make better decisions for business outcomes [1]. As of now, HR analytics literature has mostly focused on several areas; limitations, and challenges facing HR analytics development (Boudreau & Casio, 2017; Huselid, 2018; Jeske & Calvard, 2020), how to develop and utilize HR analytics (Green, 2017), and the significance and effect of analytical skills (Mc Cartney, et al, 2020)[2-6]. Now, it concentrates on the enhancement of roles and the overall contribution of HR throughout the firm (Bradley, 2017)[7]. Although these favorable conditions exist, HR analytics in the UAE is still in its infancy. Due to such a context, firms are trying to maximize the use of HR analytics, but there is insufficient data to describe HR managers' approaches to HR analytics within the region (CIPD, 2015)[8]. Spahic (2015) argues that private enterprises rely more on analytics to predict future employee training needs. In light of this, the study explores the need for HR analytics in measuring L&D and employee development, their working process, outcomes, and recommendations for its development[9].

HR analytics offers great potential for organizations in the UAE, but two challenges stand in the way: there are few HR analytics experts capable of implementing HR insights processes, and the IT infrastructure required for efficient collection and

analysis of high-quality data is lacking. Hence, the study tries to fill the gap between the approaches and incorporation of HR analytics to demonstrate the ROI. It has also been noted that small businesses are reluctant to adopt HR tools because they fear metrics and are uncomfortable with the level of statistics used in HR analytics (Vargas, 2015; Rafter, 2013)[10-11]. Additionally, this study refers to two cases, Pricewaterhouse Coopers and Frito-Lay case study, for the effectiveness of HR analytics in L&D practices. As this is a medium firm, this research proposal can be considered and developed in the future in all HR best practices to demonstrate the ROI.

2.1 Linking HR analytics and L&D

Coolen and IJselstein (2015), highlight that HR analytics is not statistics and measurements but the provision of data on understanding the business challenges and HR perspectives, such as training needs[12]. Research conducted by Best Practice Institute found that 82% of HR executives utilize analytics to determine how to develop their top talents. Around 80% of companies use analytics to determine the characteristics of leaders that demonstrate or predict their effectiveness. In a survey of HR professionals, 73% said they wanted to retain employees based on their future contributions (Carter, 2020)[13]. Thus, it can create a high-involvement work system (Ruparel et al., 2020)[14].

2.2 HR Analytics and Employee Development

Companies analyze HR analytics reports and use the data to predict the future needs of their organizations, including employee development needs (Fitz-enz & Mattox, 2014)[15]. Several studies on HR analytics highlight its impacts as improved human capital management (Mihalcea, 2017), increased employee productivity (Sharma & Sharma, 2017), enhanced workplace learning (Giacumo & Breman, 2016), and a higher return on human capital investment (Mihalcea, 2017)[16-18]. These can enhance career opportunities and less turnover. When employees' performances are evaluated, strategies can be designed to improve the KSAs of each employee. The study utilizes the 'labor markets' model to find external labor market and career issues, and business model issues to retain employees through employee engagement. Thus, it allows a correlation of the significance of HR analytics in L&D in employee engagement (Levenson et al., 2005)[19].

2.3 HR Analytics and ROI

By relying on analyzable data, HR can make a meaningful contribution to the generation of better decisions. Spahic (2015) argues that by overlooking past mistakes and instead focusing on predictive analytics, HR can be able to overcome past failures, avoid repeating them in the future, predict future outcomes, and formulate organization-wide development strategies. Therefore, HR analytics helps

a business to transform regular descriptive information and numbers into meaningful outcomes (Sharma & Sharma, 2017).

2.4 Formulation of Hypotheses

Evaluation of employee performance identifies the strengths and weaknesses of individual employees, accordingly, measures can be taken to improve the skills and abilities of each employee. This improves the competency level. The research utilizes the ‘Capability-Opportunity-Motivation’ (COM) model to link with the L&D to identify the variables that impact employee performances individually and in group roles (Blumberg and Pringle, 1982; Boudreau et al., 2003)[20-21]. It is important to quantify the ROI in L&D to achieve strategic objectives. This enhances a shared culture and creates values for the firm. Thus, the first hypothesis is,

H1: HR analytics has a significant role in employee L&D.

A study of Fortune 100 annual reports found that 14% of reports contained at least one quantitative measure (turnover rate, investment in training, percentage of pay that is variable, employee attitude survey) of HR management (General Electric annual report, 2005) that can create value to the organizations in its profitability (evidence-based platform)[22]. This allows the executives to make better decisions in compensation, improve operations by considering external factors in job design, and boost productivity through personal & professional development (Schneider, 2006)[23]. Even though HR analytics literature has advanced; on how HR analytics can improve organizational performance (Margherita, 2020), research on how HR analytics impacts, and influences, performance remains scarce (Huselid, 1995). Moreover, Schuler (2015) highlights its impact on creativity[24-26]. The next hypothesis is,

H2: HR analytics has a significant role in employee development.

HR analytics helps to produce evidence in the form of organizational facts, allowing managers with actionable insights that can be utilized as evidence in decision-making. These are long-term rather than short-term plans. Likewise, when insights derived from HR analytics are deployed for making decisions, coupled with other sources of evidence, it enhances organizational performance (Minbaeva, 2018)[27]. The dilemma here is whether it helps to communicate revised policies & strategies to the top management. The ‘organization design model’ assists in linking work and management processes, structure, rewards, and people while crafting a strategy (Galbraith, 1977)[28]. This raises another question of whether the employees are aware of the mission, the impact of performance management, & reward strategies. Thus, the third hypothesis crafted is,

H3: HR analytics plays a valuable role in ROI.

The below conceptual model illustrates the research questions based on the detailed literature review (Figure 1).

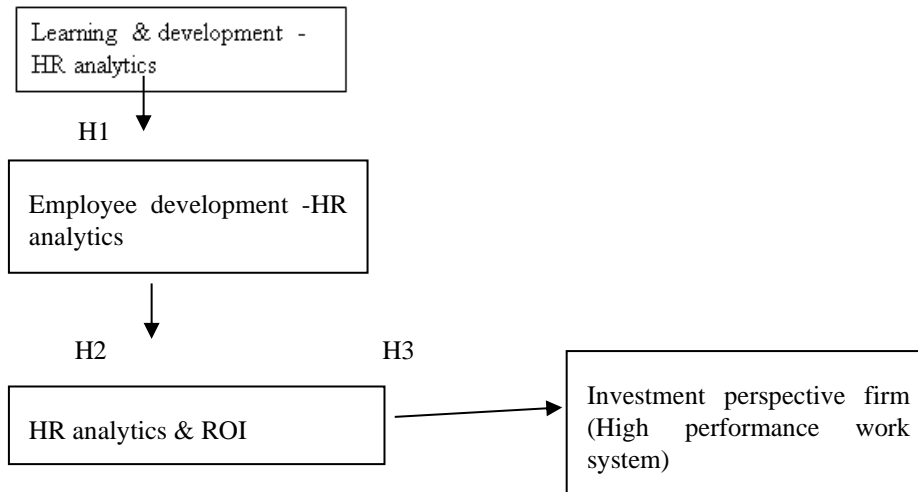


Figure 1.
Conceptual model for the study

3 Methodology

The methodology outlines the researcher's approach to ensuring reliable, valid results that address the objectives. Also, the Gantt chart assists in systematically planning the research and properly distributing the resources (Appendix I).

3.1 Data collection methods: Primary data and Secondary data

To ensure the wide applicability of results, the study tested the hypotheses on a sample of employees from a UAE-based University. The primary research method involves gathering original data tailored to the specific research question (Gratton & Jones, 2010)[29]. A questionnaire was self-developed, and 'closed' in form, based on a five-point Likert scale (1-absolutely agree to 5- disagree) (Likert, 1932) as the model of rating utilized for primary data collection[30]. This tool was developed by Cronbach in 1951, to measure the reliability of the data and tests to see if multiple-question Likert scale surveys are reliable. Additionally, interviews and interactions were done. Demographic factors were included at the beginning of the questionnaire, followed by above mentioned independent variables. Typically, secondary research involves synthesizing data and literature organized and published by others. The researcher conducts a pilot study before the secondary

research to familiarize with the topic. Various determinants of L&D, its alignment to HR analytics, and finally, the need to integrate HR analytics for human ROI were identified from various sources such as published books, peer-reviewed journals, government, and non-governmental/professional bodies and these served as secondary data (Boundarouk et al., 2017)[31]. The questionnaire has been attached as Appendix II for the identified variables and items. Moreover, the results of the demographic characteristics show that the survey contains 65 males (56.0%) and 51 females (43%) with a major share of the age group between 46 years and 55 years (45.7%)); having an experience of 10-20 years with a share of 47.4%. Also, a lion's share of respondents (56.9%) were PG or other professionals (Appendix III).

3.2 Justification of Research Methods

As the University is a growing education sector and the management is keen on expanding the academic programs and for employee retention, this type of survey is appropriate to collect information from the employees. Accordingly, the questionnaire consists of 14 questions, grouped into 3 categories, distributed to a diverse population in two rounds according to their flexibility in filling out the questions. The sampling method was stratified proportional to get a wider response from different groups of individuals. This quantitative approach assists in getting information from a large group of people within a short period. Out of 150 questionnaires, 120 were returned, and 4 of them were eliminated due to a lack of missing information. Hence, 74.7% of the total number of distributed questionnaires can be regarded as representative of the population where the study was conducted. This approach aids in choosing appropriate statistical tools, which in turn assists in providing straightforward findings and interpreting the data with less error and subjectivity. The reliability can be rechecked and less open to arguments.

Moreover, interaction with the employees provides insight into employees' experiences, feelings, and perceptions of L&D factors, and the importance of HR analytics to design, test, or improve systems or to increase employee performance. Observation aids in measuring and recording quantitative or qualitative data. By using this method, knowledge can be gained without the bias that can occasionally be present in interviews. This approach maintains flexibility as new ideas or patterns emerge, and a process in data collection and analysis can adjust. It is not rigidly predetermined at the beginning.

On the other hand, secondary data facilitates the collection of primary data in a more specific manner and helps to identify the gaps and deficiencies that need to be filled and what additional information needs to be gathered. This is more economical with less effort and saves time. The sources aid in developing hypotheses by understanding the variables in a better way and thus it evaluates the cost of primary research. Both quantitative (relates to generalizing the research findings) and qualitative research (pursues an understanding of the reality of a phenomenon) methods assist in developing a better business model. Therefore, the research

methods form a triangulation as it uses more than one data collection method, leading to the development of different databases. This assists in getting the results with the same conclusions, then the methods help to validate each other (Brender, 2006)[32].

After the great recession period of 2008, most organizations recognized the necessity of accurate evidence-based people-management practices which involve analytics, decision-making, and problem-solving (Reddy and Lakshmikeerthi, 2017)[33]. Hence, the study peeps into a business model and how it impacts the implementation of HR analytics; and perspectives on how it adds value at different stages in the business model.

3.3 Ethical issues

To design an ethically sound research project, participants, the researcher, the wider community, and the institution all need to be considered. The present study refers to the American Psychological Association (APA) Ethics Code to get acquainted with ethical practices while doing qualitative research (APA, 2017)[34]. Additionally, ethical research needs to have 'informed consent' (Denzin & Lincoln, 2011)[35]. Firstly, the study was discussed with the concerned authority in the firm to avoid any harm to the firm and any other members. Secondly, the willingness of the respondents to participate in the survey was very difficult, so the researcher explained the relevance of their feedback, the intention of the research, how it will be used, and the possible issues if any. To have mutual understanding, trust, and participation, the researcher confirms to maintain confidentiality and anonymity, and there was no coercion for the response, considers critical awareness of the participants' own bias, and upholds the appropriate time for the participation. Thirdly, to avoid own biases with varied cultural groups, the researcher was highly approachable concerning the respondent's age, gender, race, religion, etc. Lastly, the results were carefully maintained to avoid plagiarism or research misconduct.

4 Analysis, Findings, and Discussion

This section explains the statistical tools, tests, and findings.

4.1 Data measurement

A one-way analysis of variance (ANOVA) was performed to assess the representativeness and identify differences between the valid sample and the deleted responses. Similar to this, a comparison of the survey and later interactive responses has been done to ascertain the representativeness of the sample (Wilcox et al., 1994).

Measurements

Learning and Development: To measure this, four variables were used (competency development, leadership, teamwork, and shared values). Respondents were asked to mark their perspectives according to a 5-point Likert scale. All one-dimensionality scales are being determined and Cronbach's coefficient α (Table 2) was used for the evaluation of internal consistency. These questions measure latent variables and inform the researcher how closely related a set of test items is as a group (Lavrakas, 2008). The values for this item were 0.82 i.e., > 0.7 , then it can be considered a priority (Nannally, 1978), and values > 0.60 are considered acceptable (Hair et al., 1998). While considering the subjective L&D data, several previously published studies examining HR analytics and L&D have used several self-reported performance measures (Coolen and IJselstein, 2015).

Employee development: To measure this, 5 items were developed (evidence-based platform, external factors for job design, personal & professional development, compensation through skill development, and degree of creativity) (Margherita, 2020; Huselid, 2018). Each item was evaluated on a Likert scale and the alpha value was 0.83.

HR analytics and ROI: Given that no valid scale has been developed to measure ROI, the study applies a theoretical framework (Galbraith, 1977) and adopts questions from established scales to reveal the theoretical definition (Sharma & Sharma, 2017). The dimensions were; the firm's mission, the use of new strategies & policies, long-term plans for employee investment, a performance management system, and a reward system (Spahic, 2015). The alpha value was 0.87.

Subsequently, the obtained data were processed and analyzed by statistical techniques of numerical indicators. First, descriptive statistics were utilized to understand the Mean and Standard Deviation. Then, the structural equation model (SEM) was developed using the software package AMOS. Additionally, Confirmatory Factor Analysis (CFA) was performed to examine whether the hypothetical model collected data adequately.

4.1.1 Data analysis

First, descriptive statistics were done to describe the central position of a frequency distribution for the data. Psychometric characteristics of the scale, including one-dimensionality, reliability, and validity were evaluated to confirm the conceptual model (Table 1).

Variables	Mean	Std.Dev.	Variables	Mean	Std. Dev	Variables	Mean	Std. Dev
Q1_1	3.7	0.89	Q2_1	4.1	0.81	Q3_1	3.9	0.89
Q1_2	3.6	0.88	Q2_2	4.0	0.87	Q3_2	3.8	0.88
Q1_3	3.9	0.90	Q2_3	3.9	0.98	Q3_3	3.2	0.98
Q1_4	4.2	0.91	Q2_4	4.1	0.81	Q3_4	3.2	0.98
			Q2_5	4.0	0.87			

Table 1.
Descriptive Statistics of Variables

It is evident from the table that the values for Std. Dev is <1 , so the items are good enough for further analysis. To examine interdependence within a large number of variables, CFA was done where a correlation matrix was tested. Also, the maximum likelihood method was used as a method of assessment. The obtained results are satisfying, indicating a proper fitting of the measuring model.

This means that the respondents have almost the same feelings on all variables. All these items can be incorporated into the firm's HR analytics to measure L&D activities (Spahic, 2015). The estimated measuring model by using CFA determines the variables are reliable, and shows that all factor loadings are important ($p < 0.5$). Structural relations have been tested, which indicates significant differences in factor loadings in the firm. This supports the view of Mc Cartney et al (2020) that HR analytics is the effect of analytical skills. It also highlights how to utilize HR analytics about employee L&D activities. A focus on these kinds of analyzable data can enable HR to make valuable contributions to better decision-making while selecting the latent variables for L&D. Thus, the firm can transform descriptive information and numbers into meaningful outcomes by using HR analytics (Sharma & Sharma, 2017).

Model	χ^2	df	χ^2/df	p	IFI	TLI	CFI	PNFI	AIC
					0.00	0.00	0.00	0.00	5271.660
					0.170				
Independence	5183	462	11.220	<0.0001					
14 -items	961.341	423	2.271	<0.0001	0.891	0.880	0.890	0.746	1127.341
					0.059				

Table 2.
Model fit Indices for CFA- HR analytics for L&D for ROI
Source: Data analysis

4.1.2. Hypotheses test

As a next step, the study analyses hypotheses, H1 to H3. The following Table 2 establishes the influence of HR analytics on latent variables. There is statistical significance to the factor loadings ($p > 0.5$). The provision of these kinds of data identifies an understanding of the business challenges and HR perspectives, such as learning needs. This enhances talent management in the firm (Coolen and IJsselstein, 2015). Moreover, the regression coefficient for dependent and independent variables in Table 3 proves that considering these factors in HR analytics has a significant impact on human ROI as the standardized direct effect is greater than the recommended value (0.4). Moreover, the values for reaching the significance level as p-value is < 0.001 and maintains the reliability (AVE values). This illustrates the processes in L&D activities and outcomes of ROI.

Construct		Nonstandard loadings	factor	T-values	Standard loadings	factor	Convergent validity	AVE	Cronbach alpha
									0.825
L&D	L&D4	1.000			0.723		0.541	0.590	
		0.981		12.513	0.753				
	L&D3	0.930		12.224	0.728				
	L&D2	1.036		13.101	0.766				
	L&D1								
ED	ED5	1.000			0.678		0.576	0.592	0.835
		1.120		13.812	0.786				
	ED4	1.172		14.567	0.842				
	ED3	0.867		13.012	0.667				
	ED2	0.778		12.121	0.765				
	ED1								
ROI	ROI5	1.000			0.867		0.556	0.661	0.876
		1.210		18.121	0.826				
	ROI4	1.131		16.278	0.823				
	ROI3	1.145		16.121	0.799				
	ROI2	1.115		17.765	0.785				
	ROI								

Table 3
CFA
Source: Data analysis

The above values confirmed the convergent validity that indicates the extent to which the indicators utilized for measuring a particular concept related to the study.

The share of explained variance indicators is higher than 0.5 (AVE>0.5). This shows that the latent variables selected for the study can be included in employees' learning and development activities, however, appropriate metrics are to be included while incorporating HR analytics to ensure the human ROI.

4.2 Interpretation of Findings

It is evident from the result that the study throws light on a new strategy development related to incorporating HR analytics through L&D activities at CUA. The findings explain the effective accomplishment of the objectives mentioned in the introduction part as the values of all latent variables reached their significance level. HR analytics in a firm aims to make human resource decisions with the organization's overall goals and performance (Bondarouk et al., 2017). Table 2 confirms the fitness of the selected model for the study. The values of the CFA (Table 3) prove the association of each attribute to latent variables such as the significance of HR analytics on L&D to ED and ROI in the firm as the values reach their recommended value. Moreover, Table 4 confirms the regression analysis and significance level of each latent variable in the selected organization as all the values are <0.001. It clarifies that the p-value for all the factors has a significance level (<0.001) and reliability of 0.60. The hypotheses test validates the relationship of each item to their respective latent variables (L&D, ED, and ROI).

Path	Regression coefficient	t	P-value	Variance explained	Average Extracted	Variance	Composite Reliability
High-involvement work systems → ROI	0.904	25.742	<0.001	81.8			
Career opportunities → ROI	0.979	39.171	<0.001	95.8			
High productivity → ROI	1.001	65.500	<0.001	100.2	91.12		0.60
Reduced turnover → ROI	0.945	30.725	<0.001	89.3			

Table 4.
Regression Coefficient – HR analytics on L&D –ROI
Source: Data analysis

This shows that the factor loadings have statistical relevance ($p>0.5$). Through this analytics, managers can produce evidence in the form of organizational facts, allowing them to make decisions based on actionable insights. HR analytics can

reduce past mistakes and focus on future implications with relevant employee development metrics. Hence, it proves that the integration of HR analytics to measure the L&D can ensure the ROI factors that are identified in Part I.

Conclusion

Despite the claimed significance of HR analytics, more studies are vital to investigate business challenges and HR perspectives, especially learning needs (Coolen and IJselstein (2015). This is evident from Table 3 as convergent validity and the average validity for L&D are 0.54 and 0.59 respectively. The study proves the significance of HR analytics in talent management, leadership development, and employee retention (Carter, 2020). The significance level of the hypothesis test shows the importance of the COM model (Blumberg and Pringle, 1982; Boudreau et al., 2003) in the firm. If there is any time constraint for an in-depth analysis, this model can serve as a map for checking whether the appropriate questions are considered for the driving behavior related to business performance.

The study is a roadmap for Huselid's (2018), research on how HR analytics impacts and influences employee performance. It strengthens the view that those companies which analyze HR analytics reports and data for job designing, career development, compensation, and creativity, can lead to employee development (Fitz-enz & Mattox, 2014). The alpha value confirms the internal consistency and CV as 0.57 and AVE as 0.59. Thus, the second hypothesis was accepted because the result proves the significance of incorporating the 'labor markets' model to evaluate the full set of options available to an organization related to increasing profitability (Levenson et al., 2005).

The values (AVE as 0.61 and composite reliability as 0.6) from Table 4 prove the need for variables for better decision-making toward ROI, which in turn leads to higher organizational performance (Minbaeva, 2018). Thus, the result confirms the significance of the 'organization design model' in that it can be applied to different groups of people in different roles, however, it gives more accuracy for similar roles (Galbraith, 1977). Thus, the third hypothesis was accepted.

The three models (COM, labor markets, and organization design) addressed in the study bridge the gap between theory and practical implications in HR analytics.

Recommendations

The present study addresses the methods for human ROI in firms by effective HR analytics on L&D. Also, the factors to be considered by the management in expanding their tactics in capturing the full potential of the workforce. For this, HR technology in the firm needs to develop to run the reports, create dashboards, develop simulations, monitor KPIs, and perform predictive analytics. It stresses the employment relationship and long-term commitment to creating intrinsic and extrinsic factors. The cost-benefit analysis includes an alignment of the firm's goals

and objectives, how this proposal fits with the organizational needs, and the extent to which it makes a change to the organizational members.

The performance for employee development can be measured by implementing balanced scorecards, dashboards, and predictive analysis. The scorecard translates the company's strategic objectives into a set of performance measures (Kaplan & Norton, 1992). It can motivate breakthrough improvements in critical areas such as product, process, customer, and market development. Thus, it balances the external measures like operating income and internal measures like new service development.

Also, needs to include the increase or decrease in revenue, productivity/organizational performance, turnover rate, enrollment of freshmen, etc. The benefits are knowing; the extent to which the University meets the expectations of shareholders (financial perspective), delighting the customers (customer perspective, preparedness for the future (learning and growth perspective), and ways of doing the right things (internal process perspective).

The models would boost the decision-making in competency development of the workforce because many more opportunities for applying advanced statistics to diagnose HR issues will emerge from applying good analytics more broadly. So, appropriate retention strategies must be incorporated into future research as long-term planning.

Also, University needs to: prepare and prioritize plans and budgets for HR analytics in L&D; evaluate the cost of achieving the same outcomes with different approaches; analyze the effects of learning interventions. The University IT department can develop an HR analytics system to measure the delivery cost, informal coaching intervention costs, cost of learners' time, incidence rate of participants, business benefits, and organizational development initiatives.

References

- [1] "HR analytics" (2017) Human Resource Management International Digest, 25(7), pp. 9–11. Available at: <https://doi.org/10.1108/hrmid-08-2017-0137>.
- [2] Boudreau, J. and Cascio, W. (2017), "Human capital analytics: why are we not there?", *Journal of Organizational Effectiveness: People and Performance*, 4(2), pp. 119-126, doi: <https://doi.org/10.1108/JOEPP-03-2016-0029>.
- [3] Huselid, M.A. (2018), "The science and practice of workforce analytics: introduction to the HRM special issue", *Human Resource Management*, 57(3), pp. 679-684, doi: <https://doi.org/10.1002/hrm.21916>.
- [4] Jeske, D. and Calvard, T. (2020), "Big data: lessons for employers and employees", *Employee Relations*, 42(1), pp. 248-261, doi: <https://doi.org/10.1108/ER-06-2018-0159>.

- [5] Green, D. (2017), “The best practices to excel at people analytics”, *Journal of Organizational Effectiveness: People and Performance*, 4(2), pp. 137-144, doi: <https://doi.org/10.1108/JOEPP-03-2017-0027> .
- [6] McCartney, S., Murphy, C. and McCarthy, J. (2020), “21st century HR: a competency model for the emerging role of HR Analysts”, *Personnel Review*, 50(6), pp. 1495-1513.
- [7] Bradley, S. L. (2017) An exploratory study of the role of the human resource information system professional. ProQuest Dissertations (Doctoral dissertation), 10635957.
- [8] CIPD (2015) https://www.cipd.ae/Images/evolution-of-hr-analytics-a-middle-east-perspective_tcm22-22426.pdf . 2015. Evolution of HR analytics: A Middle East perspective. [online] Available at: https://www.cipd.ae/Images/evolution-of-hr-analytics-a-middle-east-perspective_tcm22-22426.pdf [Accessed 4 April 2022].
- [9] Spahic, J. (2015). Exploring HR intelligence practices in Fortune 1000 and select global organizations. ProQuest Dissertations (Doctoral dissertation), 10010853. <https://doi.org/10.1108/MRR-04-2016-0084>
- [10] Vargas, R. (2015). Adoption factors impacting human resource analytics among human resource professionals. ProQuest Dissertations (Doctoral dissertation), 3716458.
- [11] Rafter, M. V. (2013). Companies making HR big data work. *Workforce Magazine*.
- [12] Coolen, P., & IJselstein, A. (2015, May 25). A practitioner’s view on HR analytics. Retrieved August 20, 2015, from www.linkedin.com/pulse/practitioners-view-hr-analytics-patrick-coolen?trk=prof-post
- [13] Carter, L. (2020) HR Data and Analytics: How can it make the world a difference? Available at: <https://blog.bestpracticeinstitute.org/hr-data-analytics-can-make-world-difference/> [Accessed 17 June 2022]
- [14] Rupal, N. (2020). The influence of online professional social media in human resourcemanagement: A systematic literature review.
- [15] Fitz-enz, J., & Mattox, J. R. (2014). Predictive analytics for human resources. Hoboken, NJ: Wiley. <https://doi.org/10.1002/9781118915042>
- [16] Mihalcea, A. D. (2017) “Employer branding and talent management in the digital age,” *Management Dynamics in the Knowledge Economy*, 5(2), pp. 289-306. <https://doi.org/10.25019/MDKE/5.2.07>
- [17] Sharma, A., and Sharma, T. (2017) “HR analytics and performance appraisal system,” *Management Research Review*, 40(6), pp. 684-697.

- [18] Giacumo, L. A., and Breman, J. (2016) "Emerging evidence on the use of big data and analytics in workplace learning," *The Quarterly Review of Distance Education*, 17(4), pp. 21-38.
- [19] Levenson, A., Lawler, E., and Boudreau, J. (2005) *Survey on HR analytics and HR Transformation: Feedback Report*, Center for Effective Organizations, University of Southern California.
- [20] Blumberg, M. and Pringle, C. (1982) "The Missing Opportunity in Organizational Research: Some Implications for a Theory of Work Performance," *Academy of Management Review*, 7(4), pp. 560-569.
- [21] Boudreau, J. et al. (2003) "On the interface between operations and Human Resources Management," *Manufacturing & Service Operations Management*, 5(3), pp. 179–202. Available at: <https://doi.org/10.1287/msom.5.3.179.16032>.
- [22] GE releases (2005) Annual Report; "go big" theme emphasizes strength of size and opportunities for Growth (no date) GE News. Available at: <https://www.ge.com/news/press-releases/ge-releases-2005-annual-report-go-big-theme-emphasizes-strength-size-and-0> (Accessed: May 4, 2022).
- [23] Schneider, C. (2006) *The New Human -Capital Metrics*. CFO Magazine, February 15, 2006. Available at <http://www.cro.com/printable/article.cfm/5491043> [Accessed 12 July 2022].
- [24] Margherita, A. (2020) "Human resources analytics: a systematization of research topics and directions for future research," *Human Resource Management Review*, Elsevier, No. November, p. 100795, DOI: <https://doi.org/10.1016/j.hrmr.2020.100795> .
- [25] Huselid, M.A. (1995) "The Impact of Human Resource Management Practices on Turnover, Productivity, and Corporate Financial Performance," *Academy of Management Journal*, 38(3), pp. 635-672.
- [26] Schuler, R.S. (2015) *The 5-C Framework for managing talent*. *Organizational Dynamics*, 44(1), pp. 47-56.
- [27] Minbaeva, D. (2018), "Building credible human capital analytics for organizational competitive advantage", *Human Resource Management*, 57(3), pp. 701-713, doi: <https://doi.org/10.1002/hrm.21848> .
- [28] Galbraith, J. (1977) *Organization Design*, Addison Wesley publishing company.
- [29] Gratton, C., & Jones, I. (2010). *Research methods for sports studies* (2nd ed.). Taylor & Francis. https://repository.stkipgetsempena.ac.id/bitstream/575/1/Research_Methods_for_Sports_Studies.pdf

- [30] Likert, R. (1932) "A technique for the Measurement of Attitudes," Archives of Psychology, 140: 1-55.
- [31] Bondarouk, T., Ruel, H., and Parry, E. (2017) Electronic HRM in the smart era. Emerald Group Publishing. <https://doi.org/10.1108/9781787143159>
- [32] Brender, J. (2006) Introduction to: Methodological and Methodical Perils and Pitfalls at Assessment. Handbook of Evaluation Methods for Health Informatics. Academic Press. <https://doi.org/10.1016/B978-012370464-1.50032-0>
- [33] Reddy, P.R. and Lakshmikeerthi, P. (2017) "HR Analytics - An Effective Evidence-Based HRM Tool," International Journal of Business and Management Invention, 6 (7), pp. 23-34.
- [34] APA (2017) Ethical principles of psychologists and code of conduct. [online] Available at: <<https://www.apa.org/ethics/code/index>> [Accessed 10 May 2022].
- [35] Denzin, N., and Lincoln, Y. (2011) The SAGE handbook of qualitative research. Thousand Oaks, CA: SAGE.
- [36] Wam (2021) UAE is no. 1 in Education, say three global indexes, Khaleej Times. Khaleej Times. Available at: <https://www.khaleejtimes.com/education/uae-is-no-1-in-education-say-three-global-indexes> (Accessed: December 4, 2022). <http://article.sapub.org/10.5923.j.hrmr.20211101.01.html>
- [37] <http://www.ijssrp.org/research-paper-0620/ijssrp-p10217>
- [38] 2020. (PDF) HR Analytics: A Literature Review and New Conceptual Model. Available from: https://www.researchgate.net/publication/341997548_HR_Analytics_A_Literature_Review_and_New_Conceptual_Model [Accessed Apr 02 2022].
- [39] Lavrakas, P. (2008) Encyclopedia of Survey Research Methods 1st Edition. SAGE.
- [40] Nunnally, J.C. (1978) Psychometric Theory, Second ed. McGraw-Hill, New York.
- [41] Foundation for Research on Equal Opportunity (2020) <https://freopp.org/united-arab-emirates-health-system-profile-22-in-the-world-index-of-healthcare-innovation-940c64d53df>
- [42] Hair, J.F, Black, W, C., Babin, B.J., and Anderson, R.E. (2010) Multivariate Data Analysis: A Global Perspective (7 th ed.), Pearson Education, Upper Saddle River.
- [43] "HR analytics" (2017) Human Resource Management International Digest, 25(7), pp. 9–11. Available at: <https://doi.org/10.1108/hrmid-08-2017-0137> (Accessed: May 4, 2022).

Appendix - II
Questionnaire

Kind attention: Please note your responses are highly appreciated. It is used exclusively for academic purposes and maintains all confidentiality.

Section I

Demographic factors

- 1. Gender: Male 2. Female

- 2. Age:

 - 1. 25 -35 2. 36-45 3. 46-55 4. >56

- 2. Qualification:

 - a. Post-graduation b. Other Professional courses c. Ph.D.

- 3. Experience:

 - a. Less than 5 years b. 5-10 years c. 11-15 years d. more than 15 years

Section II

Latent Variables	Related Factors	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Learning & Development (LD)	Q1. I have enough opportunities for my competencies through skill and knowledge development. Q2. I have opportunities to work with leaders, managers, and customers at my organization.					

ED & HR analytics (HRA)	Q3. I have opportunities to work in a team learning environment.	
	Q4. My firm provides a shared culture and values in my organization.	
	Q5. My firm has an evidence-based platform to track L&D.	
	Q6. My firm considers external factors in job design.	
	Q7. My firm considers personal & professional development through L&D.	
	Q8. My firm provides compensation with skill development.	
	Q9. My firm gives me an opportunity for creativity.	
	ROI	Q10. Do you have specific policies and strategies approved and well communicated

by the top
management?

Q11. I am
aware of the
firm's
mission.

Q12. My firm
has long-term
plans for
employee
investment.

Q13. My firm
motivates me
through
reward
systems.

Q14. My firm
maintains
good
performance
appraisal and
employee
development
methods.

Any other comments:

Thank you for your participation!

Appendix III
Demographic characteristics of the Sample

Mark	Control Variables	Category	Frequency	Share (%)
CV1	Gender	Male	65	56.0
		Female	51	43
CV2	Age	25-35	18	15.5
		36-45	42	36.2
		46-55	53	45.7
		>56	3	2.6
CV4	Qualification	Undergraduate	5	4.3
		PG & other professional programs	66	56.9
		Ph.D.	45	38.8
CV3	Experience	<5 years	12	10.3
		5-10	45	38.7
		11-15	55	47.4
		>15 years	21	18.1

The European Union's Course Towards Resilience as a Response to Rising Global Turbulence

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Abstract: The EU has been facing numerous challenges in the 21st century. The eastern enlargement resulted in widening of socio-economic inequalities. The global financial crisis 2008+ forced the EU to introduce instruments aiming at improving financial stability. The first migrant/refugee crisis of 2015-2016 proved the need for reforms in the area of EU immigration and asylum policy. Brexit disrupted internal political dynamics of the EU and ended the period of the EU gravitation power. The COVID-19 pandemic coupled with the Russian invasion on Ukraine did show that crises become more and more complex. Moreover the EU has to face climate change, AI revolution, energy crisis, demographic changes. Thus the EU has to rethink its response to current and future threats and challenges. The main objective is to identify changes in the EU's priorities in the 21st century. The parallel goal is to study the EU's actions and mechanisms aiming at building resilience and to critically evaluate potential problems connected with practical implementation of the EU's course towards resilience.

Keywords: European Union, resilience, crisis

1 Introduction

The European Union (EU) has been facing numerous threats and challenges since the beginning of the 21st century. Some of them are internal, others result from external factors and are strongly connected with the growing turbulence of the global environment. Scientists and politicians point to a future world battered by intersecting crises, in which rising volatility and depleted resilience boost the odds of simultaneous shocks [27]. Rising instability creates the urgent need for actions directed towards resilience creation and strengthening. The paper objective is to identify main challenges and threats for the EU in the 21st century and to analyse the evolution of the EU's priorities as a result of the aforementioned problems. The parallel objective is to study the process of resilience promotion in the EU with focus on areas, mechanisms and actions, as well as problems connected with

practical implementation of the EU's course towards resilience. The following research questions were formulated:

- RQ1: What was the evolution of the EU's priorities in the 21st century?
- RQ2: What has been done so far to increase the EU's resilience?
- RQ3: What limits the EU's resilience?

The research tools used in the article include literature studies, descriptive analysis and critical analysis.

2 Challenges and threats for the European Union in the 21st century

The twenty-first century history of the European Union is full of problems and crises that require taking appropriate actions, changing integration accents and creating new solutions in order to face challenges [45].

In the very beginning of the 21st century terrorism became a global problem. Terrorist attacks of September 11, 2001 had a profound and lasting impact not only on the USA, but also on many other economies, including the EU. They instigated the multi-decade global war on terror. The EU countries have also been impacted by terrorism. Numerous terrorist attacks occurred in many EU countries (e.g. Madrid train bombings in March 2004, Paris attacks in November 2015, Nice truck attack in July 2016, London bombings in July 2005¹⁰, Brussels attacks in March 2016) [40].

The eastern enlargement itself created a huge challenge for the EU. Accepting ten relatively low-developed economies in 2004, two more in 2007 and yet another one in 2013 resulted in considerable widening of socio-economic inequalities in the EU [42]. Additionally it also posed challenges for the EU budget, Common Agricultural Policy, EU Policy of Economic, Social and Territorial Cohesion, as well as the EU labour market. Moreover, the eastern enlargement forced a gradual reform of EU institutions [37].

Because of the interconnectedness of the economy and the financial sector the crisis which started in 2008 in the United States became a global one and was rapidly transferred to the EU. The EU faced the great recession in the years 2008-2009 and later, after a short recovery, several EU Member States experienced sovereign debt crisis. The combined crises had huge negative consequences for economic growth, investment, employment and the fiscal position of many EU Member States. Therefore, the EU was forced to introduce instruments aiming at improving financial and fiscal stability [41].

¹⁰ The UK was an EU Member State till January 31, 2020, therefore it is included here.

In 2015-2016 the EU experienced the 1st migrant / refugee crisis. In 2015 alone over 1.3 million people came to the EU mostly from Syria, but significant numbers also from Afghanistan, Nigeria, Pakistan, Eritrea, Iraq and the Balkans. Such an increased influx of refugees and illegal immigrants into the EU was another challenge for the EU, and in particular for the common asylum and immigration policy. The European Commission attempted to enact some measures to address the problem, however with poor results due to huge differences of attitude of individual EU Member States [30].

Brexit referendum in 2016 [26] and official notification of the UK's will to withdraw from the EU followed by "divorce deal" negotiations and the UK's final withdrawal from the EU institutional framework in February 2020 and from the Single European Market in January 2021 ended the period of strong gravitation of the EU and disrupted internal political dynamics of the EU [29]. As a result of Brexit the EU's demographic, economic, financial, political and military potentials were considerably reduced. Moreover, the EU had to undertake actions to prevent further exits. It also had to reform common policies. Restoring the EU's image and position in the globalised economy was another challenge [8].

In February 2020 most experts considered Brexit the most important issue for the EU in 2020. On March 11, 2020, however, the World Health Organization (WHO) declared the novel coronavirus COVID-19 outbreak a global pandemic [6]. The Covid-19 pandemic impacted the EU and its Member States in many areas and aspects, including healthcare and economic systems, public health threat, challenges for coordination of economic policy, structural challenges, as well as risk of increased economic divergence [9].

Russia's military aggression against Ukraine in February 2022 did show that crises become more and more complex. It resulted in increased geopolitical instability, energy crisis, new wave of immigration to the EU, changes in geographical pattern of international trade and international transfer of capital in the form of FDI [13].

Energy crisis of 2022 stressed the urgent need for significant reform of the EU energy policy [36].

Demographic changes experienced by most EU Member States, including population ageing, shrinking working-age population and labour shortages constitute yet another pressing challenge for the EU in the 21st century [12].

In addition to the above mentioned challenges and threats, the EU has to respond to numerous global challenges of the 21st century, in that:

- Climate change (develop new climate goals, introduce considerable changes in the EU environmental policy) [44];
- AI revolution and its revolutionary impact on economy, society, education accompanied by the emergence of new risks and the need to adapt to an AI driven economy of tomorrow [25].

3 Evolution of the European Union's priorities in the 21st century

The EU attempts to respond appropriately to the internal and external challenges. Hence, it introduces strategies which include new elements reflecting new goals. One can observe a process of evolution of the EU's priorities.

The Lisbon Strategy adopted in 2000 for the years 2000-2010 aimed at transforming the EU into the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion [24]. It seems to be the most optimistic of all the strategies adopted by the EU for the 21st century. Unfortunately the Lisbon Strategy's goals had not been achieved by 2010.

The next strategy was introduced in 2010. It was called *Europe 2020 Strategy* and covered the period 2010-2020. It did reflect new realities after the global financial crisis 2008+. Three priorities were formulated in the Europe 2020 Strategy, namely [11]:

- Smart growth, i.e. developing an economy based on research and innovation;
- Sustainable growth, i.e. promoting a more ecological, greener and resource efficient economy;
- Inclusive growth, i.e. supporting high employment, fostering social inclusion and territorial cohesion.

The outbreak of the COVID-19 pandemic forced the EU to rethink its goals and priorities. *A Roadmap for recovery. Towards a more resilient, sustainable and fair Europe* was adopted in April 2020. It stressed the significance of [3]:

- Restored and deepened Single European Market in order to achieve resilience and prosperity;
- Strategic autonomy of the EU which should be obtained through dynamic industrial policy, support for small and medium enterprises, effective screening of foreign direct investment (FDI);
- Green transition and Digital transformation which should play a vital role in relaunching and modernising the EU economy.

The openscale military aggression of the Russian Federation against Ukraine in February 2022 resulted in the approval of *Strategic Compass for Security and Defence* by the Council of the EU. Strengthening the EU's security and defence policy, embracing four pillars [5]:

- Acting more quickly and decisively when facing crises;
- Securing citizens against fast changing threats;
- Investing in necessary technologies and capabilities;
- Partnering with others to achieve common goals.

In 2023 the Spanish Presidency of the Council of the EU introduced *Resilient EU 2030. A future-oriented approach to reinforce the EU's Open Strategic Autonomy and Global Leadership* [39]. *Resilient EU 2030* consists of nine lines of action within 3 priority areas, namely [38]:

- A. Bolstering and securing internal production capacities:
 - Fostering domestic production of key goods, services and raw materials,
 - Monitoring foreign ownership and control over strategic sectors,
 - Setting contingency plans to respond to future shortages,
- B. Enhancing circularity and smart consumption:
 - Increasing resource efficiency,
 - Fostering circularity in the economy and society,
 - Replacing raw materials and components by more accessible alternative,
- C. Reinvigorating global trade and the multilateral system:
 - Launching a new trade expansion,
 - Rebalancing economic relations with China,
 - Leading the renovation of the multilateral architecture.

4 Resilience promotion in the European Union

4.1 Resilience – a new motto of the European Union. Areas to consider while promoting resilience

Resilience is “*the ability not only to withstand and cope with challenges but also to undergo transitions in a sustainable, fair and democratic manner*” [17]. The EU has to be ready to face crises of various nature. Future crises can be more complex, multi-faceted and hybrid. Future crises can result in cascading effects. They can occur simultaneously.

Multidimensional approach to resilience promotion and resilience creation in the EU must be applied [4]. The following areas should be taken into consideration while promoting resilience in the EU and of the EU and its Member States:

- Health security and health care systems;
- Food security;
- Energy security and energy sector;
- Financial sector and financial institutions stability;
- IT systems;
- Military security;
- Critical infrastructure;
- Circularity and smart consumption;
- Bolstering and securing production capacities;
- Economy (in a broad sense);

- Society;
- Institutions (at the EU level and at the level of EU Member States – national, regional, local).

4.2 Examples of mechanisms and actions aiming at strengthening the European Union’s resilience

The significance of resilience has been reflected in the EU’s activity. The following steps should be mentioned here:

- Crisis Coordination Arrangements (CCA) adopted by the Council in 2006 [28];
- Integrated Political Crisis Response (IPCR) creation in 2013 – the 1st step towards cohesive decision-making at the EU level in response to cross-sectoral crisis events [7];
- Codifying the IPCR into a legal act in 2018 [22];
- Council conclusions on enhancing preparedness, response capability and resilience to future crises, adopted at the General Affairs Council on November 23, 2021 (taking into consideration the first lessons from the pandemic crisis) [23].

The EU adopted numerous mechanisms and actions aiming at building resilience. Crisis response mechanisms in the EU include the following:

- The EU Civil Protection Mechanism (embracing: The Emergency Response Coordination Center and The European Civil Protection Pool);
- Crisis coordination in the Council (which can be triggered by the Presidency and can result from the invocation of the solidarity clause by a Member State) [15];
- European Union Solidarity Fund (financial instrument that helps to respond to major natural disaster) [18];
- Resilience and Values target within MFF 2021-2027 (amounting to around EUR 47 billion at 2020 prices) [32];
- Recovery and Resilience Facility within NGEU (i.e. temporary instrument planned for 2021-2026) [21];
- Preparedness for future health emergencies (new regulation on serious cross-border threats to health, revised mandates for the European Centre for Disease Prevention and Control (ECDC) and for the European Medicines Agency (EMA), emergency framework regarding medical countermeasures, as well as The Health Emergency Preparedness and Response Authority - HERA) [19];
- European Food Security Crisis Preparedness and Response Mechanism (EFSCM) [14];
- Single Market Emergency Mechanism - SMEM planned in 2024 (SMEM is supposed to bolster the internal market in times of crisis by facilitating

- the movement of goods, services and persons, monitoring supply chains, ensuring access to critical goods) [20];
- Protection of Network and Information Systems (The directive on the security of network and information systems (NIS) of 2016 and a revised NIS directive of 2022 aiming at ensuring stronger risk and incident management and cooperation, as well as widening the scope of rules) [10];
- Protection of Critical Infrastructure (New directive introduced in 2022 aiming at reduction of vulnerabilities and strengthening the physical resilience of critical entities; the Directive covers critical entities in a number of sectors, such as energy, transport, health, drinking water, waste water and space) [16];
- IT Security of Financial Sector (Digital Operational Resilience Act – DORA, introducing uniform requirements for the security of network and information systems of companies and organisations operating in the financial sector, as well as critical third parties which provide ICT related services to them; DORA can be seen as a framework that boosts the IT security of the financial sector, preventing and mitigating cyber threats) [43].

4.3 Problems connected with practical implementation of the EU's course towards resilience

Practical implementation of the EU's course towards resilience is not easy. A number of problems can be listed. Some of them have national character, others result from international and global factors. The following obstacles for quick achievement of true resilience of the EU can be listed:

- Overlapping crises and threats [35],
- Differences in perception of threats,
- Differences in perception of integration processes [33],
- Infrastructure shortages and poor quality of infrastructure,
- Limited financial means,
- Limited skills and innovation [34],
- Brain drain and talents exodus [2],
- Dependence on imported technology and goods [1],
- Spy technology [31],
- Limited flexibility of the EU institutions, EU programmes, EU mechanisms and actions.

The final result will not depend on the decisions taken by the EU institutions alone and mechanisms implemented on the EU level only. It is of vital importance to develop real involvement of all EU Member States at national, regional and local levels.

Conclusion

When Poland and other Central European countries applied for European Union membership in the 1990s, the EU was perceived as a rich club. Since the beginning of the 21st century, however, the EU has had to face numerous threats, crises and challenges. Threats become more and more complex. Cascading crises pose direct and indirect short-term and long-term consequences. Challenges get multidimensional. The EU has to stay vigilant. It must respond appropriately to emerging current and future threats, crises and challenges.

The EU should:

- increase internal production in order to achieve autonomy;
- increase innovativeness (through talents, skills and infrastructure);
- promote further integration (e.g. in the areas of digital services, AI, energy union, health care);
- promote and lead reform of the multilateral system as an effective means of mitigating its weaknesses abroad and defending its interests globally.

Resilience seems to be a precondition for preventing the decline of the EU's position in the World. Only a more resilient EU will be capable of keeping and increasing its participation and leadership in a turbulent and changing world.

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References

- [1] Bauer Matthias, du Roy Oskar, Sharma Vanika: A Forward-Thinking Approach to Open Strategic Autonomy: Navigating EU Trade Dependencies and Risk Mitigation, European Centre for International Political Economy. Policy Brief 2023, 13, 50 pp.
- [2] Bezombes Hugo: Europe's Talent Exodus, IntoEurope, March 21, 2024, <https://intoeurope.eu/blog/europe-brain-drain-ncmmh> , (accessed: May 12, 2024).
- [3] CONSILIUM EUROPA: A Roadmap for Recovery. Towards a more resilient, sustainable and fair Europe, Brussels 2020, <https://www.consilium.europa.eu/media/43384/roadmap-for-recovery-final-21-04-2020.pdf> , (accessed: 10.05.2020).

- [4] CONSILIIUM EUROPA: How the EU responds to crises and builds resilience, <https://www.consilium.europa.eu/en/policies/eu-crisis-response-resilience/> , (accessed: April 10, 2024).
- [5] COUNCIL OF THE EUROPEAN UNION: A Strategic Compass for Security and Defence. For a European Union that protects its citizens, values and interests and contributes to international peace and security. Brussels, March 21, 2022. <https://data.consilium.europa.eu/doc/document/ST-7371-2022-INIT/en/pdf> , (accessed: April 10, 2022).
- [6] Cucinotta Domenico, Vanelli Maurizio: WHO Declares COVID-19 a Pandemic, *Acta Biomed*, 2020, 91(1), pp. 157-160. <https://pubmed.ncbi.nlm.nih.gov/32191675/> , (accessed: May 2, 2024).
- [7] Day Jonathan: What is the Crisis Response Mechanism and How Does it Work? , *Liberties*, July 8, 2022, <https://www.liberties.eu/en/stories/crisis-response-mechanism/44370> , (accessed: July 10, 2022).
- [8] De Grauwe Paul: What Future for the EU after Brexit? , *Intereconomics. Review of European Economic Policy*, 51(5), 2016, pp. 249-251. <https://www.intereconomics.eu/contents/year/2016/number/5/article/what-future-for-the-eu-after-brex.html> , (accessed: 15.04.2024).
- [9] DESTATIS: EU – Monitor COVID-19, June 2023, <https://www.destatis.de/Europa/EN/Topic/COVID-19/COVID-19-article.html> , (accessed: May 12, 2024).
- [10] EUR-LEX: Cybersecurity of network and information systems (2022), <https://eur-lex.europa.eu/EN/legal-content/summary/cybersecurity-of-network-and-information-systems-2022.html> , (accessed: April 18, 2024).
- [11] EUROPEAN COMMISSION: Communication from the Commission. Europe 2020. A Strategy for Smart, Sustainable and Inclusive Growth, Brussels, March 3, 2010 COM(2010) 2020, 32 pp.
- [12] EUROPEAN COMMISSION: Demographic Change in Europe. Report, Flash Eurobarometer 534, September 2023, 53 pp.
- [13] EUROPEAN COMMISSION, Directorate-General for Communication: EU challenges and priorities in the context of the war in Ukraine – Summary, Publications Office of the European Union, 2023, <https://data.europa.eu/doi/10.2775/915171> , (accessed: January 1, 2024).
- [14] EUROPEAN COMMISSION: Ensuring global food supply and food security, https://agriculture.ec.europa.eu/common-agricultural-policy/agri-food-supply-chain/ensuring-global-food-supply-and-food-security_en , (accessed: May 13, 2024).

- [15] EUROPEAN COMMISSION: EU Civil Protection Mechanism, https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/eu-civil-protection-mechanism_en , (accessed: May 10, 2024).
- [16] EUROPEAN COMMISSION. EU SCIENCE HUB: Critical infrastructure protection, https://joint-research-centre.ec.europa.eu/scientific-activities-z/critical-infrastructure-protection_en , (accessed: May 13, 2024).
- [17] EUROPEAN COMMISSION. EU SCIENCE HUB: Resilience, https://joint-research-centre.ec.europa.eu/scientific-activities-z/resilience_en , (accessed: April 10, 2024).
- [18] EUROPEAN COMMISSION: EU Solidarity Fund, https://ec.europa.eu/regional_policy/funding/solidarity-fund_en , (accessed: May 5, 2024).
- [19] EUROPEAN COMMISSION: Health Emergency Preparedness and Response Authority, https://commission.europa.eu/about-european-commission/departments-and-executive-agencies/health-emergency-preparedness-and-response-authority_en , (accessed: May 13, 2024).
- [20] EUROPEAN COMMISSION: Single market emergency instrument, https://single-market-economy.ec.europa.eu/single-market/single-market-emergency-instrument_en , (accessed: April 15, 2024).
- [21] EUROPEAN COMMISSION: The Recovery and Resilience Facility, https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility_en , (accessed: June 10, 2022).
- [22] EUROPEAN COUNCIL. COUNCIL OF THE EUROPEAN UNION: How the Council coordinates the EU response to crises, <https://www.consilium.europa.eu/en/policies/ipcr-response-to-crises/> , (accessed: May 13, 2024).
- [23] EUROPEAN COUNCIL. COUNCIL OF THE EUROPEAN UNION: The Council adopted conclusions on resilience and crisis response, November 23, 2021, <https://www.consilium.europa.eu/en/press/press-releases/2021/11/23/the-council-adopted-conclusions-on-resilience-and-crisis-response/> / , (accessed: June 20, 2023).
- [24] EUROPEAN COUNCIL: Lisbon European Council 23 and 24 March 2000. Presidency Conclusions. https://www.europarl.europa.eu/summits/lis1_en.htm , (accessed: 5.05.2015).
- [25] ETF: The AI revolution is underway. It will affect everyone. Policymakers must make the right decisions now to safeguard our future, European Training Foundation, February 22, 2024, <https://www.etf.europa.eu/en/news-and-events/news/ai-revolution->

- [underway-it-will-affect-everyone-policymakers-must-make-right](#) , (accessed: May 12, 2024).
- [26] Hanrahan David, Welfens Paul J. J.: The Brexit Dynamics: British and EU27 Challenges After the EU Referendum, *Intereconomics. Review of European Economic Policy*, 52(5), 2017, pp. 302-307, <https://www.intereconomics.eu/contents/year/2017/number/5/article/the-brex-it-dynamics-british-and-eu27-challenges-after-the-eu-referendum.html> , (accessed: April 20, 2024).
- [27] Horowitz Julia: Global experts worry simultaneous crises could become the new norm, *CNN Business*, January 11, 2023, <https://edition.cnn.com/2023/01/11/business/world-economic-forum-global-risks/index.htm> 1, (accessed: May 12, 2024).
- [28] Larsson Per, Olsson Stefan: The Crisis Coordination Arrangements (CCA). In: Olsson Stefan (ed.) *Crisis Management in the European Union*. Springer, Berlin, Heidelberg, 2009, pp. 127-138.
- [29] Pawlas Iwona: Brexit as a Challenge for the European Union, *Horyzonty Polityki*, 7(20), 2016, pp. 57-76.
- [30] Pawlas Iwona: Migrant/Refugee Crisis as a Challenge for the European Union, in: 11th International Scientific Conference *Secure Slovakia and the European Union*. Reviewed conference proceedings, ed. Martina Vackova. Kosice, Vysoka skola bezpecnostneho manazerstva v Kosiciach, 2017. pp 459-472.
- [31] Roussi Antoaneta: How Europe became the Wild West of spyware, *Politico*, October 25, 2023, <https://www.politico.eu/article/how-europe-became-wild-west-spyware/> , (accessed: May 12, 2024).
- [32] Sapała Magdalena: Cohesion, resilience and values Heading 2 of the 2021-2027 MFF, *European Parliamentary Research Service, European Parliament Briefing*, April 2021, [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690542/EPRS_BRI\(2021\)690542_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690542/EPRS_BRI(2021)690542_EN.pdf) , (accessed: May 10, 2021).
- [33] Schimmelfennig Frank, Leuffen Dirk, De Vries Catherine E.: Differentiated integration in the European Union: Institutional effects, public opinion, and alternative flexibility arrangements, *European Union Studies*, 24(1), 2022, <https://journals.sagepub.com/doi/10.1177/14651165221119083> , (accessed: May 12, 2024).
- [34] SCIENCE BUSINESS: Deep Tech: Europe's new wave of innovation? Brussels, April 24, 2024. <https://sciencebusiness.net/events/deep-tech-europes-new-wave-innovation> , (accessed: May 11, 2024).

- [35] SDG IISD: World Bank, IMF Discuss Ways to Respond to Global Crises, Shared Challenges, April 19, 2023, <https://sdg.iisd.org/news/world-bank-imf-discuss-ways-to-respond-to-global-crises-shared-challenges/>, (accessed: May 12, 2024).
- [36] Simon Frederic: EU economy still grappling with long tail of 2022 energy shock, EURACTIV, January 17, 2024. <https://www.euractiv.com/section/energy/news/eu-economy-still-grappling-with-long-tail-of-2022-energy-shock/>, (accessed: January 25, 2024).
- [37] Skuhra Anselm (ed.): The Eastern Enlargement of the European Union. Efforts and Obstacles on the Way to Membership, Studien Verlag, Innsbruck – Wien, 2005, 284 pp.
- [38] Spain's National Office of Foresight and Strategy: Resilient EU2030. A future-oriented approach to reinforce the EU's. Open Strategic Autonomy and Global Leadership, 2023, <https://futuros.gob.es/sites/default/files/2023-09/RESILIENTEU2030.pdf>, (accessed: January 5, 2024).
- [39] Spanish Presidency of the Council of the EU: Resilient EU2030: a roadmap for strengthening the EU's resilience and competitiveness, <https://spanish-presidency.consilium.europa.eu/en/news/the-spanish-presidency-presents-resilient-eu2030-roadmap-to-boost-european-union-open-strategic-autonomy/>, (accessed: January 5, 2024).
- [40] STATISTA: Ten worst terrorist attacks in terms of fatalities in Europe from 1980 to 2022, <https://www.statista.com/statistics/541483/worst-incidences-of-terrorism-eu/>, (accessed: May 12, 2024).
- [41] Szczepański Marcin: A decade on from the crisis Main responses and remaining challenges, European Parliamentary Research Service, 2019, 9 pp.
- [42] Szczepkowska-Flis Agnieszka, Kozłowska Anna: Eastern enlargement: analysis of development processes in the EU15 in the context of creative destruction, *Economics and Law*, 20(3), September 2021, pp. 659-673.
- [43] The Digital Operational Resilience Act (DORA) - Regulation (EU) 2022/2554, <https://www.digital-operational-resilience-act.com>, (accessed: May 13, 2024).
- [44] Tosun Jale: The European Union's Climate and Environmental Policy in Times of Geopolitical Crisis, *Journal of Common Market Studies*, 2023, 61, Annual Review, pp. 147-156.
- [45] Troitino David Ramiro, Kerikmae Tanel, de la Guardia Ricardo Martin, Sanchez Guillermo A. Perez: *The EU in the 21st Century. Challenges and Opportunities for the European Integration Process*, Springer, Cham, 2020.

The impact of green banking practices on environmental, social and economic performance. The case of the albanian banking system.

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Abstract: As environmental degradation threatens our society, the need to create sustainable green banks is becoming increasingly urgent. The main objective of this paper is to identify the impact that the application of green banking has on the environmental, economic and social performance of banks. A questionnaire was completed by the employees of commercial banks in Albania. The employees were asked what impact the application of green practices has had on their bank. In total, 155 questionnaires were collected. The answers of the bank employees show a positive relationship between the application of green practices and economic, social and environmental performance. When banks develop and practice green banking, the impact on environmental protection is obvious. Green banking practices improve banks' compliance with environmental standards and significantly reduce banks' energy consumption and use of paper and other materials. Green banking practices have a positive impact on the bank's image, create better relationships with the community and stakeholders, and increase compliance with applicable social laws and regulations. Green banking practices also have a positive impact on improving the bank's bottom line,

significantly reducing the bank's operating expenses, and improving the efficiency of the bank's resource management.

Key words: Green banking, Environmental Performance, Social Performance, Economic Performance

1 Introduction

Green Banking is a concept that is used all over the world nowadays. The main goal is the prevention of environmental degradation. Green banking includes several aspects from their activity for the protection of the environment to how and where their money is invested (Shakil et al., 2014). The concept of Green Banking is a new development that focuses on banking operations and investments that protect the environment (Mathew, Green banking: an innovative initiative for sustainable financial development, 2021). According to Tara et al., (2015) green banking is considered a sustainable, environmentally friendly bank that protects the environment and encourages clients to take care of the environment. Banks contribute directly to sustainable development through internal processes such as reducing energy consumption, and paper use, and equal and fair treatment of employees. But they also contribute indirectly by performing their function as financial intermediaries. When banks decide to grant loans, they evaluate the economic, environmental, and social effects on individuals, institutions, organizations, or projects that require loans (Araci et al., 2016). Before deciding to finance a project, banks would have to analyze the impact of this project in the environment. Decisions regarding the adaptation of green products must be in accordance with the requests of the interested parties to give them satisfaction from the use of green counter products. This will lead to the successful implementation of green banking initiatives (Choudhury et al., 2013). Banks as financial intermediaries can create sustainability by offering loans with lower interest rates for clients who support environmental protection and higher interest rates for clients who do not protect the environment but damage it. This policy leads to a decrease in the profitability of banks, but it is a situation that does not last for a long time (Jeucken & Bouma, 1999). Banks have highly developed credit management systems. They give a higher price to loans with higher risk. Through price differentiation, banks can promote sustainability (Raluca, 2012). In addition, banks can improve their internal environmental performance. According to (Gulzar et al., 2024) which analyzed the impact of green investments on environmental performance. Through a questionnaire addressed to 500 bank employees in India, it was found that green banking practices had a significant positive impact on the environmental performance of banks. Operational features of green banking practices had the greatest impact, while aspects related to employees, policies and customers did not have a significant impact on environmental performance. Green

banking practices have a positive impact on banks' environmental performance, which has a significant impact on banks' profitability. By investing in green banking, banks reduce the risk of climate change, create sustainability, save costs, enhance their reputation in the face of changing demands, and build trust and loyalty among environmentally conscious customers (Jain & Sharma, 2023).

Based on the literature review, the research questions of the paper are:

1. How do green banking practices affect employees' perceptions of the environmental performance of banks in Albania?
2. How do green banking practices affect employees' perceptions of the economic performance of banks in Albania?
3. How do green banking practices affect employees' perceptions of the social performance of banks in Albania?

Descriptive analysis will be used based on the results of the questionnaire addressed to bank employees. In previous works, the investments and efforts of banks in Albania to adopt green banking practices have been analyzed. This paper will analyze how green banking practices affect environmental, economic, and social performance. The analysis will be an initial analysis. In future papers, a more in-depth study will introduce new factors such as social capital as a strategic resource for banks in their transition toward a greener and more sustainable economy.

2 Literature Review

According to Sangiseti & Kumari (2023) green banking contributes not only to environmental protection but also to economic growth. Banks should focus on financing businesses and sectors that, in their activity, make efforts to protect the environment. This would affect the prevention of pollution but also the creation of a stable banking system. Green banking applied by banks affects the creation of a sustainable environment, but also banks increase their image and the number of clients by attracting customers who are willing to contribute to the protection of the environment. Green banking practices not only contribute to environmental protection (Shameem & Haleem, 2021). According to (Malsha & Arulrajah, Mediating role of employee green behaviour towards sustainability performance of banks, 2020) in order to have a sustainable performance, banks should focus on promoting green attitudes of employees. The factors that influence the behavior of bank employees towards the adaptation of green banking practices are management support, corporate social responsibility, potential for profit, and image improvement. Also, the more information employees have, the easier it will be for banks to adapt green practices (Jamal et al., 2020).

Banks play an important role in lending to individuals and businesses, influencing the economic development of the country. Therefore, they have an impact on the promotion of a sustainable environment (Nath, Nayak, & Goel, 2014). Also from the study done by (Shaumya & Anton Arulrajah, 2017) it was identified that green banking practices affect the bank's environmental performance. Daily operations and green practices followed by employees also affected the environmental performance of banks. However, it was observed that customer-related green practices did not have a significant impact on environmental performance. According to (Zhang et al., (2021) green banking activities have a positive effect on the environmental performance of banks. According to their study, this positive relationship is mediated by the financing of green products. The government should encourage banks to develop and offer green products. But on the other hand, the banks themselves have to finance projects and businesses that are concerned about the environment (Miah et al., 2018). According to (Tu & Dung, 2017) the main factor that influences the willingness of banks to offer green banking products is the recognition of green practices by senior managers. If senior bank managers recognize the importance of green practices, they will make it an important part of their business and promote green banking. Also, the staff should be trained to have the ability to evaluate environmental projects and use new technologies to identify the effects of these projects on environmental protection. Also in the study done in Ghana (Kwakye & Nor, 2021) the same result was evidenced that the support of the top management of banks is a main factor that affects the decision of banks to adopt green banking. Due to the fact that the application of green banking requires high capital, it definitely needs the support of the management to be implemented successfully. Another study in Pakistan by (Rehman A. et al., 2021) found that the Central Bank should create strategies for green banking that will be implemented by banks. The government, on the other hand, should make its efforts by drafting clauses for the application of green banking practices in corporate governance. Also, the study done by analyzes the factors that influence the development of green practices such as the rules of the central bank, the support of management. In their analysis Shafique & Majeed (2020) found that the factors that influence the development of green banking practices are the central bank's regulations, the support of high consumption, but also other factors such as Policy Guidelines, Attitude towards usage. Green banking initiatives not only contribute to the financial performance of banks, but also increase customer confidence and competitiveness by differentiating banks in a competitive marketplace (Chandrasekaran & Narayanan, 2024). When employees perceive that their organization contributes to social welfare, they are more likely to engage in green activities. Bamberg et al. (2015) demonstrated that awareness of a company's social impact encourages employees to take actions that reflect the company's social values, including environmental responsibility.

3 Methodology

3.1 Survey instrument

To return answers to research questions, a questionnaire was addressed to the employees of commercial banks in Albania. The questionnaire contains questions related to demographic data and green banking practices and their impact on the environmental, social, and economic performance of banks in Albania.

3.2 Sampling and Data Collection

The questionnaire was addressed to the bank's employees to capture their perceptions of the banks' efforts to adopt green practices and the impact of these practices on the banks' environmental, social, and economic performance. In total, 155 questionnaires were collected. Table 1 shows the demographics of the employees. 73% of the employees are women and 26.5% are men. The predominant age group is 31-40 years, which represents half of the employees surveyed. The 20-30 age group represents 35.5% of the selected population. The age groups 41-50 years and over 50 years are very small with 5.2% and 9.7% respectively. The dominant level of education is a scientific master's degree, or 74%, the rest 24.5% have a bachelor's degree and a very small number, only 1.3% have a PhD. Most of the respondents, 74%, have more than 6 years of experience, 26.5% have 1-3 years of experience, 13% have 4-6 years of experience.

Demographics	Value	Frequency	Frequency percentage
Gender	Male	41	26.5%
	Female	114	73.5%
Age	20-30	55	35.5%
	31-40	77	49.7%
	41-50	8	5.2%
	Over 50	15	9.7%
Educational Level	Bachelor	38	24.5%
	Master	115	74.2%
	PhD	2	1.3%
Experience	1-3 years	41	26.5%
	4-6 years	20	12.9%
	Over 6 years	94	60.6%

Table 1.
Demographics
Source: Authors elaboration

4 Results

Descriptive analysis is used to determine employees' perceptions of the impact of green banking practices on their bank's environmental, economic, and social performance. The questions regarding the environmental, economic and social performance of the banks were developed by (Malsha et al., Mediating role of employee green behaviour towards sustainability performance of banks, 2020)

Table 2 shows the results in % for 5 categories from strongly disagree to strongly agree. For each project included in the analysis, employees were asked 3 questions.

Tellers perceive that Green Banking practices have a high level of impact on environmental performance. 86% of employees perceive that green banking practices improve banks' compliance with environmental standards, 80% of employees perceive that green banking practices significantly reduce their bank's energy consumption, and 85% of employees perceive that green banking practices significantly reduce their bank's use of paper and other materials. This shows a strong link between green banking practices and banks' environmental performance.

The impact of green banking on environmental performance is also high. 82% of respondents perceive that green banking practices have a positive impact on the image of our bank, 64% of bank employees perceive that green banking practices lead to better relations with the community and stakeholders, and 63% of employees respond that green banking practices lead to increased compliance with applicable social laws and regulations.

		Strongly Disagree	Disagree	NA/D	Agree	Strongly Agree
Environmental Performance	Green banking practices improve banks compliance to environmental standard.	0.00%	2.58%	11.61%	45.16%	40.65%
	Green banking practices significantly reduce energy consumption in your bank	0.00%	1.94%	17.42	50.32%	30.32
	Green banking practices significantly reduce paper usage and other materials	0.00%	1.94%	11.61%	34.84%	51.61%
		Strongly Disagree	Disagree	NA/D	Agree	Strongly Agree
Social Performance	Green banking practices have positive effect on the image of our bank	0.00	0.65%	7.74%	43.87%	47.74%
	Green banking practices results in better relationship between community and stakeholders	0.00%	0.65%	35.48%	47.10%	16.77%
	Green banking practices results in increase compliance with applicable social laws and regulations	0.65%	0.65%	36.13%	42.58%	20.00%
		Strongly Disagree	Disagree	NA/D	Agree	Strongly Agree
Economic performance	Green banking practices significantly improve revenue and market share of our bank.	0.00%	3.87%	26.45%	36.13%	33.55%
	Green banking practices significantly decrease operational expenditure of our bank	0.00%	3.87%	22.58%	45.16%	28.39%
	Green banking practices significantly improve resource management efficiency in our bank	0.00%	0.00%	9.03%	32.90%	58.06%

Table 2.
Environmental, Social and Economic Performance
Source: Authors elaboration

Conclusion

Based on the literature review, numerous studies have shown that the implementation of green operations in the banking sector leads to significant improvements in the environmental, economic and social performance of banks. Regional studies and those specifically conducted in emerging markets such as Albania can reveal the unique nuances of the impact of green operations in a context where environmental awareness and sustainable practices are still evolving. The above analysis shows a strong correlation between green banking practices and the positive impact they have on the environmental, social and economic reputation of banks. More than 80% of employees perceive that green banking practices improve banks' compliance with environmental standards, that green banking practices significantly reduce energy consumption in their bank, and that green banking practices significantly reduce the use of paper and other materials. 82% of surveyed employees perceive that Green Banking practices have a positive impact on the image of their bank, 64% of bank employees perceive that Green Banking practices result in better relationships with the community and stakeholders, and 63% of employees answer that Green Banking practices result in increased compliance with applicable social laws and regulations. Also, over 70% of employees perceive that Green Banking practices significantly improve their bank's revenue and market share, Green Banking practices significantly reduce their bank's operational expenses, Green Banking practices significantly improve their bank's resource management efficiency. A high level of employees' perception of the positive effects created by the application of green banking practices affects the increase of awareness of the importance and necessity of these practices by their bank and will make them more aware in their work and take more actions to promote these practices.

References

- [1] Araci, H., Yüksel, F., & Ispirli, D. (2016). Sustainability And Accountability In Turkish Banking Sector. *Journal of Accounting, Finance and Auditing Studies* , 2(3), pp. 232-254 .
- [2] Chandrasekaran, S., & Narayanan, M. (2024). Green banking initiatives – an empirical study on performance of private sector banks. *Indian Journal of Psychology* , 03, pp. 75-81.
- [3] Gulzar, R., Bhat, A. A., Mir, A. A., Athari, S. A., & Al-Adwan, A. S. (2024). Green banking practices and environmental performance: navigating sustainability in banks. *Environmental Science and Pollution Research*, 31, 23211–23226. <https://doi.org/doi.org/10.1007/s11356-024-32418->
- [4] Jeucken, M., & Bouma, J. (1999). The Changing Environment of Banks. *Greener Management International*, 27, pp. 21-35. <https://doi.org/https://doi.org/greemanainte.27.21>

- [5] Kwakye, E., & Nor, K. (2021). The intention of banks to adopt green banking in an emerging market: the employees' perspective. *Economic and Political Studies*, 1-8. <https://doi.org/10.1080/20954816.2021.1899621>
- [6] Malsha, K., & Arulrajah, A. (2020). Mediating role of employee green behaviour towards sustainability performance of banks. *Journal of Governance and Regulation*, 9(2), pp. 92-102. <https://doi.org/doi.org/10.22495/jgrv9i2art7>
- [7] Malsha, K., Arulrajah, A., & Senthilnathan, S. (2020). Mediating role of employee green behaviour towards sustainability performance of banks. *Journal of Governance and Regulation*, 9(2), pp. 92-102. <https://doi.org/https://doi.org/10.22495/jgrv9i2art7>
- [8] Mathew, A. (2021). Green banking: an innovative initiative for sustainable financial development. *EPRA International Journal of Multidisciplinary Research*, 7(12), pp. 2455-3662.
- [9] Miah, M., Rahman, S., & Haque, M. (2018). Factors affecting environmental performance: evidence from banking sector in Bangladesh. *Int. J. Financial Services Management*, 9(1), pp. 22-38.
- [10] Raluca, D. (2012). Pathways to Sustainable Banking Management. *The Journal of the Faculty of Economics*, 1(2), pp. 545-550.
- [11] Rehman, A., Ullah, I., Afridi, F.-e.-A., Ullah, Z., Zeeshan, M., Hussain, A., & Rahman, H. (2021). Adoption of green banking practices and environmental performance in Pakistan: a demonstration of structural. *Environment, Development and Sustainability*. <https://doi.org/https://doi.org/10.1007/s10668-020-01206-x>
- [12] Shakil, M., Azam, K., & Raju, M. (2014). An Evaluation of Green Banking Practices in Bangladesh. *European Journal of Business and Management*, 6(31), pp. 8-16.
- [13] Shameem, A., & Haleem, A. (2021). A Study On Green Banking Practices In Banking Industry: Sri Lankan Context. *Journal of Contemporary Issues in Business and Government* 27(1), pp. 490-505.
- [14] Shaumya, K., & Anton Arulrajah, A. (2017). The Impact of Green Banking Practices on Bank's Environmental Performance: Evidence from Sri Lanka. *Journal of Finance and Bank Management*, 5(1), pp. 77-90.
- [15] Tu, T. T., & Dung, N. T. (2017). Factors affecting green banking practices: Exploratory factor analysis on Vietnamese banks. *Journal of Economic Development*, 24(2), pp. 4-30.

Improvement of customer service through generative AI

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Abstract: This paper explore the possibility to use a conversational agent system architecture to support customer services and digital marketing. An implementation of chatbot through generative AI for customer service brings a significant improvement in customer relationships. The proposed prototype system is built in a real- word of telecommunication environment. To illustrate this system as well as possible ,various technologies have been analyzed and implemented, such as : artificial intelligence, natural language processing, knowledge bases. For the proposed system, an assessment of the improvement it brings has been made , the results were satisfactory , which shows the efficiency of this system in the environment where it was implemented. This paper also explore and address some emerging issues during the system implementation.

Keywords: Generative AI, prototype disgne, costumer service

1 Introduction

Artificial intelligence is for sure one of the fields that has the highest interest from researcher. Generative AI is a type of artificial intelligence technology that is capable to generate new content that imitates human like creativity and decision making. It operates by realizing patterns from large datasets and then using that knowledge to produce new and original content. Generative AI has applications in various fields, but in this paper we will show how generative AI components can be used to improve the functions of conversational agents in customer service. In customer service as has been shown in previous literature AI can automate responses, personalize interactions, analyze data, and improve the overall customer experience. Through the use of chatbots, natural language analysis and personalization of the customer experience, companies can offer faster, more efficient and tailored service. Chatbots have become popular over the past years in social networking sites, such that a useful and helpful chatbot is positively associated with consumer attitudes toward the brand [1] and reduces the perceived intrusiveness of subsequent chatbot advertising [2] . Chatbots and virtual assistants

are AI-based systems that can communicate with customers via chat or voice, simulating a human conversation. These systems can be integrated into various channels, such as websites, apps, social media, instant messaging or telephone, and can provide 24/7 support with no wait times. Thanks to machine learning, chatbots can constantly improve their abilities to understand and respond to user requests can be used in different ways to improve customer service, depending on the needs and objectives of each company. One of the characteristics of AI, in fact, is the extreme flexibility of the solutions, which can have practically an infinite number of declinations to be adapted to the specific case and respond to the specific needs of the user.

Research Objective This study's research goal is to undertake a detailed narrative analysis of the role of generative Artificial Intelligence (AI) in transformation of customer service management. The study's goal is to investigate and explore the effects of AI chatbot components on customer service operations and customer experiences. The methodology used is an valuation of relevant literature, academic papers, and case studies relating to the use of AI in customer service management. The study will also evaluate a framework design for chatbot prototype with a generative AI component.

2 Literature review

By implementing AI-based customer service approach, companies can offer users direct benefits in various ways. By using AI component costumer service is informed and designed using algorithms that constantly learn from historical datasets and real-time data from different source. This is very important to personalize the service involvement to fit the customer's needs. This results in a more relevant and effective service that addresses the customer's wants and needs [3]. From the user's evaluation, AI-based services are often very cost-effective as they can be provided at a fraction of the cost of high-touch human-delivered services and, in some cases, are offered entirely for free [4]. In addition , AI-powered customer service is significantly less expensive than conventional human-delivered service and can be easily transformed with minimal additional cost. This includes even virtual service robots, such as chatbots. While the digital service revolution offers many exciting possibilities, it also brings potential downsides and risks for service users [5][6].

When using AI technologies the companies will have to negotiate with data and privacy concerns. Ethical dilemmas are posed by digital technology advancements such as AI, intelligent automation, and machine learning.[5]

In many studies, different architectures and frameworks have been presented for building a task-oriented chatbot, including tourism [7], e-commerce [8], and telecommunication [9]. Also a prototype for a knowledge based conversational agent to support e-commerce customers sale and marketing [10]. The proposed

prototypes according to the evaluation results, report that chatbot perform very well and significantly improve the user experience.

3 Prototype design for a generative AI agent to improve customer service.

In this study we evaluate and propose a framework, to integrate generative AI with a conversational agent. This will help companies to move from a reactive to a proactive approach to customer service management. By analyzing the collected data, AI can predict problems before they occur and propose solutions, reducing the number of complaints and improving customer satisfaction. The proposed prototype flowchart has different processes (figure 1):

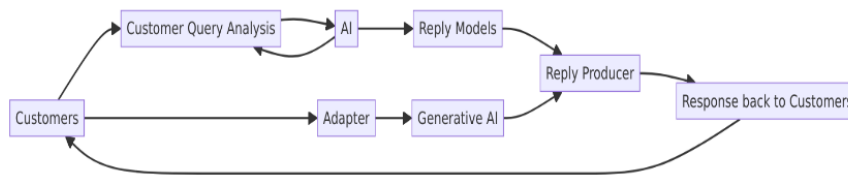


Figure 1
Prototype flowchart

The system design (figure 2) describes an integrated process that combines Natural Language Processing (NLP) and various AI models to handle customer service inquiries effectively.

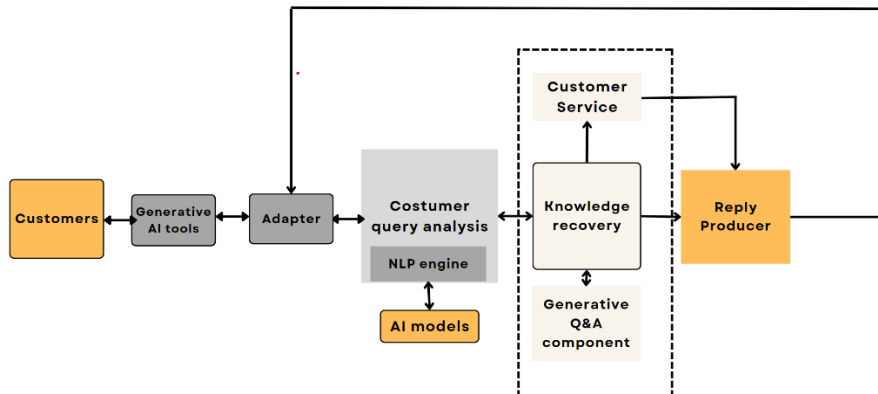


Figure 2
Prototype architecture

Customers as the initiators of service process submit their queries through various channels such as email, chat, or web forms. **Generative AI Tools** utilize AI technologies to preprocess the customer queries. This may include tasks like language translation, sentiment analysis, and initial categorization. In this path it is possible to involve tools like chatbot frameworks, machine learning models, and automated response generators. The **adapter** transforms and formats the data coming from the generative AI tools to ensure compatibility with the next processing steps. Acts as a middleware, ensuring seamless data flow within the system.

Customer Query Analysis is one of the main component. Queries can be understood combining different NLP and machine learning techniques. The queries from customers are first processed using generative AI tools, which may involve initial filtering, language translation, or format standardization. **NLP Engine**: Breaks down the natural language input to understand the context and intent behind the queries. It involves parsing, tokenization, and semantic analysis. **AI Models**: Includes specific models trained for various purposes such as classification, intent recognition, and contextual understanding. These models analyze the parsed data to derive actionable insights.

Knowledge Recovery: Searches internal and external databases for relevant information, it can include knowledge bases, documentation, and past resolved queries. The information will be transmitted to the reply generator if the knowledge recovery has all the required information. The knowledge recovery will forward the customer's request to the appropriate human customer service if the necessary information cannot be found. The **reply producer** will get the answer it needs from the customer support agent when they have finished answering the question. In order to build a response and send it back to the user via the adapter, the reply producer combine the templates for responding to queries with different purposes and the information that has been obtained.

Generative Q&A Component: Uses AI to formulate answers based on the retrieved information and is capable of constructing responses that are coherent and contextually appropriate, potentially leveraging generative models like GPT.

4 Evaluating the integration of AI generative component in costumer management process: Challenges and Benefits.

4.1 Challenges to considerate

Before introducing AI in costumer we have to considerate some aspect of every commercial activity:

Choose the right AI solutions - Before making choices, must be evaluated company's specific needs and select the most suitable AI solutions. Not all solutions are the same, so it's important to choose the ones that best align with customer service aims.

Improve the staff AI expertise - In spite of the automation offered by AI, human staff remains essential to customer service. It is important to provide adequate training to agents to work in cooperation with AI systems and effectively manage complex situations.

Integrate AI with existing systems - The implementation of AI in customer service must be integrated with existing systems and processes, such as CRM, to ensure a complete and effective experience. In fact, AI does not operate in isolation. Integration with CRM, data management systems and analytics platforms makes AI even more powerful. For example, CRM integration can provide chatbots with immediate access to customer information, allowing for more accurate and personalized responses.

Monitoring system results - Finally, it is important to continually monitor the performance of AI systems and analyze data to identify areas for improvement and ensure that the objectives we set ourselves are achieved.

4.2 Benefits

Improvement of customer experience - Improve the possibility to personalize the experience of the customer, who loves to be recognized in his needs and to be treated as unique and not as one among many, one of the major advantages of AI in customer service is the ability to quickly carry out this customization based on customer preferences and behavior, to then be applied to the individual case.

Continuous system progress – As the system adopts the NLP technology and machine learning technique to retrieve updated and the most relevant information on the Internet, the system can be adjusted continuously with new data.

Efficiency gains in human operation - Most of the customer queries are managed automatically by a machine, human experts are invoked only to handle more complex queries that the machine cannot resolve.

Conclusion

The application of generative AI in customer service offers a revolutionary way to improve customer interactions, especially when it comes to the complicated processes involved in consumer question analysis. In order to respond to customer enquiries in a quick and correct manner, it is necessary that Natural Language Processing (NLP) and AI models be integrated. This enables for a comprehensive and tailoring of consumer questions. Furthermore, proactive customer care is made possible by the use of generative AI, since any problems may be identified early on and resolved before they become more serious. It is To successfully integrate generative AI in customer service important to deal with the difficulties posed by

such a system, such as choosing the best AI solutions, enhancing employee AI knowledge, etc.

References

- [1] Zarouali, B., Van den Broeck, E., Walrave, M., Poels, K., 2018. Predicting Consumer Responses to a Chatbot on Facebook. *Cyberpsychol. Behav. Soc. Network.* 21 (8), pp.491–497.
- [2] Van den Broeck, E., Zarouali, B., Poels, K., 2019. Chatbot advertising effectiveness: when does the message get through? *Comput. Hum. Behav.* 98, pp. 150–157.
- [3] Wixom, B. H., & Ross, J. W. (2017). How to monetize your data. *MIT Sloan Management Review*, 58(3), pp. 1–13.
- [4] Gu, X., Kannan, P. K., & Ma, L. (2018). Selling the Premium in Freemium. *Journal of Marketing*, 82(6), pp. 10–27.
- [5] Belk, R. (2021). Ethical issues in service robotics and artificial intelligence. *The Service Industries Journal*, 41(13–14), pp. 860–876.
- [6] Breidbach, C. F., & Maglio, P. (2020). Accountable algorithms? The ethical implications of data-driven business models. *Journal of Service Management*, 31(2), 163–185.
- [7] Acharya AK, Sneha Y, Khettry A, Patil DI. AtheNA an avid traveller using LSTM based RNN architecture. *J. Eng. Sci. Technol.* 2020 Apr;15:1413-28.
- [8] Bhawiyuga A, Fauzi MA, Pramukantoro ES, Yahya W. Design of e-commerce chat robot for automatically answering customer question. In 2017 International Conference on Sustainable Information Engineering and Technology (SIET) 2017 Nov 24, pp. 159-162. IEEE.
- [9] Paikens P, Znotiņš A, Bārzdiņš G. Human-in-the-loop conversation agent for customer service. In *Natural Language Processing and Information Systems: 25th International Conference on Applications of Natural Language to Information Systems, NLDB 2020, Saarbrücken, Germany, June 24–26, 2020, Proceedings 25 2020* pp. 277-284. Springer International Publishing.
- [10] Ngai EW, Lee MC, Luo M, Chan PS, Liang T. An intelligent knowledge-based chatbot for customer service. *Electronic Commerce Research and Applications.* 2021 Nov 1;50:101098.