INTERDISCIPLINARY DESCRIPTION OF COMPLEX SYSTEMS

Scientific Journal

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INNOVATIONS & INTERACTIONS: A MULTIFACETED EXPLORATION OF EUROPE'S DIGITAL, CULTURAL, AND ECONOMIC LANDSCAPE. EDITORIAL*

This thematic issue of INDECS brings together articles and research on information systems and technology, circular economy, ethical and corporate social practice, technological advancements, managerial and corporate performance, and ways to sustain innovative business practices and sustainable development.

On 17-18 June 2022, the 8th Enterprise Research Innovation Conference (ENTRENOVA) was conducted virtually and in Opatija, Croatia, to present the newest trends, methodologies, and research achievements in this subject. IRENET, Society for Advancing Innovation and Research in Economy, organises ENTRENOVA, an international scientific conference, in collaboration with Međimurje University of Applied Sciences, Faculty of Tourism and Hotel Management, Kotor, Montenegro, and University North, Varaždin, Croatia. This multi-disciplinary conference explores innovation, knowledge management, and R&D concerns in commercial contexts specific to ICTs. More than 140 writers from 24 nations presented 68 abstracts and 43 papers at ENTRENOVA 2022.

This INDECS thematic issue was open to all interested authors, researchers, and practitioners from economics, organisation and management science, information technology, and managerial aspects of innovative business practices and sustainability, not just ENTRENOVA 2022 participants.

Eight contributions were received for the thematic issue of INDECS, including expanded journal versions of conference short pieces. After guest editing and two anonymous reviews, six articles were accepted for this issue.

The first article, DIGITAL TECHNOLOGY INTEGRATION AMONG EASTERN EUROPEAN COMPANIES, BASED ON THE DIGITAL ECONOMY AND SOCIETY INDEX, by Tünde Zita Kovács, András Nábrádi and Beáta Bittner investigates the digital evolution of Europe, emphasises the European Commission's commitment since the early 2000s to the transformation of the region's socio-economic domain. The study leverages the Digital Economy and Society Index, which, by 2021, was harmonised with the objectives of the Digital Agenda 2030. Through rigorous σ - and β -convergence analyses, the authors deduced no discernible reduction in disparities or a standardised catch-up pace in digital integration across Member States. Notably, countries from the Eastern enlargements consistently fell behind the EU average. The findings resoundingly stress the need for enhanced strategies, championing a more cohesive and inclusive digital advancement within the Union, particularly for its newer members.

In their analytical study of e-learning trends within the European context, INEQUALITY IN E-LEARNING IN EUROPEAN UNION COUNTRIES: ROLE OF GENDER, EDUCATION AND URBAN DEVELOPMENT, the authors of the second article, Berislav Žmuk, Fayyaz Hussain Qureshi, and Sarwar Khawaja address the heightened importance of digital educational methods, further magnified by the circumstances of the COVID-19 pandemic. The

research focuses on discerning potential disparities related to gender, education, and urban development, offering insights into the digital divides present among EU countries. By concentrating on data from the pre-pandemic years, 2017 and 2019, and comparing the elearning uptake among distinct groups, the authors aim to provide a more controlled assessment. Their findings reveal that the EU-15 member states consistently demonstrate better e-learning adoption compared to other EU nations. This pattern suggests an enduring digital divide, highlighting the challenges in achieving technological parity among member countries, even in the context of the broader Digital Europe initiative.

The third article, A PREFERRED REPORTING ITEMS FOR SYSTEMATIC REVIEWS AND META-ANALYSIS GUIDED SYSTEMATIC REVIEW OF DATA ENVELOPMENT ANALYSIS APPLICATIONS by authors Katerina Fotova Čiković, Mario Tomiša and Joško Lozić inquiry explores the utilisation of the non-parametric Data Envelopment Analysis (DEA) methodology, with a particular focus on its pertinence to efficiency assessments in the creative and cultural industries and sectors. This study aims to compile and analyse existing literature in this field, with the goal of summarising the present state of knowledge in the creative and cultural industries and the DEA methodology. Additionally, it aims to provide a theoretical framework for understanding these sectors and the DEA methodology. Utilising the comprehensive Preferred Reporting Items for Systematic Reviews and Meta-Analysis framework, this article conducts a systematic review of relevant uses of Data Envelopment Analysis (DEA) within the industries above. Thirteen relevant publications were identified by the adopted technique, shedding light on the utilisation of the DEA (Data Envelopment Analysis) within the creative and cultural domains. Interestingly, the authors have identified a gap in the literature where no studies utilising the DEA technique in these industries were found prior to 2012. This finding raises important issues for future academic research. Moreover, the article provides a comprehensive analysis of different perspectives on efficiency evaluations within these industries. In conclusion, the authors strongly support the expanded use of the DEA approach in the creative and cultural industries. They emphasise the need to reassess research goals in these industries for the worldwide academic and analytical community.

In their work, THE NINTH DIMENSION OF NATIONAL CULTURE: UNPACKING CROSS-CULTURAL COMMUNICATION STYLES by Marjan Bojadjiev, Marjana Vaneva, Ana Tomovska Misoska, Ivona Mileva, and Marija Andonova, the authors undertake a comprehensive analysis of communication styles within various country cultures. The examination of the relationship between national culture and communication modalities is conducted by referencing the well-regarded Hofstede model. The study employs a sequential methodology, commencing with the identification and analysis of different communication styles. Subsequently, these styles are examined in connection to diverse cultural contexts. Differences and similarities in communication styles across a range of countries were revealed through the utilisation of component analysis and the analysis of variance (ANOVA) test. The study comprises samples from ten diverse civilisations, including Germany, Sweden, Japan, and the United States, among others. By employing a communication evaluation tool in conjunction with Hofstede's six-dimensional cultural framework, this study aims to explore the differences in communication practises seen among the nations included in the sample. Prominent observations arise on Germany's proclivity for formal communication and Japan's preference for informal discourse. In a comparative comparison of communication styles,

Sweden and the United States are situated at different ends of the spectrum. In addition to its empirical findings, this study possesses significant scholarly significance as it introduces a novel cultural dimension, asserting that a comprehensive comprehension of one's native culture is crucial for effectively navigating intercultural interactions. The authors argue that nations must utilise cultural self-awareness as an essential instrument for understanding and actively interacting with a wide range of cultures.

The fifth article, INTERDISCIPLINARY APPROACH TO WINE PREFERENCES: CASE OF NORTH CROATIA, is written by Dijana Vuković, Damira Tkalec, and Antonija Ivančić. This scholarly investigation examines the complexities of the worldwide wine market, with a particular focus on its advanced stage of development and the persistent endeavours of prominent producers to maintain their dominance. The growing field of wine tourism has been driven by a combination of respect for traditional wine cultures and local grape types, as well as the willingness of tourists to support these distinctive experiences financially. This trend has become particularly prominent in the last twenty years. The convergence of wine consumption, gastronomy, hospitality, and regional viticulture results in a cohesive amalgamation, a subject of investigation in this essay, with specific attention given to North Croatia. Acknowledging the complex and diverse characteristics of consumer behaviour, this study employs an interdisciplinary approach to analyse the preferences of wine fans in this particular geographical area. By employing chi-square tests, this study substantiates its fundamental hypotheses, providing valuable insights into the historical development of wine production, attributes of wine consumers, and intricacies of wine trade within the contexts of Croatia and the global arena. The results serve as a great resource for anyone involved in the tourism industry in North Croatia, facilitating a more comprehensive understanding of the preferences and interests of wine enthusiasts in the region.

Finally, the sixth article, entitled OPTIMISING INVESTMENT DECISIONS IN R&D INTENSIVE PRIVATE MICRO-ENTITIES USING GAME THEORY by Andreas Georgiou, analyses optimal investment strategies for three European private micro-entities focused on R&D. This analysis uses game theory and content analysis. The research creates a game theory matrix for each organisation to improve comprehension. The assumption is that investment exposure is connected to the capitalisation of internally generated intangible assets. Intangible asset capitalisation is seen as an indicator of economic growth. Therefore, investors adjust their investment allocations. Game theory matrices, generated from publicly available empirical data from financial statements, reveal how managerial choices affect investor risk preferences. It illuminates the effects of capitalising or escaping development costs for internally generated intangible assets. Investment strategies are then categorised by risk. Equity is high-risk, longterm debt is medium-risk, and short-term debt is low-risk. The author found the current investment strategies for potential investors after analysing the matrices (2015 for one company and 2016 for the other two). One entity chose medium risk with long-term debt, while the other two preferred low risk. These strategies are then retrospectively evaluated using current financial data and accompanying documents to ensure their efficacy.

In summary, this editorial provides a thorough exploration of various urgent topics, including the advancements in digital technology and the complexities surrounding wine tastes in the northern region of Croatia. The comprehensive examinations and evaluations across several fields, including digital technology, e-learning, cultural industries, communication paradigms, and strategic financial decision-making, demonstrate the dedication of researchers to advancing our comprehension. These books possess more than mere academic value; they offer deep insights that have the potential to influence legislation, industrial norms, and transdisciplinary methodologies in our constantly changing world. As readers and practitioners, we are presented with an opportunity to broaden our understanding and actively participate in ongoing discussions, fostering critical analysis, thoughtful reflection, and meaningful contributions to these enduring discourses.

Zagreb, 15th September 2023

Guest editors Mirjana Pejić Bach Igor Klopotan Sanja Pekovic

DIGITAL TECHNOLOGY INTEGRATION AMONG EASTERN EUROPEAN COMPANIES, BASED ON DIGITAL ECONOMY AND SOCIETY INDEX

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ABSTRACT

The European Commission has given special attention to the digital evolution of the European economy and society since the early 2000s. Starting with 2014, the Digital Economy and Society Index has become a key monitoring and assessment instrument. In 2021, the main indicators of the Digital Economy and Society Index were matched with the Digital Agenda 2030 targets, which encompass four dimensions: human capital, connectivity, digital technology integration, and digital public services. The article aims to verify the convergence amongst Member States in integrating digital technologies, which is the third dimension of the Digital Economy and Society Index yearly database. The σ -convergence analysis assessed decreased disparities in digital technology integration between Member States over time. The β -convergence analysis was used to evaluate the pace of catch-up from the initial development level. The σ - and β -convergence were not confirmed. The specific digital technology integration indicators (11) are studied to identify crucial areas that must be addressed in the future to guarantee that digital inclusion is as widespread as feasible. The present research is concentrated on the member countries that joined the EU during the Eastern enlargements. All individual indicator performance is typically behind the EU average, and as the β -convergence study indicates, the average catch-up rate is not encouraging.

KEYWORDS

convergences, digital transformation, SMEs, EU enlargements

CLASSIFICATION

JEL: M15, O14

INTRODUCTION

For the European Union, the knowledge-based economy serves as the foundation for the development of human resources, and ongoing research and development (R&D) in information and communication technologies is directly related to the EU's competitiveness [1]. In order to accelerate their development and make them strong, resilient, efficient, and independent contributors to the national economy, micro, small, and medium-sized enterprises (MSMEs) need to be encouraged and strengthened [2, 3].

All of these were intentionally developed at the EU level beginning in 2000 with the Lisbon Strategy, followed in 2010 by the EU 2020 Strategy, which, for the first time, outlined the crucial role of ICT in accomplishing European goals. The Digital Agenda was enhanced further in 2015 by the European Digital Single Market Strategy, which also laid out specific guidelines based on three pillars to establish a just, open, and secure digital environment:

- improving access to digital goods and services for consumers and businesses across Europe,
- increasing the growth potential of the digital economy.

Three primary digital goals were the focus of the second five-year Digital Agenda, "Shaping Europe's Digital Future" in 2020:

- technology for people,
- fair and competitive economy,
- an open, democratic and sustainable society.

The Digital Agenda for Europe serves as the vehicle for these strategies to advance digital technology in Europe. The European Commission (EC) developed the Digital Economy and Society Index (DESI), which has been released annually since 2014 [4, 5] to gauge and track progress. The DESI last underwent a substantial reorganisation and methodological revision in 2021. The European Commission presented the Path to the Digital Decade, a program to aid in the digital transformation of the European economy and society, the same year the European Parliament adopted the Digital Agenda 2030: A European Method to accomplish the Digital Decade [6].

Currently, the DESI index ranks the EU Member States and tracks their development using 33 distinct and four main indicators. The four key areas are as follows:

- desi_1 Digital skills and competencies of human capital,
- desi_2 Internet coverage and quality of access,
- desi_3 Digital technologies in the enterprise,
- desi_4 The penetration of digital public services.

A recent study investigated whether member-state convergence could be identified using the annual databases of the DESI [7]. We discovered statistical evidence of convergence between the EU27 Member States for the DESI overall index using the σ - and β -convergence tests. One can wonder, though, if the convergence for the core indicators (desi_1, desi_2, desi_3, desi_4) can be shown independently [8-10].

The third dimension of the DESI index, which gauges the level of digital technology adoption in EU Member States, is the topic of this study. As shown in Table 1, the core indicator desi_3 consists of 11 individual indicators and three sub-dimensions:

The weighted value of the desi_3 subdimensions 15-70-15 % determines the degree of digital technology integration ranking:

 $desi_3a \times 0,15 + desi_3b \times 0,75 + desi_3c \times 0,15.$

desi_3 subdimensions	Individual indicators						
Digital intensity (desi_3a)	SMEs with at least a basic level of digital intensity						
	Electronic information sharing						
	Social media						
	Big data						
businesses (desi 3b)	Cloud						
· · · /	AI						
	ICT for environmental sustainability						
	e-Invoices						
	SMEs selling online						
e-Commerce (desi_3c)	e-Commerce turnover						
	Selling online crossborder						

Table 1. The desi_3 core indicator's structure.

The article aims to verify the convergence amongst Member States in integrating digital technologies, which is the third dimension of the DESI yearly database. Convergence calculations are used to track the level of cohesiveness in various sectors. The convergence of the development of the Member States that joined the European Union (EU) during the 2004-2007-2013 enlargements (Eastern European enlargements) and the old EU Member States is a priority. The article emphasises two different types of convergence. The average relative deviation of the DESI index values from the mean, presented as a percentage, is the first, also known as the relative standard deviation or σ -convergence. There is a convergence when the development levels' dispersion decreases with time. β -convergence is another well-known convergence indicator [11, 12]. The neoclassical growth theories of Ramsey [13], Solow [14] and Koopmans [15] are the foundation for this growth indicator. The Solow-based and endogenous growth theories asserted that national economic policies and nation-specific features are significant predictors of a country's catching-up performance from the 1980s onward. Foreign capital inflows speed up growth, which eventually causes the gap between developed and developing countries to close.

Another focus area is the digital development of businesses, as this is a crucial factor in determining R&D and regional economic growth [16, 17]. Schumpeter asserted that technological advancement would be the deciding factor as early as 1934. Businesses would be driven out of the market and the competition if they could not adapt to these technological advancements [18]. Porter contends that a company's competitive edge stems from how it organises and conducts its numerous operations. However, to achieve a competitive edge, it must offer a service comparable to its rivals but more effectively or with a value distinction that sets its goods or services apart [19, 20]. The differential implies that effective adoption and use of digital technology at the corporate level can lead to more productive operations and, thus, higher levels of competitiveness.

In order to prepare human resources for changes in the labour market, industrial revitalisation 4.0 must be implemented. A serious challenge, especially in the manufacturing sector, is the reduction of the workforce's low-skilled and average workers. More jobs will likely be created than destroyed in the future due to the demand for new skills and job types. In order to meet the demands of technical competence, professional/methodological competence, social

competence, and personal competence needed in the future, higher education must be able to adapt learning approaches and topics [21].

In order to determine whether existing convergence in the use of digital technology by businesses across the Member States, we examined the desi_3 index of the EU Member States between 2016 and 2021. There are no published predictions or data, and no other authors have addressed this issue.

The following null hypothesis was formulated for the desi_3 core indicator:

Ho: We assumed no convergence between the Member States based on the desi_3 core indicator change between 2016 and 2021.

Following the introduction in the part of the literature review, a bibliometric analysis was conducted for the DESI index topic in the Web of Science Core Collection - Clarivate Analytics database between 2014 and 2022 using VOSviewer. The methodology part presents all the statistical instruments used for DESI index analysis, followed by the results and discussion part, which presents the main findings of the present research. During the conclusion, the contribution of research and practice are stated as research limitations and possible further research directions.

This article is a revised, expanded version of the presentation published in the 2022 Enterprise Research Innovation (ENTRENOVA) conference proceedings.

LITERATURE REVIEW

Web of Science Core Collection – Clarivate Analytics, the database we used. A bibliometric analysis was conducted to investigate the literature by analysing or discussing the DESI index. In order to accomplish this, we looked at keywords of articles that addressed the DESI index theme. We investigated the correlations among them using the free bibliometric program VOSviewer 1.6.17 [22], as Vida, Kovács, Nagy, Madai and Bittner [23] also used similar analyses to investigate a topic in her research. Another work of consistent terminology is presented in Gašpar, Seljan and Kučiš [24], where the Herfindahl-Hirshman Index is used to evaluate terminology diversity. Scholarly journal articles and conference proceedings were analysed between 2014 to 2022 that had the terms *integration of digital technology* and *business digitalisation*. These terms were examined in the title, abstract, author-provided keywords, and keyword plus. The database analysis produced 143 direct results and 49 related documents relevant to the search terms and might aid in a more thorough understanding of the area.

Colours are used by the VOSviewer program to identify the clusters detected throughout the investigation. The software discovered 1082 keywords in the research study, some of which were similar; therefore, we chose to combine them using a thesaurus file. After integrating the thesaurus results in 1070 terms, 33 matched the criteria with a minimum recurrence rate of 7 times the given criterion. Figure 1 depicts the network of relationships between the relevant keywords, which can be interpreted as follows: the size of the nodes represents the frequency of occurrence; the thickness of the edges connecting the nodes represents the strength of the relationship between the keywords.



Figure 1. The frequency of keywords in the selected publication database passing the threshold of 7.

The minimal occurrence in the chosen database for analysing keyword associations had to be seven. Four clusters were detected using the software's default resolution level for producing clusters. The clusters are colour-coded and are represented by

Figure **1** and Table 2. In each cluster, the most frequent terms are *innovation* (40 occurrences), *performance* (33 occurrences), *digitalisation* (69 occurrences) and *technology* (27 occurrences).

1 st cluster (red)	2 nd cluster (green)	3 rd cluster (blue)	4 th cluster (yellow)	
business models	adoption	big data	framework	
capability	competitive advantage	blockchain	information	
creation	ICT	digital economy	Internet	
digital platform	impact	digitalisation	management	
digital technologies	integration	industry 4.0	technology	
digital transformation	performance	Internet of things	transformation	
entrepreneurship	strategy	logistics		
innovation	systems			
perspective				
platforms				
servitisation				
value creation				

 Table 2. Keyword clusters.

The main keyword of the first cluster, highlighted in red, is *innovation*, which is frequently mentioned alongside the keywords *digital transformation*, *capability*, and *business models*, implying that a company's ability to transform digitally and the degree of integration of digital technology in the business model are essential determinants of its innovation activity [25-27]. The significance and possibility of integrating digital technology vary across company structures and sectors [23, 28-33]. Small businesses have a reduced intensity of digital technology integration, but large businesses are further reinforced by their digitalisation capabilities, as their vast corporate structure increases their chances of success [34-36]. However, a favourable association exists between digital technology adoption, industrial processes' digitalisation, and environmental sustainability [37]. Digital transformation can only be effective according to a well-defined plan [38-41].

The second cluster, denoted in green, has the most often occurring term, *performance*, which is connected to the keywords *ICT* and *integration*, implying that firm performance is directly linked to ICT technology integration. It influences business strategy creation and achieving competitive advantage [42, 43]. Given the importance of digitalisation, integrating the IT department is critical to digital transformation [44-47]. Mandl, Schwab, Heuwing, and Womser-Hacker [48] concluded from focus group discussions with business decision-makers that the failure of digitisation is frequently human, mainly management. Nábrádi, Madai and Lapis [49] emphasised the special importance of digital technology in agriculture by using precision technologies as a tool for effectiveness and managing risk [50]. The complexity of integrating information systems and the lack of structure in information management were both mentioned as impediments.

Considering the resource needs of digitisation before implementing its potential [51-53]. The most significant keyword in the third blue cluster is *digitalisation*, which has enabled the establishment of the *digital economy*, allowing industry transformation, currently known as Industry 4.0. Massive data volumes, blockchain technology, and smart devices that connect are all part of the digital transformation (IoT). Along the digitalisation road, many ecosystembased business models have arisen, emphasising the necessity of cooperation [54-57]. Unfortunately, even in more developed countries, the degree of digitalisation of businesses is only moderate, so Volkova, Kuzmuk, Oliinyk, Klymenko and Dankanych [22] investigated the application and diffusion trends of various digital technologies such as blockchain technology, 3D printing, IoT, 5G networks, cloud computing, automation and robotisation, and artificial intelligence and data analytics. Ahmad and van Looy state that the fastest-increasing trends are Industry 4.0, blockchain technology, and IoT [58]. Automation, digitalisation of the whole value chain, and simultaneous consideration of Industry 4.0 success criteria will considerably boost the company's success and performance [59]. Following a thorough literature review, Fonseca [60] identified the dimensions that Industry 4.0 entails: the digitisation and integration of industrial manufacturing and logistics processes, the use of the Internet and IoT, and the fusion of physical and virtual reality combined with the application of ICT technology. Simultaneously, Industry 4.0 business models have arisen, with potential benefits such as shorter operating cycles, shorter delivery times, faster time to market for new goods or services, enhanced quality, product or service customisation, and more loyal consumers [60-62].

Finally, the fourth cluster, highlighted in yellow, contains the most relevant keyword, *technology*, which has presented substantial difficulties to management, frequently necessitating organisational transformation. Management's attention determines the effectiveness of digital transformation and its capacity to acquire information from inside and outside the organisation [26]. The state's involvement in advancing digitalisation initiatives cannot be overlooked since it must provide the necessary framework for use in the commercial

domain with adequate efficiency [63]. As a helpful structuring tool, a framework for digital advancement should be established at the state level and by all firms, saving resources [64].

The bibliometric analysis suggests that the digitalisation of companies is based on the following pillars: leadership, size, innovation, performance and technology used. Considering this, we analyse desi_3 data over the 2016-2021 period.

METHODOLOGY

The term σ -convergence refers to closing the gap between Member States over time, whereas the term β -convergence focuses on identifying a prospective catching-up process.

The σ -convergence (relative standard deviation or coefficient of variation) allows comparing manifolds or samples with various averages and attributes to be compared. The coefficient of variation is the proportion of the average relative departure of the parameter values from the mean. σ -convergence occurs when the dispersion of development levels diminishes with time. In our scenario, we are dealing with a manifold comprising the desi_3 index values from 2016 to 2021.

The calculation of relative dispersion is given in formula (1):

$$V_{(\%)} = \frac{\sigma_t}{\bar{x}} (100) \%, \tag{1}$$

where: σ_t = the variance of the desi_3 indices at time t and (\bar{x}) = the average of the desi_3 indices. The standard deviation is calculated according to formula (2):

$$\sigma_{t} = \sqrt{\frac{\sum_{i=1}^{n} (x_{it} - \bar{x})^{2}}{n}},\tag{2}$$

 x_{it} = the desi_3 index of an ith Member State at time t; (\bar{x}) = the average of the desi_3 index, and n denotes the number of Member States.

Based on the hypothesis of absolute β -convergence, formula (3) expresses the empirical relationship between growth per Member State and the initial level of development:

$$\frac{1}{T-t_0-1}\ln(\frac{X_{iT}}{X_{it_0}}) = \alpha + \beta * \log(x_{it_0}) + \varepsilon_i,$$
(3)

where $\frac{1}{T-t_0-1} \ln(\frac{X_{iT}}{X_{it_0}})$ is the average annual growth rate of the values of the desi_3 index for the ith Member State; t₀ is starting year; *T* ending year; x_(ito) the initial level of development of the desi_3 index; ε_i the error, which is assumed to be independent and identically distributed; while α and β denote the parameters to be estimated.

In this expression, the initial development level alone explains the catching-up rate. The sign and value of the β coefficient indicate the strength of the effect. Univariate linear regression (OLS) was used to estimate the α and β coefficients. However, the estimation would be errorfree only in the case of a perfect relationship (r = 1 or r = -1), and therefore ϵi is the error of the estimate. The least-squares procedure was used to minimise the squared error to estimate the coefficients α and β . The β -coefficient was considered significant only if the empirical significance level (p-value) was less than 5 %. However, conditional convergence suggests too much information hidden in α and ϵi to be extracted on a case-by-case basis, but in this case, we only tested absolute convergence.

RESULTS

In 2016, the desi_3 core indicator values varied from 10 % to 40 % (with most Member States falling between 21 % and 30 % (15 states). Finland received the highest score (37,39 %),

somewhat behind but still in the same ballpark as Sweden and Denmark (31 % - 40 %). Bulgaria, Latvia, Romania, Poland, and Hungary rank last (10 % to 20 %).

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Figure 2. Distribution of desi_3 core indicator values in 2016 and 2021.

The dispersion of the core indicator values has expanded from three to four ranges by 2021, from 21 % to 60 %. Most Member States fall between 31 % and 40 % (8 countries). There has been no notable change at the top, while Malta and the Netherlands have joined Finland, Sweden, and Denmark in the top quadrant. Looking at the absolute values of the desi_3 core indicator, Bulgaria, Poland, Hungary, and Romania did not significantly improve their position; therefore, they remain at the bottom of the ranking. They have not made considerable progress in digital inclusion during the last six years. Croatia, Luxembourg, the Czech Republic, and Spain matched the EU average between 2016 and 2021. Finland will have the most significant level of digital technology integration in 2021, followed by Denmark and Sweden (Figure 3). Bulgaria, Hungary, Romania, and Poland are on the other side. The ranking of nations for the desi_3 core indicator has not changed much during the reviewed time. Latvia has the highest average growth rate (14.3 %) and one of the lowest rates in 2016; thus, its strong growth rate is predictable, but it still has a long way to go. Estonia, Malta, and Croatia are next in line in terms of catching-up rates, followed by nations that have been and are already at the forefront of digital technology integration, with an average rate of progress of between 9 % and 10 %.



Figure 3. Country rankings based on the desi_3 core indicator. Additional information from 2016-2021 and the average rate of development.

The underlying premise of β -convergence is that increases in the desi_3 core indicator are more significant in nations with a lower value. This assumption, however, is not supported in our scenario. Although there is a negative connection (-0,0197) between the starting level of development and the average growth rate of the desi_3 core indicator from 2016 to 2021, the regression coefficient is not significant since the p-value (0,0556) is higher than α (0,05), Table 3.

No. Observations	R-squared	Intercept Coeff.	β	θ	t-value	p-value
27	0,1388	0,1548	-0,0197	_	-2,0075	0,0556

 Table 3. Linear regression values for the desi_3 core indicator.

Because the dispersion of the desi_3 core indicator displays a declining tendency over time, the EU-27 Member States converge, but this is not the case here. The relative dispersion amongst the EU-27 Member States is not diminishing; therefore, the desi_3 indicator displays a slight divergence, Figure 4. The disparities shrank between 2016 and 2018. Following that, the tendency reversed, and the dispersion of development levels began to expand again.



Figure 4. σ -convergence for the desi_3 core indicator between 2016-2021.

The β -convergence serves the σ -convergence since it is required for the compression and densification of cross-sectional data from worse-performing nations. However, Ligeti [65] has mathematically demonstrated that β -convergence is only required but insufficient for σ -convergence.

As a subdimension, digital intensity (desi_3a) assesses utilising various digital technologies at the corporate level, Figure 5. The digital intensity of a corporation is determined by how many of the following 12 technologies it employs: 1) website; 2) the fastest fixed internet connection has a maximum contracted download speed of at least 30 Mb/s; 3) the website has at least one of the following: description of goods or services, price lists; possibility for visitors to customise or design goods or services online; tracking or status of orders placed; personalised content on the website for regular/returning visitors; 4) businesses where more than 50 % of employees used a computer with internet access for business purposes; 5) providing more than 20 % of employees with a portable device that allows internet access via a mobile phone network for business purposes; 6) sending e-invoices for automated processing; 7) cloud computing; 8) hiring ICT professionals; 9) companies with at least 1 % of turnover from e-

commerce; 10) analysing data sets from any source (external or internal); 11) using industrial or service robots; 12) using 3D printers.



Figure 5. Country rankings based on the digital intensity of SMEs (2021).

The percentage of firms using digital technologies varies between 55 % and 65 % across Member States, and the intensity of use ranges from 4 to 6 technologies [66]. Companies in Denmark and Finland have very high digital penetration, with at least 4 to 9 of the 12 digital technologies listed above being used. The percentage in Eastern European enlargement nations is significantly lower, with Bulgaria and Romania at the bottom of the scale (30 %). In Latvia and Hungary, the situation is slightly better but far from ideal because the proportion of SMEs that integrate digital technologies is low (between 40 % and 45 %), but the digital intensity, which would imply merging them, is at most 3.

The EU Member States of Finland, the Netherlands, Belgium, and Denmark are at the forefront of enterprise use of digital technology (desi_3b), Figure 6. Digital technology application in the company includes:

- enterprise resource planning (ERP) and customer relationship management (CRM) systems,
- use and adoption of social media tools companies that use at least two of the following: social networking sites, corporate blogs and microblogs, multimedia content-sharing websites, wiki-based knowledge-sharing tools,
- big data analytics companies that analyse data sets from any source,
- cloud computing services companies that purchase at least one of the following cloud computing services: Enterprise database hosting, accounting software, online case management systems (CRM), operational performance,
- artificial intelligence businesses that use at least two: written language for analysis; machine learning; automation of various work processes or decision making; conversion of spoken language into machine-readable format; identification of objects or people based on images; generation of written or spoken language and AI technologies that allow machines to physically move based on autonomous decisions based on observation of the environment,
- ICT for environmental sustainability number of environmentally friendly measures adopted by the company,
- e-invoices use of e-invoices that allow automated processing.



Figure 6. Ranking of Countries Based on the Degree of Integration of Digital Technologies in Enterprises (desi_3b) (2021).

Finland is the leader in social media adoption and cloud service use, Belgium is the leader in electronic information exchange, and Maltese firms are leaders in big data analytics and artificial intelligence. More than 85 % of businesses in Portugal indicate that their use of ICT has resulted in substantial green initiatives, putting them top. Nearly 95 % of Italian businesses send electronic invoices (32 % in the EU-27). Less than a fifth of firms in Hungary, Poland, Bulgaria, Romania, Slovakia, and Latvia use any digital technologies listed here.

Furthermore, Ireland, the Czech Republic, Denmark, Belgium, and Sweden have the highest aggregate performance in e-commerce (desi_3c). Individual indicators for e-commerce as a sub-dimension include SMEs selling online (at least 1 % of total revenue), total e-commerce turnover, and the percentage of SMEs selling online across borders (Figure 7).

Ireland is the undisputed leader in all three of these categories. SMEs in Bulgaria, Greece, Luxembourg, and Latvia have yet to recognise the numerous opportunities e-commerce presents.



Figure 7. Ranking countries by e-commerce (desi_3c) (2021).

DISCUSSION

Because they constitute the preponderance of EU enterprises and are a major source of innovation, SMEs play a critical role in this transformation. Digitalisation may give SMEs several chances to increase their manufacturing processes' efficiency and produce more creative goods and business models. There are many ways to measure efficiency: partial, complex, social, corporate, regional and macro-economical [67]. Blockchain, artificial intelligence, cloud computing, and high-performance computers may significantly boost competitiveness. The European Commission's 2030 goal is to have more than 200 European Digital Innovation Centres and industrial clusters in the EU to support the digital transformation of both innovative and non-digital SMEs, ensuring that they have straightforward and fair access to digital technologies or data under appropriate regulatory conditions and receive appropriate digitisation support. The goal is to achieve high digital intensity to ensure no one falls behind. To achieve the 2030 targets, the Commission will reform its industrial strategy to expedite the digital transformation of industrial ecosystems. The "Digital Agenda 2030: A European Way to Achieve the Digital Decade," adopted by the European Parliament in March 2021, is overseen by the "Digital Agenda for the Decade" policy, which establishes the following end goals for digital business transformation to achieve the EU-wide digital goals by 2030:

- 75 % of EU businesses use cloud services, big data and artificial intelligence,
- more than 90 % of EU SMEs achieve at least a basic level of digital intensity,
- the EU will increase the opportunities for its growing innovative businesses and improve their access to finance, leading to a doubling of unicorns [68].

According to classical and neoclassical economics, technical development and innovation are the primary drivers of growth [14, 69-72]. Economic growth can only be accomplished by investing in human capital and increasing the integration of digital technologies. The incorporation and use of digital technologies are inextricably related to human capital development [73]. As a result, the emphasis should be on increasing learning opportunities and research, exploration, and development efforts at both the government and industry levels. A framework for digital advancement should be built at the state level and by all firms as a resource-saving structuring tool [64]. The state's responsibility in fostering companies' digitalisation efforts cannot be avoided since it should provide the necessary framework to guarantee that it can be used in the business sector efficiently [26]. Management's attention to digitalisation and its capacity to acquire information from within and outside the organisation influence the effectiveness of digital transformation.

The desi_3 core Indicator is divided into digital intensity, digital technology integration, and e-commerce. Digital intensity and technological integration are essentially the product of the firm owners' decisions and their ability to recognise digitalisation's opportunities. To make the digital shift a reality, they require the proper skills and financial backing [51-53]. The degree of digitalisation also varies among economic activities, with high degrees of digitisation in sectors such as computing, telecommunications, publishing, cinema and music, television, travel and tour operators, and so on. [36]. We confirm that the shift in the desi_3 indices does not imply any convergence amongst the Member States, according to hypothesis H_0 . The main premise of β -convergence is that increases in the desi_3 core indicator are more significant in nations with a lower value. However, this assumption is not statistically supported, although the starting level of development is negatively related to the average growth rate of the desi_3 core indicator from 2016 to 2021.

Company Size And Digitalisation – A Case In Hungary

Development policy divides companies into four categories according to their size: micro, small, medium and large. Depending on the enterprise size, the nature of the digitalisation solutions used, their embeddedness in day-to-day operations, and their impact on competitiveness vary widely. From a digitalisation perspective, the number of employees/users is a key characteristic of an effective work organisation.

Table 4 shows the business results by company size for SMEs operating in Hungary in 2021 [74]. It is clear from the revenue per employee data that the smaller the enterprise, the less productive it is, and the larger the size of the enterprise, the more productive it is. From our point of view, this is interesting because efficiency is closely related to digitalisation, and experience shows that the smaller the enterprise, the less it uses the opportunities offered by digitalisation. In many cases, this is due to the difficulty of generating the costs of the digital switchover and the "brain drain" effect of large international companies offering more competitive salaries, which makes it very difficult for domestic SMEs to attract workers with high digital skills.

Table 4. Business	performance	indicators by	category	of small	and	medium-	sized	enterprises
in Hungary (2021)								

SME's enterprise category	Number of enter- prises	Number of emplo- yees	Turn- over per em- ployee, Eur	Distribution of number of employees, %	Net turn- over from sales, million Eur	Distribution of net turnover of sales, %	Value added (at factor cost), million Eur	Distribution of value added (factor cost), %	Turn- over from export sales, million Eur
Microenter- prise with 0 employees	41 732	-	_	-	880	0,2	199	0,2	60
Microenter- prise with 1 employee	604 145	604 145	23 897	19,0	14 438	3,8	4 780	5,7	562
Microenter- prise with 2-9 employees	196 878	656 385	50 916	20,6	33 421	8,8	9 534	11,4	1064
Small enterprises	36 119	560 430	95 263	17,6	53 389	14,1	13 247	15,9	4 864
Medium enterprises	5 602	365 226	145 732	11,5	53 225	14,0	11 329	13,6	12 123
Non-SME's organisa- tions	7 630	1001 496	224 051	31,4	224 387	59,1	44 417	53,2	106 270
Total	892 106	3187 682	119 127	100	379 739	100	83 503	100	124 942

Over several years, let us look at the KSH's relevant statistics (Hungarian Central Statistical Office). We can report an improvement: the value added and productivity ratio of the SME sector has improved greatly compared to large enterprises, but further strengthening is needed to exploit the economy's growth potential [74].

CONCLUSIONS

Integrating and properly implementing digital technology at the company level is a crucial differentiator that leads to a competitive advantage. We may infer that, at the moment, neither β - nor σ -convergence is seen between the Member States by reviewing and evaluating the values of the European Commission's DESI index on digital technology integration. Although the coefficient is negative, the gap between developed and undeveloped Member States is narrowing, which is not statistically significant (p-value > α). The insignificance indicates that the growth rate of digital technology integration in less developed Member States is not greater than that of developed Member States. The presence of σ -convergence would suggest a decrease in the disparities between Member States over time, i.e. a decrease in the relative dispersion between levels of development over time. Because β -convergence is a required but not sufficient condition for σ -convergence, the lack of β -convergence anticipated the absence of σ -convergence.

Members of the European Union who joined after 2004 were often rated in the bottom half of the rankings. Regarding digital technology integration, the key aggregate indicator, Hungary was just one rank ahead of Bulgaria in 2021 and one place below Romania in 2016. Romania's average annual growth rate was one percentage point greater during this period.

Looking at specific metrics, Hungary has a long way to go. The proportion of SMEs having at least basic digital intensity is 46 %, which is lower than the EU-27 average of 60 % but higher than Bulgaria, Romania, and Latvia. At the EU level, the 90 % aim is still far from being met, with Hungary accounting for half of the target and Bulgaria and Romania accounting for barely a third. The Commission stresses using big data analytics, cloud services, and artificial intelligence as examples of digital technologies for business use. Hungary is likewise in the bottom third, coming in 22nd and 23rd place. It only qualifies for last place when seen as a whole (as seven distinct indicators combined). 14 % of enterprises in Hungary (27th) utilise some ERP system, while the same proportion uses social media (25th). E-invoices for automated processing are used by 13 % of Hungarian enterprises, which is still less than one-third of the EU average. In e-commerce, Hungary's difference from the EU average is not clear, with a more considerable disparity in cross-border online sales. Given the low degree of digital penetration among firms, ranking 22nd in e-commerce is not a bad outcome. Overall, we confirm the digital divide among enterprises in the European countries [75].

To summarise, increasing the usage of digital technologies in businesses requires educating the business community on the various applications of digital technology. Many breakthrough technologies are viewed as threats rather than opportunities. As we will explore in the literature review, the combination of leadership, size, innovation, performance and technology is necessary for digitalisation efforts to be realised within a company. The absence or underdevelopment of these factors can affect overall success. At the same time, it is critical to recognise that digital technology-based advancements come at a high financial cost, which must be offset by human resource development. In order to calculate the return on investment, the expenses of human resource deployment, training, and retraining must be included. The government should encourage digital growth through different procurement methods, which is also inadequate. Developing the ICT sector as an integrated component with the firm in question would also be necessary, surrendering independence to implement projects efficiently.

We believe that, particularly in the case of SMEs, entrepreneurs are more likely to engage in different digitalisation-related activities instinctively rather than deliberately, considering the possible benefits/disadvantages.

Complementing the descriptive statistics currently used in analysing the desi_3 core indicator with the methods presented in this study could help connect macroeconomics to solutions. The evolution of the DESI index and its main constituent indicators, and their monitoring, will provide evidence of whether the Member States currently lagging in the digitalisation process are catching up and the effectiveness of the improvements.

LIMITATIONS

To perform the σ - and β convergence calculations, we used the values of the DESI overall index, which are presented as a transformed percentage. This database was used as the basis for our analysis and was not compared with other databases monitoring the digital development of human capital.

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INEQUALITY IN E-LEARNING IN EUROPEAN UNION COUNTRIES: ROLE OF GENDER, EDUCATION AND URBAN DEVELOPMENT

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ABSTRACT

E-learning is increasingly used in modern educational institutions, especially since the COVID-19 pandemic. By examining the role of gender, education, and urban growth in e-learning, we can learn more about possible differences and digital divides within and between EU countries. To successfully address inequality in education, legislators need to understand the causes of inequalities. The paper aims to examine e-learning inequality across European Union (EU) countries, comparing the most developed EU countries (namely the EU-15) with other EU countries. To avoid the possible biases that could occur due to the COVID-19 infection, we focus on two years before the pandemic, 2017 and 2019. To account for gender, education, and urban development differences, we compare the usage of e-learning among the individuals belonging to these groups. The results show that the EU-15 countries consistently perform better compared to the other EU countries. This suggests that the digital divide is difficult to overcome, as it persists despite the EU's strong efforts under the Digital Europe umbrella to align its member countries by technological level.

KEY WORDS

e-learning, inequality, gender, education, urban development, European Union

CLASSIFICATION

JEL: D23, M54

INTRODUCTION

E-learning has become prevalent in higher education institutions worldwide [1] and especially became the predominant model for education delivery after COVID-19 [2]. In e-learning, the digital divide refers to inequalities or imbalances in accessing and using digital resources for educational or non -non-educational purposes [3]. The causes for the digital divide might range from age, cost, and know-how perspectives such as the "Z" and "X" generations, the devices' exorbitant cost, lack of know-how, availability of devices, internet access, digital skills, and affordability are all critical factors in online learning [4]. Furthermore, online participation can be hindered in rural or underserved areas by inadequate Internet connectivity, low digital literacy, and high costs [5]. The reduced digital divide in e-learning can promote social mobility, inclusion, and social cohesion and enable more people to participate actively in educational, economic, and social activities [6].

E-learning has also become a prominent mode of education in the European Union, offering numerous benefits such as flexibility and accessibility. However, despite its potential to bridge educational gaps, e-learning may inadvertently exacerbate existing inequalities. To bridge the digital divide in e-learning, governments and organisations must invest in infrastructure, provide subsidies for digital devices and Internet access, offer digital literacy training, and implement policies to promote inclusive e-learning initiatives. In this way, countries can help reduce the digital divide and provide equitable access to education and engagement in the digital age [7]. The European Union (EU) has actively supported the growth of e-learning through numerous programs, policies, and funding initiatives. The Digital Literacy Action Plan (2021-2027) aims to develop digital literacy, improve the quality of digital learning, and provide equitable access to high-quality, inclusive digital education for all learners, regardless of their socioeconomic background [8].

In addition to the vigorous efforts of the European Commission to promote digital literacy in e-learning, there are still significant differences between European countries [5]. Other factors such as gender, education level, and urbanicity also affect the level of e-learning adoption. Therefore, the study aims to explore the role of gender, education, and urban development in shaping the digital divide within the context of e-learning in EU countries, not only at the country level but also at the level of specific gender, education, and urban-rural groups. Since the two groups of European countries, i.e. the EU-15 and the other countries, differ significantly in their development, the use of e-learning at the level of specific gender, educational, and urban-rural groups is compared between these two groups of EU countries. Since Covid-19 significantly impacted e-learning adoption, we focus on the pre-pandemic period. To confirm the significance of our findings, we compare two years, 2017 and 2019.

The paper is organised as follows. After the introduction, the second part presents the theoretical background. In the third part, the methodological approach is presented and explained. The fourth part presents and discusses the results of the analyses, while the fifth part concludes the study.

BACKGROUND

E-LEARNING BENEFITS

The importance of education for human development is well documented and under percentages the catalytic role of education in developing national and human capital [1]. Education is a means of self-development through learning, knowledge, skills, and habits that are transmitted across generations. E-learning has become a widely used concept for higher education institutions as the use of Information and Communication Technologies (ICT) to

deliver educational content and learning support has become ubiquitous. Even before the COVID-19 pandemic, e-learning has become the accepted norm for many higher education institutions worldwide [9]. Various proponents of e-learning believe that it can significantly impact the quality of education, student achievement, and student engagement [10]. What is important and worth exploring is that the context and universities have shifted to online mode and radically changed their educational processes, as universities, even those that were previously reluctant to change their educational approach, had no choice but to shift to online teaching and learning [11] fully.

The role and popularity of ICT in society are evident, mainly its role in supporting education during the COVID-19 pandemic as institutions migrated to the online world [12]. Consequently, the pandemic pushed educational institutions to prioritise remote learning [13]. Large segments of the developed world have embraced the Internet, virtual reality, and related technologies to work and learn from home [14]. Researchers report that students prefer digital media to printed materials to support learning [15]. On the other hand, researchers are concerned that some educational institutions are using traditional, teacher-centred methods rather than 21st-century learning techniques that support critical thinking and independent and learner-centred learning [16]. Digital technologies allow learners to access rich multimedia materials that are more effective than printed materials beyond space and time constraints [17]. In the 21st century, online learning methods are increasingly used to support distance and blended learning for on-campus and off-campus students [18]. E-learning is a viable solution for people with busy and conflicting schedules that prevent them from attending face-to-face classes. e-Learning technologies improve knowledge sharing between students and instructors and strengthen communication channels, leading to better performance [19].

From our superficial understanding of online learning is a type of method in which (1) the learner is at a distance from the educator, (2) the learner uses some form of technology (Internet and a device-computer, laptop, tablet or smartphone, etc.) to access the learning materials or interact with an educator and other learners (3) some support is provided to learners [20].

It is essential to understand the impact of distance education on the effects of education and the social consequences of retaining this type of education. Many researchers have studied the effects of distance education on education in depth and have concluded that distance education has several advantages, such as ensuring continuity of education [21], ensuring lifelong learning [22], and reducing the high costs associated with traditional education [23]. Constraints such as teaching methods, scheduling, and time existed as teachers and learners were in different locations [24]. The impact was not limited to the educational system but also impacted the student learning experience when it comes to accessing research and study materials. For example, students' access to textbooks and resources to review may be hindered by a lack of copyright restrictions and exceptions. Hebebci et al. [25]conducted a study in Turkey to determine what teachers and students thought about the COVID-19 pandemic distance education applications. According to the study, students in distance education mode have difficulties in doing group projects because they lack socialisation on campus, as 42.9 percent of the respondents reported. Sadeghi [26] comprehensively explained the advantages and disadvantages of distance education. He argued that distance learning has the advantages of studying from anywhere at any time, saving significant amounts of money, not having to commute, having the flexibility to choose the learning course, and saving time. However, it also has some disadvantages, such as the high risk of distraction, the use of complicated technology, no social interaction, the difficulty of keeping in touch with instructors, and the fact that labour markets do not accept online degrees.

THE DIGITAL DIVIDE IN E-LEARNING

The digital divide is the difference between people or communities accessing and effectively using ICT and those without [27]. It is the inequality in access to digital devices, Internet connections, and digital navigation capabilities[3]. The digital divide is often measured at the national level, that is, between countries or regions with higher levels of advanced technology use and those with lower levels of use [5]. Recent research indicates that the digital divide is still strongly present in the European Union countries [28].

The digital divide in e-learning refers specifically to inequalities in access to and use of digital resources for educational purposes [3]. As education increasingly incorporates digital technologies such as online courses, educational apps, and digital learning platforms, students and faculty who do not have access to these tools are at a disadvantage. Access to devices, internet connections, digital literacy, and affordability are critical to online learning [29]. In rural or underprivileged areas, limited internet access, limited digital literacy, and high costs can hinder participation. Providing these resources can help disadvantaged students succeed in online learning and, consequently, succeed in education. The digital divide in e-learning is critical for several reasons, including educational equity, workforce readiness, economic growth, social mobility, and inclusivity [6]. Access to quality education is essential for personal development and socioeconomic advancement, but a digital divide creates inequities and makes it difficult for some students to access resources. A well-educated and technologically skilled population contributes to a country's growth and innovation [30]. Reducing the digital divide in e-learning can also improve social mobility and promote inclusivity and social cohesion, allowing more people to participate fully in educational, economic, and social activities [31].

To bridge the digital divide in e-learning, governments and organisations must invest in infrastructure, subsidise digital devices and Internet access, provide digital literacy training, and adopt policies to promote inclusive e-learning efforts [7]. In this way, countries can work to close the digital divide and ensure that all citizens have equal access to education and participation in the digital age. The EU has actively supported the development of e-learning through various programs, policies, and funding initiatives. The Digital Education Action Plan (2021-2027) aims to improve digital literacy, enhance the quality of digital learning, and ensure equitable access to high-quality and inclusive digital education for all learners, regardless of their socioeconomic background [8].

The Erasmus+ program supports education, training, and youth projects and provides funding opportunities for e-learning projects, virtual mobility, and digital innovation. The European Institute of Innovation and Technology (EIT) drives innovation and entrepreneurship across Europe and fosters partnerships between academia, research, and industry to promote digital skills and technologies in education. Horizon Europe is the EU's research and innovation program that provides funding opportunities for research projects in digital education and elearning. The European Structural and Investment Funds (ESIF) provide financial support to EU member states to address regional disparities and promote economic and social cohesion. EU Code Week encourages citizens to engage with programming and digital literacy while policy frameworks promote technology use, data protection, and innovation in e-learning. The European Digital Skills Awards recognise individuals, organisations, and initiatives that make an outstanding contribution to the development of digital skills and e-learning. The EU also supports the development and deployment of e-learning platforms and tools through various funding programs and partnerships that provide accessible and interactive learning experiences for learners across Europe.

Previous research on e-learning adoption has examined in depth the differences in usage patterns by gender, education level, and residential setting. Several studies have reported notable differences in the use of e-learning by men and women. In general, women are more likely to participate in e-learning, especially in higher education, suggesting that they are more likely to prefer digital learning platforms. According to one study, female students have a stronger intrinsic motivation to take online courses than their male peers [32]. Another study suggests that women are more confident online than in a face-to-face setting, more willing to learn from other students and seek support, more self-directed than men, and strongly desire to engage academically [33]. A growing body of research suggests that women are particularly suited to online learning [34]. However, the reasons for this trend are unclear and require further research.

Regarding educational level, research has consistently shown that individuals with higher levels of formal education are more likely to engage in e-learning activities than those with lower levels of education [35]. This trend may be due to the fact that individuals with higher levels of education have better digital skills and access to technology, which makes it easier for them to participate in online learning environments. In addition, research has shown that the acceptance of e-learning varies greatly depending on where people live [36]. In urban areas, e-learning adoption tends to be higher due to better Internet connectivity and access to digital devices. In contrast, rural areas face challenges related to Internet infrastructure and limited access to technology, resulting in lower e-learning participation among residents.

METHODOLOGY

DATA

To analyse the level of e-government in European countries, we use data collected by statistical offices and available at Eurostat. Respondents were asked many questions about e-learning. We focused on a broad question in which respondents answered whether they had done at least one of the following in the last year: (i) participated in an online course (of any subject); (ii) used online learning materials; (iii) communicated with teachers or students via educational websites/portals. The level of e-learning adoption, as measured by the broad question above, was examined for different statistical groups, as shown in Table 1. For example, the variable ALL measures the percentage of individuals at the country level who have completed at least one of the e-learning measures in the last year. On the other hand, the variable F- HIGH measures the percentage of women with high formal education who have done at least one of the e-learning actions in the last year.

To determine the extent of e-learning inequality in European Union countries, two groups of countries were observed: EU-15 and rest of the countries. The term EU-15 (EU-15) refers to the 15 Member States of the European Union as of December 31, 2003, before the new Member States joined the EU. The 15 Member States are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. Since in 2017 and 2019, the UK was still a member country, we take it into account as member of EU-15. On the other hand, EU-Other is the abbreviation for the member states of the European Union (EU), which consists of a group of 13 countries (Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia). The variable EU-GROUP indicates the group to which the country belongs.

Indicator	Code	Statistical groups	Measurement
	ALL	All Individuals	
	M_LOW		
Any of the	F_LOW	Females with low formal education	
following	M_MED	Males with medium formal education	
doing an online	F_MED	Females with medium formal education	
course (of any	M_HIGH	Males with high formal education	
subject); (11)	F_HIGH	Females with high formal education	
learning	ALL_LOW	Individuals with no or low formal education	% of
communicating	ALL_MED	marviauais	
or students using	ALL_HIGH	Individuals with high formal education	
educational	CITY	Individuals living in cities	
websites/	TOWN	Individuals living in towns and suburbs	
portais	RURAL	Individuals living in rural areas	
	BROAD	Individuals living in a household with broadband access	
Country Group	EU_GROUP	EU-15 vs. EU-28	EU-15 (1); Other (2)

Table 1. Indicators used in the analysis.

STATISTICAL ANALYSIS

The statistical analysis is conducted in two steps and answers to two research questions:

RQ1: What is the impact of education, gender and urban development on e-learning inequality?

RQ₂: What are the differences between EU-15 and other countries on e-learning indicators?

For obtaining answer to the first research question, Paired Wilcoxon-signed rank test of differences in e-learning between 2017 and 2019 has been conducted. For obtaining the answer to the second research question, T-test comparison of e-learning adoption indicators between EU-15 and other countries has been conducted.

RESULTS

IMPACT OF EDUCATION, GENDER AND URBAN DEVELOPMENT ON INEQUALITY IN E-LEARNING

Figure 1 shows the mean values of the percentage of citizens using e-learning for different genders, educational groups, and groups with different levels of urbanisation. This information is used to answer the first research question (RQ1) about the influence of education, gender and urbanisation on e-learning inequality. For all observed groups, the indicator measuring the percentage of citizens using at least one form of e-learning increased. The highest increase was in the groups (all, male and female) of citizens with high formal education and citizens living in cities. Conversely, the lowest increase was among citizens with low and medium formal education. For all observed indicators, the percentage of males who used at least one type of e-learning activity was greater than that of females.



Figure 1. Mean values of e-learning indicators of EU countries; 2017 and 2019, n = 28 European Union member states.

Table 2 shows the descriptive statistics of the observed variables for all European Union Member States for 2017 and 2019. Individuals with low formal education use e-learning the least for both genders, but also experience the slowest growth in e-learning use. On the other hand, individuals of both genders with high formal education use e-learning to the highest extent and with the strongest growth, both in absolute and relative terms.

	2017						Mean				
Indicator	Min	Max	Mean	St. Dev.	Min	Max	Mean	St. Dev.	difference (2017-2019)		
All individuals											
ALL	7	40	19,82	8,794	8	41	22,68	8,90	2,86 (+14 %)		
			Indivi	iduals with	low fo	ormal ec	lucation				
M_LOW	0	39	16,50	11,574	2	41	17,96	11,34	1,46 (+9 %)		
F_LOW	1	42	14,46	11,909	0	43	15,75	11,61	1,29 (+8 %)		
ALL_LOW	1	40	15,46	11,542	2	42	16,64	11,30	1,18 (+8 %)		
			Individu	uals with m	nedium	formal	education	ı			
M_MED	6	40	18,00	10,077	7	37	19,46	9,90	1,46 (+8 %)		
F_MED	4	37	17,54	9,712	7	37	19,82	9,83	2,28 (+13 %)		
ALL_MED	5	35	17,79	9,739	7	35	19,64	9,71	1,85 (+10 %)		
			Indivi	duals with	high fo	ormal e	ducation				
M_HIGH	14	55	31,54	11,536	15	56	36,18	10,07	4,64 (15 %)		
F_HIGH	14	54	30,43	11,210	15	55	35,36	10,03	4,93 (+16 %)		
ALL_HIGH	15	53	30,89	11,246	16	55	35,93	9,94	5,04 (+16 %)		
		Indi	viduals,	according	to diffe	rent urb	panisation	level			
CITY	9	46	23,57	9,086	10	48	27,21	9,90	3,64 (+15 %)		
TOWN	4	39	18,57	8,813	6	41	21,61	8,82	3,04 (+16 %)		
RURAL	3	39	16,86	9,395	4	34	17,96	8,26	1,1 (+7 %)		

Table 2. Descriptive statistics of the observed variables; 2017 and 2019, n = 28 European Union member states.

Table 3 shows the results of the paired Wilcoxon signed rank test. The differences between the level of e-learning in 2017 and 2019 among individuals with low levels of formal education and those living in rural areas are statistically significant at the 5 % level. On the other hand, the differences between the level of e-learning in 2017 and 2019 among individuals with high levels of formal education who live in urban areas are statistically significant at the 1 % level.

Measure 1	Measure 2	w	z	р	VS- MPR ^ª	Rank- Biserial Correlation
ALL_2017	ALL_2019	33,000	-3,748	<,001***	450,991	-0,825
M_LOW_2017	M_LOW_2019	89,500	-1,729	0,043**	2,724	-0,403
F_LOW_2017	F_LOW_2019	96,500	-2,006	0,023**	4,286	-0,450
ALL_LOW_2017	ALL_LOW_2019	101,000	-2,114	0,017**	5,229	-0,466
M_MED_2017	M_MED_2019	62,500	-2,500	0,006***	11,588	-0,583
F_MED_2017	F_MED_2019	31,000	-3,400	<,001***	135,252	-0,793
ALL_MED_2017	ALL_MED_2019	55,000	-3,030	<,001***	49,467	-0,687
M_HIGH_2017	M_HIGH_2019	21,500	-3,911	<,001***	787,130	-0,877
F_HIGH_2017	F_HIGH_2019	28,000	-3,985	<,001***	1.057,314	-0,862
ALL_HIGH_2017	ALL_HIGH_2019	12,500	-4,240	<,001***	2.865,929	-0,934
CITY_2017	CITY_2019	20,500	-3,821	<,001***	581,387	-0,874
TOWN_2017	TOWN_2019	30,000	-3,695	<,001***	367,772	-0,829
RURAL_2017	RURAL_2019	87,500	-2,018	0,022**	4,358	-0,462
BROAD_2017	BROAD_2019	35,000	-3,431	<,001***	158,053	-0,785

Table 3. Paired Wilcoxon-signed rank test of differences in e-learning between 2017 and 2019.

Vovk-Sellke Maximum p -Ratio: Based on a two-sided p-value, the maximum possible odds in favour of H₁ over H₀ equals $1/(-e p \log(p))$ for $p \le .37$ [36]

***statistically significant at 1 %

**statistically significant at 5 %

DIFFERENCES IN E-LEARNING INDICATORS BETWEEN EU-15 AND OTHER EU COUNTRIES

The descriptive statistics of e-learning indicators for the EU-15 and other EU countries in 2017 and 2019 are summarised in Table 5 and Table 6 to provide an answer to the following second research question (RQ2), which examines the differences between the EU-15 and other countries in terms of e-learning indicators.

Country-by-country data for the variable ALL can be found in Appendix. The lowest percentages of e-learning use stand out in several countries. The percentage of all individuals using at least one form of e-learning varied widely across EU countries. In Bulgaria, for example, it was among the lowest at around 8,20 % in 2017 and increased slightly to 9,23 % in 2019. In Greece, e-learning adoption was also relatively low, at 6,57 % in 2017 and 8,35 % in 2019. The use of e-learning was also down in Hungary, at about 9,61 % in 2017 and 10,38 % in 2019.

On the other hand, in Sweden, about 40.04 % of students used e-learning in 2017 and 41,20 % in 2019. Finland showed significant e-learning penetration, with 31,35 % in 2017 and 37,27 % in 2019. These figures show how widespread e-learning is in these countries, where a higher percentage of the population actively used e-learning platforms for educational purposes during this period.

It is noteworthy that the leaders in the use of e-learning are all EU-15 members: Finland and Sweden. This observation shows that the EU-15 countries have adopted e-learning to a greater extent than the rest of the EU during the study period. This result is in line with the theoretical conclusions of the study, as it supports the idea that the more developed EU countries are more successful in adopting e-learning than their less developed counterparts.

Table 4 shows the descriptive statistics of the 2017 e-learning indicators comparing the EU-15 countries and other EU countries. As before, the indicators are grouped by different categories such as gender, education level, and living environment.

Indicator	Groups	Ν	Mean	SD	Var. C., %	Mean difference (EU-15 vs. other)
ALL	Other EU	13	15,85	6,829	43,1 %	7,42
	EU15	15	23,27	9,043	38,9 %	
M_LOW	Other EU	13	15,92	11,729	73,7 %	1,08
	EU15	15	17,00	11,826	69,6 %	
F_LOW	Other EU	13	13,62	11,384	83,6 %	1,58
	EU15	15	15,20	12,695	83,5 %	
M_MED	Other EU	13	12,38	7,974	64,4 %	10,48
	EU15	15	22,87	9,311	40,7 %	
F_MED	Other EU	13	13,15	8,802	66,9 %	8,18
	EU15	15	21,33	9,069	42,5 %	
M_HIGH	Other EU	13	27,62	10,767	39,0 %	7,32
	EU15	15	34,93	11,430	32,7 %	
F_HIGH	Other EU	13	27,23	10,232	37,6 %	5,97
	EU15	15	33,20	11,614	35,0 %	
ALL_LOW	Other EU	13	14,85	11,379	76,6 %	1,15
	EU15	15	16,00	12,053	75,3 %	
ALL_MED	Other EU	13	12,69	8,230	64,8 %	9,51
	EU15	15	22,20	8,938	40,3 %	
ALL_HIGH	Other EU	13	27,38	10,276	37,5 %	6,55
	EU15	15	33,93	11,492	33,9 %	
CITY	Other EU	13	19,46	6,267	32,2 %	7,67
	EU15	15	27,13	9,812	36,2 %	
TOWN	Other EU	13	14,69	7,598	51,7 %	7,24
	EU15	15	21,93	8,614	39,3 %	
RURAL	Other EU	13	13,77	8,418	61,1 %	5,76
	EU15	15	19,53	9,643	49,4 %	

Table 4. Descriptive statistics of e-learning indicators in EU-15 and other EU countries in 2017.

The results suggest that EU-15 countries had slightly higher rates of e-learning adoption than other EU countries in 2017. Significantly higher e-learning rates were observed in the EU-15 countries, particularly in the M_MED and ALL_MED categories, which include men and women with intermediate formal education and those with middle formal education. In contrast, differences in the groups M_LOW, F_LOW, and ALL_LOW, which include individuals with limited or no formal education, were quite small in the EU-15 and other countries.

In terms of the urbanisation situation, there was a notable discrepancy in the use of e-learning by people living in cities in the EU-15 countries, as shown by the category CITY. Conversely, the discrepancies in the use of e-learning were comparatively smaller among residents of cities and suburbs, characterised by the category TOWN, and among residents of rural areas, represented by the category RURAL.

Regarding the urbanisation situation, there was a remarkable discrepancy in the use of elearning by people living in the cities of the EU-15 countries, as shown by the category CITY. Conversely, the discrepancies in the use of e-learning were comparatively smaller among the inhabitants of cities and suburbs, characterised by the category TOWN, and among the inhabitants of rural areas, represented by the category RURAL.

Table 5 provides an overview of the descriptive statistics of e-learning indicators in the EU-15 and other EU countries in 2019. The indicators are divided into two groups: Other EU, which includes 13 observations, and EU-15, which includes 15 observations.

Indicator	Groups	N	Mean	SD	SE	Var. C., %	Mean difference (EU-15 vs. Other)
ALL	Other EU	13	18,15	7,175	1,990	39,5 %	8,45
	EU15	15	26,60	8,559	2,210	32,2 %	
M_LOW	Other EU	13	17,85	12,335	3,421	69,1 %	0,22
	EU15	15	18,07	10,840	2,799	60,0 %	
F_LOW	Other EU	13	15,85	13,133	3,642	82,9 %	0,179
	EU15	15	15,67	10,581	2,732	67,5 %	
M_MED	Other EU	13	13,08	6,639	1,841	50,8 %	11,92
	EU15	15	25,00	8,968	2,316	35,9 %	
F_MED	Other EU	13	14,69	8,548	2,371	58,2 %	9,58
	EU15	15	24,27	8,836	2,281	36,4 %	
M_HIGH	Other EU	13	31,69	9,105	2,525	28,7 %	8,37
	EU15	15	40,07	9,460	2,443	23,6 %	
F_HIGH	Other EU	13	31,69	8,410	2,333	26,5 %	6,84
	EU15	15	38,53	10,494	2,710	27,2 %	
ALL_LOW	Other EU	13	16,54	12,421	3,445	75,1 %	0,20
	EU15	15	16,73	10,667	2,754	63,7 %	
ALL_MED	Other EU	13	13,92	7,455	2,068	53,5 %	10,68
	EU15	15	24,60	8,806	2,274	35,8 %	
ALL_HIGH	Other EU	13	32,00	8,813	2,444	27,5 %	7,33
	EU15	15	39,33	9,861	2,546	25,1 %	
CITY	Other EU	13	22,62	7,795	2,162	34,5 %	8,59
	EU15	15	31,20	10,009	2,584	32,1 %	
TOWN	Other EU	13	17,46	7,633	2,117	43,7 %	7,74
	EU15	15	25,20	8,377	2,163	33,2 %	
RURAL	Other EU	13	13,69	6,969	1,933	50,9 %	7,97
	EU15	15	21,67	7,641	1,973	35,3 %	

Table 5. Descriptive statistics of e-learning indicators in EU-15 and other EU countries in 2019.

When analysing the use of e-learning across different levels of education (ALL_LOW, ALL_MED, and ALL_HIGH), it is clear that the EU-15 countries consistently have higher average percentages than other EU countries in each category. For individuals classified as having low or poor formal education (ALL_LOW), the average percentage for the EU-15 countries was 16,73, but for the other EU countries it was 16,54. For individuals with a moderate level of formal education (ALL_MED), the average percentage for the EU-15 countries was 24,60, while for the other EU countries it was 13,92. For individuals who have achieved a high level of formal education (ALL_HIGH), the average percentage for the EU-15 countries was 39,33, while it was 32,00 for the other EU countries.

Regarding the classification of residential areas (CITY, TOWN and RURAL), the EU-15 countries have continuously better average percentages in the respective category compared to other EU countries when evaluating the use of e-learning. To illustrate, the average percentage for those living in urban areas (CITY) was 31.20 for the EU-15 countries, but 22.62 for the other European Union (EU) countries.

Table 6 presents significant data results on the differences in e-learning adoption between the EU-15 countries and other countries within the European Union.
Indicator			2017.		2019.					
indicator	Т	df	Р	VSMPR ^a	Т	df	р	VSMPR ^a		
ALL	2,418	26	0,023**	4,255	2,804	26	0,009***	8,367		
M_LOW	0,241	26	0,811	1,000	0,050	26	0,960	1,000		
F_LOW	0,345	26	0,733	1,000	0,040	26	0,968	1,000		
M_MED	3,172	26	0,004***	17,160	3,944	26	<,001***	90,387		
F_MED	2,413	26	0,023**	4,215	2,903	26	0,007***	10,089		
M_HIGH	1,735	26	0,095*	1,650	2,377	26	0,025**	3,977		
F_HIGH	1,432	26	0,164	1,241	1,883	26	0,071*	1,959		
ALL_LOW	0,259	26	0,798	1,000	0,045	26	0,965	1,000		
ALL_MED	2,911	26	0,007***	10,253	3,432	26	0,002***	29,406		
ALL_HIGH	1,579	26	0,127	1,407	2,061	26	0,049**	2,473		
CITY	2,421	26	0,023**	4,270	2,502	26	0,019**	4,892		
TOWN	2,341	26	0,027**	3,758	2,539	26	0,017**	5,212		
RURAL	1,672	26	0,107	1,542	2,868	26	0,008***	9,437		
BROAD	2,108	26	0,045**	2,644	2,611	26	0,015**	5,902		

Table 6. T-test comparison of e-learning adoption indicators between EU-15 and other countries.

Vovk-Sellke Maximum p -Ratio: Based on a two-sided p-value, the maximum possible odds in favour of H₁ over H₀ equals $1/(-e p \log(p))$ for $p \le .37$ [36]

***statistically significant at 1 %

** statistically significant at 5 %

*statistically significant at 10 %

The results of the t-test show a statistically significant difference in the overall indicator of elearning adoption (ALL) between the EU-15 and the other countries in both 2017 (t = 2,418, p = 0,023**) and 2019 (t = 2,804, p = 0,009***). The results indicate that, on average, EU-15 member states have higher rates of e-learning adoption than other countries within the European Union in both years. When examining e-learning adoption in terms of gender and education level, the t-tests revealed intriguing trends. In both 2017 (t = 3,172, p = 0,004***) and 2019 (t = 3,944, p < 0,001***), there was a statistically significant difference in e-learning adoption between the EU-15 and the other countries, especially among men with an intermediate level of formal education (M_ MED). Similarly, for females with an intermediate level of formal education (F_ MED), the t-tests show a statistically significant difference between the EU-15 and other countries in both 2017 (t = 2,413, p = 0,023**) and 2019 (t = 2,903, p = 0,007***). The results indicate that EU-15 countries have higher adoption of elearning among women and men with an intermediate level of formal education in both years.

The results of the t-tests show no statistically significant difference between EU-15 and other countries in 2017 (t = 1,579, p = 0,127) on the overall indicator of e-learning adoption for individuals with high formal education (ALL_HIGH). However, a statistically significant difference was found in 2019 (t = 2,061, p = 0,049**). This indicates that the rates of e-learning use among individuals with a high level of formal education were comparable in the EU-15 and other EU countries in 2017. However, in 2019, EU-15 countries had higher rates of e-learning use among this population. When we focus on women with a high level of formal education (denoted as F_HIGH), the results of the t-tests show that in 2017 there were no statistically significant differences in the rates of e-learning use between countries within and outside the EU-15 (t = 1,432, p = 0,164). In 2019, a slight but statistically striking difference was found between the two groups (t = 1,883, p = 0,071*). Looking more closely at men with a high level of formal education (M_HIGH), the t-tests performed show that there was a slight but statistically significant difference between the EU-15 countries and the other nations in terms of e-learning use in 2017 (t = 1,735, p = 0,095*). In addition, a statistically significant

difference was found in 2019 (t = 2,377, p = 0,025**). The results suggest that although there were no statistically significant differences in e-learning adoption rates among men and women with high levels of formal education in 2017, by 2019, the EU-15 countries had higher e-learning adoption rates among these groups. Nevertheless, t-tests performed for indicators such as M_LOW, F_LOW, M_HIGH, and F_HIGH did not reveal statistically significant differences between the EU-15 and other countries. This suggests that the adoption of e-learning within these groups showed comparable trends in the EU-15 and the other EU countries in the years studied. In addition, when the level of urbanisation (CITY, TOWN and RURAL) is taken into account, the t-tests show statistically significant differences between the EU-15 and for TOWN in both 2017 (t = 2,421, p = 0,023**) and 2019 (t = 2,502, p = 0,019**), and for TOWN in both 2017 (t = 2,341, p = 0,027**) and 2019 (t = 2,539, p = 0,017**). The results of this study show that the adoption rate of e-learning was comparatively higher in the metropolitan regions of the EU-15 countries than in other countries in both years.

The findings provide important insights into the digital divide in e-learning use within the European Union. They underscore the need to take targeted initiatives to ensure equal access to digital education in all members countries.

CONCLUSION

SUMMARY OF FINDINGS

After the COVID-19 pandemic, e-learning has become popular in modern educational institutions, providing a new method of learning and knowledge acquisition. However, the widespread use of e-learning has made potential inequalities and digital divides between and within European Union (EU) member states more apparent. This scholarly article examines how gender, education, and urbanisation influence e-learning inequality across EU member states.

To reduce the impact of COVID-19 related biases, the study focuses on a comparative analysis between the most developed EU countries (EU-15) and other EU countries using data from the two years prior to the pandemic, 2017 and 2019. The researchers hope to learn about the discrepancies by looking at citizens of different groups by gender, education, and urban development standards.

According to the study's findings, the EU-15 countries consistently outperform other EU member states in e-learning. The digital divide persists despite significant EU efforts, including projects under the Digital Europe umbrella, to close technological gaps and promote equal access to online learning resources.

THEORETICAL AND PRACTICAL IMPLICATIONS

The study provides theoretical support for the claim that educational inequalities significantly affect the adoption of e-learning in European Union countries. The negative impact seen in rural areas and among those with less education highlights the need to close the digital divide by increasing access to e-learning tools and technology in underserved areas, confirming the conclusions of Vogels [37]. To promote the adoption of e-learning for all, policymakers and educators should focus on targeted interventions to improve educational opportunities in these marginalised groups.

Living in urban areas has a positive impact on the adoption of e-learning, highlighting the importance of these areas as centres for technological development and easy access to online resources, and reaffirming Vogels' findings [36]. According to the findings, targeted efforts to

improve technological infrastructure and e-learning resources in rural areas are needed to close the gap in access to online education between urban and rural areas. Policymakers should consider initiatives to close this gap, as they can have broader implications for socioeconomic development and regional expansion.

Living in urban areas has a positive impact on the adoption of e-learning, highlighting the importance of these areas as centres for technological development and easy access to online resources, and confirming the findings of Vogels [37]. According to the findings, targeted efforts to improve technological infrastructure and e-learning resources in rural areas are needed to close the gap in access to online education between urban and rural areas. Policymakers should consider initiatives to close this gap, as they can have far-reaching implications for socioeconomic development and regional expansion.

However, the results of our study suggest that women in disadvantaged situations, such as having little formal education and living in rural areas, were less likely to participate in elearning. The study highlights the importance of gender in elearning adoption, especially among people in rural areas with low levels of education, which is also pointed out by Almasri (2022) [38]. A more inclusive elearning environment that empowers and encourages all genders to participate in online education is necessary to address these gender inequalities, which requires gender-sensitive policies and targeted interventions [39]. These findings are even more worrying considering that recent research indicates that girls had more anxiety related to the usage of elearning during pandemics [40]. These findings are especially important, since higher inclusion of women overall has a positive impact on economic development, especially for the developing countries [41].

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

The research results of this paper are preliminary, which is due to the limited methodological approach. However, these limitations also provide a good foundation for future research. First, the use of data from the two years preceding the COVID-19 pandemic is a limitation (2017 and 2019). This decision was made to avoid potential pandemic-related bias. Future studies could incorporate information from the post-pandemic years to provide a more thorough and up-to-date analysis of the changing e-learning landscape.

Second, the study is not able to establish a causal relationship between the variables since the effects of educational level, gender, and urbanisation level were not directly observed but were indirectly expressed through the analysis of different groups of individuals. Future research could use longitudinal or experimental designs to learn more about the causes of these relationships, such as [42]. Supplementing quantitative data with qualitative research techniques such as focus groups or interviews can shed light on the perspectives and life experiences of people affected by educational disparities in e-learning. Studies that track e-learning adoption and associated factors over time, or longitudinal studies, may be able to identify changing patterns and trends in educational inequality. Long-term analyses would be beneficial in understanding the impact of policies and technological advances on e-learning adoption.

Future research could also shed light on emerging trends and specific areas and conditions, such as pandemics. First, although the pandemic had a significant impact on e-learning, research indicated that the country's response significantly depended on the level of economic development, thus raising additional concerns about the digital divide in e-learning [43]. Since the pandemic stopped, researchers should investigate its long-term effects on e-learning since the question emerges whether the changes implemented in classrooms will pertain, how long and to what extent [44]. Second, research on the implementation of e-learning in specific

disciplines, such as economics and business, should shed light on the country differences. For example, research indicates that although there are some significant improvements in elearning implementation at the country level, such as in Croatia [45, 46], there are still significant differences between countries [47]. Finally, future research is strongly encouraged by emerging technologies, such as machine learning [48] and simulation games [49].

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APPENDIX

Table 7. Percentage of all individuals using at least one of the e-learning activities in 2017 and 2019 (source: Eurostat).

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Country	2017	2019	Country	2017	2019
Austria	19,92	22,22	Italy	16,37	18,84
Belgium	20,29	23,73	Latvia	19,11	22,26
Bulgaria	8,20	9,23	Lithuania	20,99	23,77
Croatia	10,01	15,67	Luxembourg	36,60	27,56
Cyprus	10,42	12,55	Malta	25,05	24,04
Czechia	12,99	15,54	Netherlands	26,37	29,64
Denmark	24,06	32,29	Poland	11,34	12,96
Estonia	30,90	35,29	Portugal	24,41	25,49
Finland	31,35	37,27	Romania	16,68	16,35
France	14,66	18,18	Slovakia	13,05	14,84
Germany	17,51	20,56	Slovenia	18,14	22,93
Greece	6,57	8,35	Spain	27,65	30,89
Hungary	9,61	10,38	Sweden	40,04	41,20
Ireland	13,27	26,38	United Kingdom	29,57	36,83

EFFICIENCY OF CULTURAL AND CREATIVE INDUSTRIES: A PREFERRED REPORTING ITEMS FOR SYSTEMATIC REVIEWS AND META-ANALYSIS GUIDED SYSTEMATIC REVIEW OF DATA ENVELOPMENT ANALYSIS APPLICATIONS

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ABSTRACT

This article identifies and analyses the applications of the main non-parametric Data Envelopment Analysis methodology in the efficiency measurement of the creative and cultural industries and sectors. The overarching goal of this study is to survey all the relevant published studies in this area and present and analyse their results to synthesise the state of knowledge in the creative and cultural industries and sectors. Moreover, another goal is to provide a theoretical background to the creative and cultural industries and the Data Envelopment Analysis methodology.

This article conducts Preferred Reporting Items for Systematic Reviews and Meta-Analysis – a guided systematic review with stringent selection criteria to include relevant Data Envelopment Analysis applications in the creative and cultural industries. The methodology resulted in 13 relevant articles regarding the efficiency of creative and cultural industries and the application of the Data Envelopment Analysis methodology in the creative and cultural industries and sectors. The main findings reveal that there are no studies employing the Data Envelopment Analysis method in the creative and cultural industries many issues for future consideration. Moreover, all the different perspectives on the efficiency evaluation of the creative and cultural industries are presented. The ultimate objective is to point out to academic members, researchers and analysts globally to apply the Data Envelopment Analysis methodology more often in the creative and cultural industries and sectors and refer to future research priorities in this field.

KEY WORDS

cultural and creative industries, data envelopment analysis, DEA creative economy, literature review

CLASSIFICATION

JEL: C14, C44, Z10

INTRODUCTION

One of the most popular and commonly used efficiency evaluation methodologies is the Data Envelopment Analysis (DEA). It is a non-parametric methodology that has been primarily developed for the efficiency evaluation of nonprofit organisations (such as the humanitarian assistance organisations in South Korea in [1] and the efficiency evaluation of university departments in [2] but has evolved into one of the most applied non-parametric methodologies in many industries today, such as banking [3, 4], transportation [5], public sector [6], and others. More on the DEA methodology is given in Subsection 2.2. The main objective of this study is to identify all the relevant published studies in this area up to this point, as well as to present, address and analyse their findings as a means for the synthesis of the state of knowledge in the field of the creative and cultural industries and sectors (CCS). For reference, [7] focused on human creativity as the most important economic resource to assess the efficiency of the creative sector, i.e. the production of creative goods in Mexico and examined 36 metropolitan areas in four different periods. For that reason, they implemented the DEA to estimate the static performance of creative industries and the Malmquist productivity index to evaluate the dynamic efficiency of the creative industries. Article [8] highlights corporate social responsibility, i.e. the influence of corporate social responsibility on financial performance in the creative industry in a sample of 53 creative firms in China.

In this article, the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines for systematic literature review were applied to summarise relevant past findings regarding the efficiency of creative and cultural industries, focusing on the different applications of the leading non-parametric methodology DEA. The contribution of this article is reflected in the identification and presentation of the different perspectives shown when employing the DEA methodology in CCS, as well as the summing up of the findings and research trends of the field.

Based on the above, the work is structured into 5 sections. In addition to this introduction, the second section provides a literature review of the culture and creative industries and the DEA, addressing the research gap. Section 3 revolves around the methodology. Section 4 presents the results, i.e., the surveyed articles, their used DEA models, the combinations of different methodologies, and their findings. Section 5 opens up a discussion and provides concluding remarks.

LITERATURE REVIEW

CREATIVE AND CULTURAL INDUSTRIES

There is no single definition of the term "creativity", and it is studied by different disciplines such as psychology, arts and sociology and creativity "as a concept is subject to a myriad of interpretations" [9; p.3]. It can be defined as "the results of individuals exercising their imagination and exploiting (or preventing others from exploiting) its economic value" [10; p.21]. Moreover, "human creativity is the most important economic resource" [7; p.1] and "the use of creativity, skills and individual talents to create prosperity and employment by generating and exploiting the individual's creative and creative power" is a definition to the creative industry as an economic branch [11; p.1]. Creativity is "a complex and multidimensional phenomenon which includes skills, talent, cultural support, and innovative capacity" [9; p.3].

However, how and when the creative and cultural industries emerged reflects different opinions in the literature. [12; p.30] claim CCS are not new economic industries and have existed "since the early history of mankind". According to [13], the introduction and inception of the creative and cultural industries and sectors date back to the late 1990s, when the Creative Industries Task Force of the Department for Culture, Media and Sport established the CCS's first

definition. Their definition included 13 subsectors of creative industries, including advertising, architecture, arts and crafts, designer fashion, broadcast media, film, games, music, performing arts, publishing and printing, software and computer service. Even though these industries have already been established, their collection "under the umbrella of a single category" was in the late 20th century [14; p.7]. Following its rapid growth and development, the creative and cultural industries have gained huge popularity in the 21st century. Nevertheless, they hold a crucial position in the economy due to their contribution to gross domestic product (GDP), production scale, international trade cooperation and the creation of new jobs "while accomplishing tenable development and high-technology interaction" [15; p.2]. Moreover, they represent "a significant engine of economic growth, job creation, and social cohesion" [16; p.1] as well as "a hub of managerial innovation and experimentation and new organisational and business practice to stimulate innovation and entrepreneurship in other sectors of the economy" [16; p.1].

Therefore, creative and cultural industries attract so much attention from academic members and researchers nowadays. Moreover, the issue of the efficiency of creative and cultural industries has become appealing as the industry's rapid growth continues. There are three most known and used approaches to measure efficiency in the literature, as follows: the ratio indicators, the parametric (Stochastic Frontier Approach - SFA, Thick Frontier Approach -TFA and Distribution Free Approach – DFA) and the non-parametric methodologies (the DEA and Free Disposal Hull - FDH) [17]. The term "creative industries" is a relatively new concept which evolved from the terms cultural industries and creative art [18]. Even though the creative and cultural industries are a young economic sector and "emerging industries that are still under development" [8; p.256], they are rapidly growing throughout the world and have become one of the most important and innovative economic sectors, as a result of the "rapid development of economic globalisation and the creative economy, as well as the international division of labour and industrial value chain" [19; p.154]. Moreover, scholars claim that these industries "promote human development while promoting economic growth, while maintaining and protecting historical and cultural heritage, improving cultural capital, and fostering communities as well as individual creativity" [11; p.3].

The creative and cultural industries have become the "most dynamic sector of the world trade", growing 12 % faster in Europe than the average rate [20; p.29]. The importance of these industries is reflected as multi-layered. Namely, they increase the cultural and societal force of the societies, they move the creative capital and empower the creative workers, and they originate economic growth (through the "ripple effect") [21; p.31]. The literature thus far has referred to creative and cultural industries as "creative industries, cultural industries, creative economy or cultural economy" [13; p.2]. They have also been regarded as "a means to cure economic stagnation and boost sustainable development", especially in developing countries [22; p.1].

The definition today is much wider. Namely, [12; p.20], classify creative industries into "Arts, Media and Creative business services". Moreover, they claim that "the creative industry is a heterogeneous sector, with a multiplicity of varied branches and firms" [12; p.24] that are different in size, market coverage, labour intensity, productivity and business performance. On the other hand, [23; p.759], refers to Creative industries as "a range of selected economic activities in the sectors of advertising, architecture, arts, culture tourism services, design, fashion, film, R&D, high-tech, games, and media".

The main specifics of the creative industries are that "consumption is taste-driven and thus, products and services derived from these industries are subjective to each individual" [24; p.203], and the diversity of the creative industry's products is due to their origin stemming from "creativity, skill and talent" [24; p.203]. Moreover, they are characterised as industries with "low resource consumption, low environmental pollution, intense creativity, and high added worth" [15; p.1].

The emancipation and modernisation of the creative sector have accelerated the popularity, contribution to the economy and recognition of the creative and cultural industries [12]. Their contribution to regional economic growth, though, has introduced these industries as "the new drivers in economic development" [8; p.274].

Empirical studies on the efficiency and performance of the creative and cultural industry are still scarce, and this systematic review aims to inspire scholars to evaluate different sectors and subsectors of these industries empirically.

DATA ENVELOPMENT ANALYSIS

DEA is a data-oriented approach and a non-parametric method for linear programming used for evaluating the performance (i.e. the relative efficiency) of a set of units called decision-making units (DMUs), which uses multiple input and output variables in the evaluation.

Since its introduction in 1978 by Charnes, Cooper and Rhodes, researchers in numerous fields have widely applied the DEA methodology. This method is widely recognised as an excellent and easy-to-use method for modelling operational processes for performance evaluation [25].

DEA methodology's main strength over the regression analysis is the unnecessary a priori specification of the model. Instead, it provides information on whether the analysed inputs and outputs of the analysed DMUs lie below or above the efficient frontier. However, it should be considered that it is a method that analyses the relative efficiency within the analysed sample of peer units [26; p.159].

The DEA methodology has two basic models: the CCR model (which got its name from the first letters of the surnames Charnes, Cooper, Rhodes [27] and the BCC model (after Banker, Charnes and Cooper [28]. The main difference between these two models is how they treat returns to scale, i.e. ranking. While the BCC model allows variable returns to rank – the variable returns-to-scale (VRS) assumption, the CCR model assumes that each DMU (homogeneous decision unit) operates with constant returns to the scale used – constant returns-to-scale (CRS), which means that all units operate at their optimum. [28] extended the CRS model to consider VRS probability.

The results obtained from DEA classify the units into efficient and inefficient. Efficient Units (DMUs) are those best-practice banks that score 100 %, while other banks score between 0-100 %.

RESEARCH GAP

The main purpose of this article is to contribute to the theory regarding the applications of the DEA methodology in CCS. Therefore, the main research question is mirrored in the efforts to identify all the relevant published studies in this area up to this point and to present, address and analyse their findings as a means for the synthesis of the state of knowledge in the field of the CCS. Through the answer to the research question, the primary theoretical contributions are mirrored in summarising the findings and research trends of the field.

METHODOLOGY

In this research, the PRISMA-guided literature review has been applied as a means to summarise relevant past findings regarding the efficiency of creative and cultural industries, with focused attention to the different applications of the leading non-parametric methodology DEA. The PRISMA guidelines were first introduced in 2009 as a means to "help systematic reviewers transparently report why the review was done, what the authors did, and what they found" [29; p.1] and are very convenient for "syntheses of the state of knowledge in a field, from which future research priorities can be identified" [29; p.1].

The PRISMA-guided review and the research design are presented in Figure 1. Namely, the first step of the research was a survey and exploration of the two selected scientific databases (Scopus and the Clarivate Web of Science) using several keywords and key phrases to encompass all relevant published studies. The selected databases are the most relevant global scientific databases. The studies we wanted to survey are published in Scopus-indexed or Web of Science-indexed peer-review journals. The used keywords are as follows: *data envelopment analysis (dea), creative sector, creative industries, cultural industries, and creative economy*. This resulted in a total of 100 studies.

In the second step, the search was refined, and the focus was set on studies published in English and fully downloadable studies. However, no years of publication were entered as a criterion for this research, which means all the published studies since the introduction of DEA in 1978 have been included. This was done on purpose since all the relevant articles have been included since the introduction of the DEA. Moreover, this also highlighted the research gap in the applications of DEA in the CCS sector. This approach resulted in 85 hits.

In the following steps (screening and eligibility), an exclusion criterion has been applied to duplicate articles (i.e. articles that were indexed in both Scopus and Clarivate Web of Science databases) and to articles that did not concern the creative and cultural sectors (which was decided after the initial screening and manual abstract review). Finally, after applying all of the exclusion criteria, 13 publications remained in the inclusion phase, representing the basis for our further and more qualitative analysis, which is carried out in the next section.



Figure 1. The research design and the selection process of the articles for the literature review (PRISMA-guided).

APPLICATIONS OF DEA IN THE CULTURAL AND CREATIVE INDUSTRIES

This study has surveyed the most relevant scientific databases (i.e. Scopus and Web of Science) in systemising the previous relevant published work regarding the efficiency of the creative and cultural industries and sectors with the application of DEA. The research design makes it evident that the DEA methodology, although very popular in banking, agriculture, supply chain, transportation, and public policy [30], is insufficiently applied to the creative and cultural industries globally.

This section presents a tabular overview of the research results (Table 1), and a qualitative analysis of each of the 13 surveyed articles and their findings has been made after that.

A quantitative analysis of the creative sector has been conducted by [12]. In their study, they investigate the spatial economic nature of the creative sector, with a particular view to both the spatial genesis of this sector in the Dutch economy from 1994 to 2009. Therefore, they explored the role of four large agglomerations in the Netherlands, i.e. Amsterdam, Rotterdam, The Hague, and Utrecht. The findings from their 'Flying Disc' developed model indicate that the level of implementation of SPM (Strategic Performance Management) significantly contributes to the higher super-efficiency of firms and the "access to agglomeration and spatial economies, available resources, knowledge and financial institutions, trade associations, do not dominate in a firm's location in the later stage of the SPM implementation process" [12; p.30].

In the study of [23], an exploration of whether the geographical location of business firms influences the performance of creative high-tech sector firms is performed. They provide a micro-business perspective of business performance and its interrelatedness with spatial entrepreneurship and general economic conditions. Their findings reveal that the adoption of SPM and the geographical position in the country significantly affect the firms' performance. They included performance indicators (e.g., turnover, profit, cost) and relevant background variables (managerial quality, employee satisfaction, innovative milieu, industrial networks, spatial accessibility). The results indicate that implementing SPM provides many financial and non-financial benefits to the firms, "location matters, but not to the same extent for all firms, and distance matters more for some businesses than others" [23; p.773]. This study provides great scientific and practical contributions because it connects location and cultural organisation theories with the SPM model and literature.

The authors [19] employed the DEA methodology to evaluate the efficiency of cultural creative industries in ten cities in China in 2014. In their model, they have applied several cultural creative industries parks, the proportion of cultural creative enterprise, proportion of creative class, proportion of R&D expenditure, quantities of patent application, per capita GDP as inputs and proportion of cultural creative industries in added value as an output. Their findings reveal that Dalian's cultural creative industry parks lack efficient planning, independent innovation and creative talent cultivation mechanisms. The practical contribution of this study is great since they have drawn conclusions and recommendations for the government as follows: "The government should extend the humanistic context of the city, improve the cultural quality of the city, and develop Donggang District into several industrial clusters" [19; p.159].

Lu, W.-M. et al. [31] have implemented DEA methodology and the network-based approach to evaluate the cultural and creative promotion performance of the cities/counties in Taiwan that can be treated as benchmarks. Namely, this study offers the most important input and output variables and identifies cities and counties that could be treated as benchmarks.

Article (Year)	Application	DEA model	Time frame	Country
[12] (2012)	Creative firms as change agents in creative spaces	DEA + spatial- econometric approach + 'Flying Disc' model (SEM)	1994-2009	Netherlands
[23] (2013)	In search of creative champions in high-tech spaces: a spatial application of strategic performance management	DEA + SPM model - 'Flying Disc' model (SEM) + GIS-oriented statistical analysis	2008	Netherlands
[19] (2017)	Evaluation of cultural creative industry efficiency in Dalian	DEA CCR model + evaluation index system	2014	China
[31] (2017)	Exploring the cultural and creative promotion performance	DEA and network- based approach	2008-2012	Taiwan
[7] (2017)	Examination of the efficiency of the production of creative goods	DEA + Malmquist productivity index	1998, 2003, 2008, 2013	Mexico
[32] (2018)	Creative industries agglomeration and industrial efficiency	VRS model of DEA	2004-2014	China
[8] (2019)	Influence of corporate social responsibility on corporate performance	Dynamic DEA approach + regression (OLS)	2010-2013	China
[11] (2020)	Assessing the efficiency of sub-sectors of the creative industry	Output-oriented CRS DEA model	n.d.	Indonesia
[9] (2020)	Reliability of Creative Composite Indicators with Territorial Specification in the EU	Principal Component Analysis (PCA), (DEA) and Distance P2(DP2)	2011, 2012 and 2015	20 EU countries
[33] (2020)	Measuring European cultural and creative cities efficiency	A meta frontier DEA approach + the composite index (IEC3)	2017	European cities
[34] (2021)	Measuring and Decomposing SMEs' Productivity in Creative Economic Sector	DEA + Malmquist Total Factor Productivity (TFP) index	2014-2018	Indonesia
[35] (2021)	Benchmarking culture in Europe: A data envelopment analysis approach to identify city- specific strengths	DEA + BoD approach	n.a.	European cities
[15] (2022)	Efficiency Measurement and Heterogeneity Analysis of Chinese Cultural and Creative Industries	A three-stage DEA model + stochastic frontier analysis (SFA)	2012-2018	China

Table 1: Applications of DEA in the creative and cultural industries.

The findings reveal an economic gap between urban and rural areas considering the "promotion and development of the cultural and creative industries in Taiwan" [31; p.1], i.e. the CCI promotions in the urban areas are considered more efficient and successful than those in the rural areas of Taiwan. They also found some geographical differences, stating northern Taiwan as the most efficient area in Taiwan. This study provides crucial practical implications and suggestions for further CCI development that could contribute to worldwide policy-makers and city governments.

The focus on human creativity as "the most important economic resource" [7; p.1] to assess the efficiency of the creative sector, i.e. the production of creative goods in Mexico, is the main concept of the study of [7]. As a result of this, an examination of 36 metropolitan areas in four different periods, 1998, 2003, 2008 and 2013, is conducted. Their findings indicate that "most of the efficient, creative industries in Mexico are to be found in metropolitan areas that are not relatively large" [7; p.1]. Moreover, their results show that a great portion (over three-fourths) of the creative sectors in metropolitan areas are inefficient. This study provides scientific and practical implications since it covers Florida's 3T model to investigate what factors affect these inefficiencies.

An investigation of the agglomeration externalities of creative industries that affect industrial efficiency at the regional and sector levels has been undertaken by [32]. The findings show that "the efficiency of creative industries is relatively low and distributed unequally, not only across different provinces but also among different creative domains in China" [32; p.17]. More importantly, they claim that creative industries' efficiency could improve if a cluster area consists of more small-sized creative firms than larger ones, which is an important input for policy-makers.

The relevant issue of corporate social responsibility, i.e. the influence of corporate social responsibility on financial performance in the creative industry, is the main motivation behind the work of [8]. Their findings indicate that "content media-related businesses, which include motion pictures, publishing, and broadcasting, are the performance growth leaders, and the regression result showed that corporate social responsibility has a significant positive influence on the financial performance of the creative industry" [8; p.269]. Moreover, the results reveal that "risk-taking and capital-oriented characteristics exist within the creative industry" [8; p.255].

Handayani et al. have conducted a study to evaluate the efficiency of 15 Batique enterprises in Semarang, Indonesia, with the application of the output-oriented CRS (Constant Return to Scale) DEA [11]. Their findings indicate that nine Batique firms are considered efficient, while the rest are relatively inefficient. Based on the obtained results of the inefficient DMUs, they propose targets for improvement, which is the greatest scientific contribution of this article.

A synthetic and composite indicator of creativity at a (NUTS 2) regional disaggregation level for a wide sample of 20 EU countries to enhance the assessment of "creative potential and to gain an insight into territorial behaviour" [9; p.1] have been constructed by [9]. The results from their work imply disparities and "inequality in the regional distribution of creativity" [9; p.1] among EU countries. Moreover, they found central and northern Europe, particularly national capital cities, to be the "principal creative clusters" [9; p.1]. These findings provide significant practical implications.

A "benchmark analysis of European cities based on the estimation of a composite index of efficiency from the dimensions of the Cultural and Creative Cities Monitor (CCCM) 2017" has been carried out by [33; p.891]. Interestingly, their study references cities such as Paris, Louvain and Cork as a basis for potential improvements. The benchmark analysis applied in

this article captures these cities with the best practices. It presents the interrelatedness of these three cities as a reference for the rest of the sample.

In the study of [34], the main focus is on measuring the productivity of SMEs in the creative economic sector across 23 districts/cities in Aceh, Indonesia, over the 2014-2018 period. The findings show "a low productivity level SMEs across the province" [34; p.7]. They go one step further and guide SMEs to improve efficiency, i.e., to implement good business governance principles and to extensively use ICT facilities, such as online sales and the Internet of things, in their marketing activities to improve their pure and technical efficiency. They also provide suggestions regarding the future government strategy, i.e. they suggest that a priority for promoting low-productivity SMEs be set with the help of "financial assistance and regular entrepreneurial and managerial training programs" [34; p.8].

The study of [35] examines the cultural sector as "an integral part of a city's quality of life, a driver of urban change, and a genuine economic sector" [35; p.584]. This proposed model provides valuable practical implications for city management due to its recommendations, identification of relative strengths and areas to be improved for each city, and overcoming the models' disadvantages and limitations with fixed weights. Moreover, "this approach allows for a 'fairer' comparison between cities by respecting their different local contexts and policy choices" [35; p.595]. Ultimately, their proposed model could help European cities in the processes toward a "culture-led development" [35; p.584].

A three-stage BCC DEA model for the period 2012 – 2018 was developed by [15] for the purpose of measuring the operating efficiency of 56 cultural and creative enterprises in China. The results show differences between the established efficiencies of the observed enterprises, and they found these differences are impacted by "environmental elements and white noise" [15; p.1]. Moreover, the overall technical efficiency results show that the efficiency of the CCIs is generally low. They propose a better "collaboration, support, and enhancement in the activities of the CCIs to serve as an engine for industrial and economic growth" [15; p.1].

The findings from the 13 qualitatively analysed studies in the inclusion phase of the research process reveal that there is a need for greater promotion and development of the cultural and creative industries in Taiwan, as there is an economic gap between urban and rural areas [36]; there is a need for the use of "approach that allows for a 'fairer' comparison between cities by respecting their different local contexts and policy choices" [35; p.595]. Other studies suggest benchmark analysis of cities with the best practices [33] and claim that corporate social responsibility has a significant positive influence on the financial performance of the creative industry [8]. Many studies provide guidance and suggestions regarding the future government strategy [19; p.159, 34] suggest that "the government should extend the humanistic context of the city, improve the cultural quality of the city, and develop Donggang District into several industrial clusters"; promotion of the development of creative industries agglomeration is initiated as it "can significantly increase the efficiency of creative industries" [32; p.17].

DISCUSSION AND CONCLUSION

This article employed a PRISMA-compliant systematic literature review of publications that employ DEA methodology in evaluating the efficiency of the creative and cultural industries worldwide. The research design (shown in Figure 1) has been initiated by exploring the two largest and most relevant scientific databases: the Scopus and the Web of Science database, which resulted in 100 studies. The employed PRISMA guidelines have eventually led to a total of 13 studies to be qualitatively analysed. Therefore, this study focuses solely on measuring the efficiency of CCS industries by applying the non-parametric mathematical programming methodology – the DEA.

This systematic review has revealed that all of the surveyed studies published in the Scopus and/or Clarivate Web of Science database were published between 2012 and 2022. Interestingly, no studies have employed the DEA method in CCS industries before 2012. Three of the studies were published in 2017 and three in 2020. Most of these 13 studies involve China's cultural and creative industries (four out of thirteen); two revolve around the EU cities, two around the Netherlands and two around Indonesia. Two studies [12, 23] have included the Flying Disc model in combination with the DEA. In contrast, [34] and [7] have combined the DEA with the Malmquist index.

The scientific contribution is reflected in the promotion of the DEA methodology among researchers in the creative and cultural industries and scientists in any scientific field. This systematic literature review would significantly contribute to the scholarly literature and is a stepping stone for future work and research on the CCS by implementing the DEA methodology. This study shows all the different perspectives on the efficiency evaluation of the creative and cultural industries. However, this study has several limitations. First, it is intriguing that there is a disproportion between the studies of DEA in CCS and the total number of DEA research. Namely, when exploring Scopus and Clarivate Web of Science databases with the keyword "DEA", 40 768 articles appear. However, the number dramatically goes down to a larger number of studies when combined with the *creative sector, creative industries, cultural industries, and creative economy.* This calls for additional efforts to incorporate the DEA methodology and all of its models in the creative and cultural industries field. Second, possibly not all relevant studies on the efficiency of the CCS industries have been analysed since, in this study, we focus on Web of Science and Scopus.

In future work, the authors plan to focus on the situation in the CCS Industries in Southeast European countries and address their common problems, such as the "brain-drain" phenomenon, the fact that the CCS industries are still developing, the high rate of unemployment, the underdevelopment of the relationships between the public, private and civilian sector, the reduced cultural spending and others. [21]. This scope would require a different approach, such as qualitative research among the cultural workers and operations research experts. Future research could also be directed towards the specific applications relevant to the regional development in Eastern European countries, such as arts in the development of tourist experience [37], as well as broader research areas taking into account specific performance cultures in companies [38]. Since CCS Industries, in some cases, have a significant impact on the environment, the balance between economic development and sustainability should also be the focus of future research [39].

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THE NINTH DIMENSION OF NATIONAL CULTURE: UNPACKING CROSS-CULTURAL COMMUNICATION STYLES

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ABSTRACT

This article aims to study the communication styles among different national cultures; that is, we examine the relationship between national culture, based on the Hofstede model, and communication styles. In order to investigate the role of national culture, it is fundamental first to analyze the communication styles and then identify how these are related to each other, with the purpose of identifying differences (or similarities) in communication styles across selected countries, a factor analysis was conducted, combined with an ANOVA test. Based on a sample from 10 different cultures: Germany, Sweden, Japan, China, Russia, Italy, the United States, the United Kingdom, Serbia and North Macedonia, and using communication assessment instrument as well as the data on Hofstede's six dimensions of national culture model, the findings show that different national cultures practise different communication styles. When the Professional-Casual communication style is concerned, Germany is the most professional, while Japan is the most casual; that is, the least professional of all while the analysis of the Cold-Warm communication style leads us to the fact that Sweden is the coldest, and the US is the warmest country. The study's significance is hopefully fundamental since it proposes an additional dimension, which is as frequent among cultures as it is rooted deeply in each culture. In this way, the article recommends that the countries ought to both comprehend their national culture and utilize it as a "tool" for understanding other cultures as well.

KEY WORDS

national culture, Hofstede, dimensions, communication, communication styles

CLASSIFICATION

JEL: D83

INTRODUCTION

Throughout the years, researchers have developed a number of hypotheses regarding national culture and how it is perceived in the society [1, 2]. According to Hofstede [3], culture is collective mental programming that differs one society from another. Symbols, rituals, ideals, and heroes are the four levels of culture in the society. By serving as symbols, objects and natural phenomena can change over time. In order to accomplish desired goals, rituals are particular beliefs that are practised in culture. In the society, heroes are revered as national icons where values are crucial components. They can be learnt early in life, are unseen, and do not alter [4]. In order to better understand the concept of national culture, identification of its different dimensions has greatly affected progress over the past several decades in comprehending cultural variations. The dimensions of national culture have been examined in numerous studies and have been frequently used in research, with Hofstede's model being one of the most common frameworks that has been utilized extensively in relation to national culture.

On the other hand, by definition, interpersonal communication is commonly characterized as "dyadic communication in which two individuals, sharing the roles of sender and receiver, become connected through the mutual activity of creating meaning" [5, 6]. Therefore, the acts of communication consist of content and relationship aspects, and of the need that all participants in the communication have to understand and interpret the content in a proper way, as well as to build a relation in order to come to a mutually accepted meaning [7].

Although cultural differences in communication have been explored for many years [8], there is a lack of studies that focus on the contrast of communication styles across more than a few countries. Moreover, more frequently, the studies are based on secondary data on national culture, which are not directly related to communication.

The purpose of this research is to suggest additional cultural dimension that will help us understand the cultural roots of communication and enable cultural comparisons that are directly related to how other different cultures use different communication styles. In doing so, the research makes use of Hofstede's dimensional model of national culture, a theory that has been mostly used when examining cultural differences. By using primary research data, the study suggests adding an extra dimension that can assist to explain cultural differences related to communication.

LITERATURE REVIEW

The concept of culture has been debated by anthropologists since the last 1800s, and it is still debatable regarding its proper meaning [9], but Taylor's definition is considered a foundation for all further interpretations of the concept [10]. In his view, culture is seen as "that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society" [11].

Yet, culture is not manifested in an individual; instead, it refers to the whole group.

It can be viewed at the level of organizations and nations. At the organizational level, Robbins and Judge [12] maintain that culture can be understood as a system of shared meaning held by members that distinguishes the organization from other organizations. When Schein [13] talks about culture, he defines it as: "a pattern of basic assumptions – invented, discovered, or developed by a given group as it learns to cope with its problems of external adaptation and internal integration – that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems". Consequently, Bojadjiev [14] defines organizational culture as "an unwritten system of values and norms that determines interactions, behaviours, decision making and processes within the organizations."

Hofstede, Hofstede and Minkov [4], in their examination of culture at national level, associate culture with DNA: "any particular organism (country) preserves its identity long after its initial cells have perished and been replaced because its cells (citizens) continue to pass on the same DNA (culture) through generations [4; p.26]. In this direction, cultures can maintain a constant state over lengthy periods of time, evolve over time, or react to unexpected changes. In [4], the authors argue: "national value systems should be considered given facts, as hard as a country's geographical position or its weather" [4; p.20]. Still, different studies show that cultures do change over decades. In his study, Iglehart [15] demonstrates a different trend in "selfexpression" among Western Europeans in years before and after 1990s. In addition, Olivas-Lujan, Harzing, and McCoy [16] provide evidence of short-term changes in American cultures in terms of "collectivism", "power distance" and "cosmopolitan" due to the terrorist attacks of 9/11, while Murphy, Gordon and Mullen [17] consider changes in American cultures in terms of "family security" and "freedom". Consequently, depending on different study methods, cultural aspects may be considered as fixed and steady, or changeable, both in short and long term. Minkov [9] reveals that there is no one-size-fits-all solution to the question of how stable or changeable culture is in all instances. It rather depends on the society, the type and degree of the influences putting pressure on its culture, and the type of change being tracked.

According to Hofstede [18], national culture means mental programming: "a pattern of thoughts, feelings, and actions that each person acquires in childhood and then applies throughout life". National culture explains the differences in attitudes towards work through differences in age, gender and workplace. In his model of national culture, Hofstede [18] describes the society's culture effect on values, by looking at six dimensions: Power Distance, Uncertainty Avoidance, Individualism/Collectivism, Masculinity/Femininity, Long-/Short-term Orientation and Indulgence/Restraint [2].

Some researchers question the accuracy of the original data and are not sure whether the data represents cultural trend in modern societies [19]. As a response to this criticism, Hofstede, Hofstede and Minkov [4] believe that, from theoretical standpoint, cultural values remain stable across generations.

Drawing from Hofstede's work on six dimensions of national culture and bringing it into business context, Bojadjiev et.al [20] propose a seventh and eighth dimension called 'fear of failure' and 'high status of entrepreneurs', respectively. They say these dimensions are important since they have an impact on the development of entrepreneurial business, but they are also very much connected with culture because the individuals' entrepreneurial behaviors are influenced by cultural norms and practices [21, 22]. These categories - 'fear of failure' and 'high status of entrepreneurs' are new dimensions that are to be added to Hofstede's already existent six-dimensional model. Figure 1 presents these eight dimensions.



Figure 1. The values of Hofstede indicators.

THE NINTH DIMENSION – COMMUNICATION TYPES

Yet, we do not think Hofstede's model should be only limited to these eight dimensions. As it is a fact that culture does have influence on doing business, we strongly believe that in this interconnection between culture and business, there is another dimension largely affected by culture; thus, we propose the concept of communication, which is normally defined as a two-way process wherein the information, ideas, opinions, thoughts, feelings, etc. are transmitted between the individuals through the use of mutually understood symbols and semiotic rules (signs and symbols) [23].

For the purpose of introducing our analysis, we have examined the two main communication types: non-verbal and verbal.

Non-verbal communication is defined as "communication without words" [24; p.105], "communication without words through a variety of communication channels" [25; p.200], "messages expressed by non-linguistic means" [26; p.200], and also as "all behaviours, attributes and objects (not related to words) that transmit messages and have a common social meaning" [27; p.110].

Psychologist Z. Vybíral accents the following means by which a person communicates in a non-verbal way: 1) gestures; 2) postures; 3) facial expressions (mimics); 4) gaze; 5) the distance and the occupation of location in the space; 6) bodily contact; 7) the tone of voice and other non-verbal aspects of speech; and 8) clothing, jewellery, and other physical aspects of their appearance [28; pp.64-66]. In [29], Broszinsky-Schwabe refers to the language of non-verbal communication through body postures, gestures, facial expressions, eye contact, touches, smells, and the usage of space (distance and proximity).

On the other hand, verbal communication is a type of oral and written communication wherein the message is transmitted by using words. In this case, the sender gives words to his feelings, thoughts, ideas and opinions and expresses them in the form of speeches, discussions, presentations, conversations, but also in emails, letters, reports, and proposals. The effectiveness of the verbal communication depends on the: 1) tone of the speaker, 2) clarity of speech, 3) volume, 4) speed, 5) body language, and 6) the quality of words used in the conversation (written and oral).

Both types of communication (non-verbal and verbal) are connected, but the verbal one is empowered by adding voice to the message, and it is consequently categorized according to the speaking style.

These two types of communication – non-verbal and verbal – are basic elements of our questionnaire, which researches Warm vs. Cold and Professional vs. Casual types of communication. Therefore, they are added to the dimensional model of national cultures.

WARM VS. COLD COMMUNICATION STYLE

Warm vs. Cold style of communication explains the degree to which people belonging to a specific culture use expression, emotion, and empathy while communicating. Our research aims to investigate *touch*, *gestures*, *elaborateness*, *personal space*, *being personal* and *loud* as types of Warm vs Cold communication style.

In continuation, we define the elements that influence the styles we have chosen to research:

Touch

Touch, together with *gestures*, is the very first non-verbal communicative style. As Sekerdej, Simão, Waldzus, and Brito [30] say, it varies in duration and may involve a number of different body parts. People may touch each other simultaneously (e.g., hugs) or there may be a certain

order of touching (e.g., someone reaches out his/her hand first, someone accepts it, or not, and so forth). Either way, Sekerdej et al. state that haptic behavior (i.e., touching) conveys proximity and intimacy that help to establish and maintain a close relationship.

Gestures

As for *gestures*, everybody gestures, and gesture is reduced to a subcategory of non-verbal communication as Clough and Duff [31] say, but that does not mean non-language; on the contrary, it is particularly well-suited for communicating visuo-spatial information which is often omitted from speech entirely.

Elaboreteness

De Mooij [32] defines *elaborate style* as rich, expressive language. Exact or precise style is a style where no more and no less information than required is given. High-context cultures of moderate to strong uncertainty avoidance orientation tend to use the elaborate style. Arab cultures draw on this elaborate style of verbal communication, using metaphors, long arrays of adjectives, flowery expressions and proverbs.

Personal space

As stated by Iizuka, Goto and Ogawa [33], *personal space* was studied by Sommer [34] as one index of people's space behavior and was defined as "a domain of a certain size demarcated by an invisible boundary line" which surrounds an individual and into which others may not come.

Being personal

Murphy [35] defines *being personal* as valuing emotional language, being good at connecting with others, and at assessing how people think and feel. By being personal we approach people more easily, better connect with them and, hopefully, communicate more successfully.

Being loud

Usually, loud people are extrovert, as Kendra Cherry [36] ascribes to extroverts the tendency to think aloud. Lindsay Dodgson [37] is another author who claims that a stereotypical extrovert is loud, sociable, and the life of the party. A study by Min Lee and Nass (2003), cited by Houston [38], postulates that the cause of the extrovert's strong social presence is their tendency to talk more often and in louder voices, to take up more physical space with broader gestures and to initiate more conversations than introverts. Furthermore, extroverts are significantly more confident and accurate when interpreting the meaning of nonverbal communication than introverts [39].

The description of these characteristics enables us to categorize Warm communication as high on *touch, gestures, being elaborate, personal* and *loud,* but low on *personal space,* while Cold communication as low on *touch, gestures,* on *being elaborate, personal* and *loud,* but high on *personal space,* as shown in Table 1.

PROFESSIONAL VS. CASUAL COMMUNICATION STYLE

Based on the literature review, for styles that label one country as Professional or Casual in communication, the authors suggest a typology that will measure how: 1) *direct*, 2) *quick to provide feedback*, 3) *clear*, 4) *prone to making eye contact*, and 5) *punctual* the population of one country is, Table 2.

Country	Touch (Non- -verbal)	Ges- tures (Non- -verbal)	Elaborate Both (Verbal & Non-verbal)	Perso- nal space (Non- -verbal)	Personal Both (Verbal & Non- -verbal)	Loud (Verbal)
the United States	\checkmark	\checkmark	×	\checkmark	\checkmark	
the United Kingdom	×	×	×	\checkmark	×	×
Germany	×	×	Х		×	×
Sweden	×	×	Х		×	×
China	×	×	Х	×	×	
Italy				×		
Russia				×		
Japan	×		×		×	×
Serbia	×	×				
North Macedonia	\checkmark	\checkmark		×		

Table 1. Warm vs. Cold communication styles to be measured as a part of the proposed ninth dimension.

Direct

Emerson [40] maintains that *direct* means preferring no-frills communication, backed by hard facts, focusing on the end result, being intense and very blunt.

Feedback

As feedback is the process of evaluating, discussing and organizing an employee's performance, an action used to offer constructive information to a team member, one is the most efficient communicator if the feedback is timely. This implies offering it when the team member can take action to improve, either immediately or shortly after the event in question [41] and, we would say, not later than that. Therefore, *being quick to provide feedback* is of utmost importance for any kind of communication.

Clear

As Worthington [42] in her Forbes article states, *being clear* means being kind, since clear communication creates accountability, builds a positive, trusting environment, avoids confusion, and provides a guiding source of vision.

Eye contact

Eye contact is one of the easiest and most powerful ways to make a person feel recognized, understood and validated. It makes words and people more memorable, makes people more honest, increases self-awareness, creates and deepens attraction [43]. This characteristic, of *being prone to making eye contact*, is a crucial part of the communication process as eyes can tell a big part of the story which we want to share.

Punctuality

Being punctual – arriving on time – is very important in all walks of life; thus, by the way we view and appreciate our and the interlocutor's time, our communication style is being assessed.

Hence, Professional style scores high on all of these categories: *direct, quick to provide feedback, clear, prone to making eye contact* and *punctual, while* Casual is low on all of these elements.

Country	Direct Both (Verbal & Non-verbal)	Quick to provide feedback (Verbal)	Clear Both (Verbal & Non-verbal)	Eye contact (Non- -verbal)	Punctual Both (Verbal & Non-verbal)
the United States	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
the United Kingdom	×	\checkmark	×	\checkmark	
Germany					
Sweden					
China	×		×	×	
Italy	×	×	×		×
Russia	×	×	×		×
Japan	×	\checkmark	×		\checkmark
Serbia	×	×	×		×
North Macedonia	×	×	×		×

Table 2. Professional vs. Casual communication styles to be measured as a part of the proposed ninth dimension.

RESEARCH METHODOLOGY

The main goal of the research is to investigate the communication styles among different cultures and provide evidence of how they differ based on different parts of the world.

The subject of analysis in our research are randomly selected respondents from 10 different cultures: Germany, Sweden, Japan, China, Russia, Italy, the United States, the United Kingdom, Serbia and North Macedonia. For this reason, a questionnaire was created and adapted to fit the purposes of this research. Part of the questions (from number 5 to 9 and from number 11 to 15) were taken from Richmond et al. [44], whose questionnaire was used as a starting point, to which Bojadjiev and Vaneva added their own statements. In total, the questionnaire consists of 24 questions, which the respondents could complete with one of the answers offered on a 6-point Likert scale (1 - never, ..., 6 - always), and 4 questions dedicated to the demographic profiles of the respondents. (The whole questionnaire is given in Appendix A).

Prior to distributing the questionnaire, a pilot testing was conducted in order to examine the validity of each question. Then the questionnaire was emailed to potential respondents who were randomly selected, and the survey was conducted electronically, using the Microsoft Forms web service.

The sample consists of at least 50 respondents per culture, among which 71 % were females and 29 % were males, while most of them were aged between 20-30 years (35 %), followed by 41-50 aged (25 %), 31-40 years (23 %) and those older than 50 (18 %).

In order to identify differences (or similarities) in communication styles across selected countries, and how many factors are needed to explain these common themes, a factor analysis is conducted. After the identifications of the two factors (Warm vs Cold, Professional vs Casual), in order to check the internal consistency of the questions in each factor, Cronbach's Alpha analysis was used, which showed that all the questions answered in each of these two factors are consistent. Moreover, ANOVA was used to show that there is a difference among the countries in relation

to the factors. Numeric details of the ANOVA analysis are presented in Appendices B and C. And lastly, since there is a difference, the authors classify and group the countries.

RESULTS AND DISCUSSION

The main aim of this article is to propose an additional dimension to Hofstede's model of national culture and, this time, the authors propose a dimension of communication as they believe that communication styles differ among cultures.

Factor analysis

The factor analysis was used to explain to which extent each question from the questionnaire is associated with a common factor. This analysis identified two main factors: Professional vs Casual and Warm vs Cold communication culture. In Table 3, questions associated with relevant factors are presented.

Factor 1 (Cold vs Warm)	Factor 2 (Casual vs Professional)
 Q5. I use my hands and arms to gesture while talking to people. Q6. I touch others on the shoulder or arm while talking to them. Q9. I move closer to people when I talk to them. Q12. I avoid touching people when I talk to them. Q13. I avoid gesturing while I am talking to people. Q14. I frown or smile while talking to people. Q15. I try not to sit or stand close to people when I talk with them. Q17. I speak loudly whenever I get into conversation. Q22. In communication, I value emotional language and connection. Q23. I am quiet when talking with people. Q27. I tend to keep my expression short. Q28. Regardless of the message I need to convey, I try to be impersonal. 	 Q7. I maintain eye contact with people when I talk to them. Q10. I tend to be on time for any appointment I have. Q11. I look over or away from others while talking to them. Q19. I give feedback within 24 hours. Q20. I tend to keep my messages clear. Q21. Instead of sugarcoating, I prefer telling people directly what I mean. Q24. I give myself time and reply within 3 to 5 days. Q26. Clarity of the message is not the first thing I go to.

Table 3. Questions associated with identified factors.

Running the Cronbach's Alpha test proved internal consistency of the questionnaire regarding the identified factors with score of 0,717 for factor 1 (Cold vs Warm) and 0,769 for factor 2 (Professional vs Casual). The descriptive statistics at the summary level for each factor is presented in Table 4, while for each country individually in Table 5.

Comparing countries by how *direct*, *quick to provide feedback*, *clear*, *prone to making eye contact* and *punctual* one country is, reveals that Serbia, North Macedonia and Germany are significantly different from the rest of the countries included in the research (see Appendix C). What is more, not many countries share similarities regarding this factor compared with the rest of the countries in the research.

Table 6 presents the factor value of countries and their ranking according to Factor 1, from Cold to Warm, and Factor 2, from Casual to Professional. Countries are ranked according to factor values.

Table 4. Descriptive statistics at the summary level for each factor									
	N	Min.	Max.	Mean	Std. Dev.				
Factor_1 (Warm vs Cold)	648	1,33	5,58	3,6623	0,62025				
Factor_2 (Professional vs Casual)	648	2,75	6,00	4,5143	0,64867				

	N	Min.	Max.	Mean	Std. Dev.
Factor_1 (Warm vs Cold)	648	1,33	5,58	3,6623	0,62025
Factor_2 (Professional vs Casual)	648	2,75	6,00	4,5143	0,64867

		Min.	Max.	Mean	Std. Dev.
	Factor_1	2,08	5,17	3,8708	0,57956
UN	Factor_2	3,00	5,38	4,2971	0,49867
116	Factor_1	2,08	5,58	3,9094	0,63758
03	Factor_2	3,00	5,63	4,3766	0,55243
Swadan	Factor_1	1,83	4,67	3,0273	0,55242
Sweden	Factor_2	2,88	5,63	4,1918	0,52316
Sarbia	Factor_1	2,33	5,00	3,8660	0,64076
Serbia	Factor_2	3,00	5,88	4,8897	0,62332
Puesia	Factor_1	2,58	4,92	3,7610	0,52299
Nussia	Factor_2	2,75	5,50	4,4505	0,61743
North Macadania	Factor_1	2,50	5,00	3,7388	0,54060
	Factor_2	3,13	6,00	4,8771	0,60256
lanan	Factor_1	2,67	4,08	3,4565	0,33131
Japan	Factor_2	3,25	4,75	4,0489	0,42262
Italy	Factor_1	2,58	5,08	3,7833	0,57726
italy	Factor_2	3,13	6,00	4,5659	0,63777
Germany	Factor_1	1,33	4,83	3,4292	0,74911
Germany	Factor_2	3,63	5,88	4,9125	0,55345
China	Factor_1	2,50	4,50	3,5375	0,40433
Cillia	Factor_2	3,00	5,63	4,1359	0,61211

Table 5. Descriptive statistics at country level for each factor.

Table 6. The countries' values of Factor 1 and Factor 2.

Country	Factor 1		Country	Factor 2	
Sweden	3,027300	Cold	Japan	4,048900	Casual
Germany	3,429200		China	4,135900	
Japan	3,456500		Sweden	4,191800	
China	3,537500		UK	4,297100	
Mean	3,662300		US	4,376600	
North Macedonia	3,738800		Russia	4,450500	
Russia	3,761000		Mean	4,514300	
Italy	3,783300		Italy	4,565900	
Serbia	3,866000		North Macedonia	4,871100	
UK	3,870800		Serbia	4,889700	
US	3,909400	Warm	Germany	4,912500	Professional

Finally, both factors were combined to classify the countries by their style of communication, and that leads us to the countries' distribution in Figure 2. There are 2 axes in this figure: X, the horizontal one, represents factor 1 (Cold-Warm), while the Y, the vertical one, stands for factor 2 (Professional-Casual).

If the mean value for factor 1 is 3,662300, and for factor 2 is 4,514300, by comparing each country's value with the mean and by interpreting the countries' distribution, this is what we come to: Germany is extremely professional, with a value of 4,912500, while it is moderately cold, with a value of 3,429200. Staying on the Professional-Casual axis, we see that Sweden is moderately casual, with a value of 4,191800, but extremely cold, with a value of 3,027300. The Casual-Cold quadrant shows that Japan is extremely casual, with 4,048900, but moderately cold, with 3,456500, which is a lot warmer than Sweden, and just a bit warmer than Germany. When it comes to China, it is less casual than Japan but more casual than Sweden, and warmer than all previously analyzed countries: Germany, Sweden and Japan. China scores 4,135900 on casual and 3,537500 on cold.

Moving to the second vertical half of the graph, we see that Italy is the least professional country and moderately warm. Its values are 4,565900 on casual and 3,783300 on warm. North Macedonia is very professional (4.871100), less professional than Germany, though, which is in that group, and moderately warm (3,738800). Serbia is extremely professional (4,889700), more than North Macedonia, however, less than Germany, and moderately warm (3,866000). Russia is the least casual of all countries (4,450500), almost bordering with professional, and it is moderately warm (3,761000). The US is the warmest country of all (3,909400) and moderately casual (4,376600), more casual than Russia, while the UK is more casual than the US (4,297100), but less warm than the US (3,870800).

Commenting on the parts of the dimensions and their extreme values in countries, as far as professionalism is concerned, Germany ranks the highest, being the most professional, while Japan is the most casual; thus, the least professional of all.

The horizontal, Cold-Warm axis leads us to the conclusion that Sweden is the coldest, and the US is the warmest country.



Figure 2. Distribution of countries according to factor 1 (Cold-Warm) and factor 2 (Professional-Casual).

The evidence provided in figure 2 is in line with Lanier [45] that Canada; the northern states of the US; Northern Europe; Israel; the countries that were settled by Europeans, including New Zealand, Australia, Brazil, Argentina, and South Africa are considered to be cold countries. Unsurprisingly, the cold communication style is present in the "cold temperature" cultures. People belonging to these cultures usually avoid touching others and gesturing while talking with others. However, they appreciate being impersonal and closer to the interlocutors.

On the other hand, according to Ting-Toomey and Chung [46], the communication casualty level is mostly affected by the level of power distance in each culture, where power distance is

defined as "the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally" [18]. Consequently, the communication style is influenced by culture, which may be measured not only through Hofstede's model, but also by the level of cultural affectiveness, meaning that affective cultures tend to share their emotions, while neutral cultures value keeping their emotions under check when interacting. Besides that, the communication style of a particular culture also differs based on whether a specific culture relies more on their social resources or skills.

Because culture affects communication, different aspects such as: beliefs, habits, values and norms, customs influence communication. The more similar they are, the easier the communication between the interlocutors is. The geography, climate, and history of a nation all influence its culture. Language, communication techniques, and beliefs are just a few examples of how these elements may have an impact on culture.

Anova analysis

After identifying the factors and checking the internal consistency of the questions related to the identified factors, ANOVA test was conducted in order to investigate differences between the means of the factors in the selected countries. The differences of each country compared to the other countries from the data set regarding factor 1 (Warm vs Cold) are presented in Appendix B, while differences of each country regarding factor 2 (Casual vs Professional) are presented in Appendix C. These tables reveal that, when countries are compared by the degree to which people belonging to a specific culture use expression, emotion, and empathy while communicating, Germany and Sweden are different from most of the countries in the data set, while Russia, Japan, Italy and North Macedonia have different communication styles from one to two countries in the data set, respectfully. The pairs of countries which are different against each other at statistical level of minimum 5 % for factor 1 (Cold vs Warm) are presented in Table 7, while Table 8 presents the same for factor 2 (Casual vs Professional).

CONCLUSION

In this article, numerous significant cultural trends have been studied and communication styles pertinent to ten different nations have been discussed. Namely, as the main goal of the research was to investigate the communication styles among different cultures and provide evidence of how they differ based on different parts of the world, randomly selected respondents from ten different cultures: Germany, Sweden, Japan, China, Russia, Italy, the United States, the United Kingdom, Serbia and North Macedonia filled out a 24-item questionnaire with answers on a 6-point Likert scale. The sample consists of at least 50 respondents per culture, among which 71 % were females and 29 % were males, with most of them aged between 20-30 years (35 %), and the smallest portion (18 %) consisting of those older than 50. Upon identifying two factors (Warm vs Cold, Professional vs Casual), a factor analysis was conducted, and in order to check the internal consistency of the questions in each factor, Cronbach's Alpha analysis was used, which showed that all the questions answered in each of these two factors are consistent. Moreover, ANOVA was used to show that there is a difference among the countries in relation to the factors.

Since a difference does exist, we classify and group the countries. When countries are compared by the degree to which people belonging to a specific culture use expression, emotion, and empathy while communicating, Germany and Sweden are different from most of the countries in the data set, while Russia, Japan, Italy and North Macedonia have different communication styles from one to two countries in the data set, respectfully. Comparing countries by how *direct*, *quick to provide feedback*, *clear*, *prone to making eye contact* and

(I) Country	(J) Country					
	Sweden					
UK	Germany					
	China					
	Sweden					
211	Japan					
03	Germany					
	China					
	UK					
	US					
	Serbia					
Swodon	Russia					
Sweden	North Macedonia					
	Italy					
	Germany					
	China					
	Sweden					
Serbia	Germany					
	China					
Russia	Sweden					
North Macedonia	Sweden					
	Germany					
Japan	US					
Italy	Sweden					
italy	Germany					
	UK					
	US					
Germany	Sweden					
,	Serbia					
	North Macedonia					
	Italy					
_	UK					
China	US					
	Serbia					

Table 7. The pairs of countries which are different against each other at statistical level of minimum 5 % for factor 1 (Cold vs Warm).

Table 8.	The	pairs	of a	coun	tries	which	are	different	against	each	other	at	statistical	level	of
minimum	15%	for fa	acto	r 2 (Casu	al vs P	rofe	ssional) (continue	d on j	p.483)).			

(I) Country	(J) Country
UK	Serbia
	North Macedonia
	Germany
US	Serbia
	North Macedonia
	Germany
Sweden	Serbia
	North Macedonia
	Italy
	Germany

Table 8. The pairs of countries which are different against each other at statistical level of minimum 5 % for factor 2 (Casual vs Professional) (continuation from p.482).

Serbia	UK
	US
	Sweden
	Russia
	Japan
	China
Russia	Serbia
	North Macedonia
	Germany
North Macedonia	UK
	US
	Sweden
	Russia
	Japan
	Italy
	China
Japan	Serbia
	North Macedonia
	Italy
	Germany
Italy	Sweden
	North Macedonia
	Japan
	Germany
	China
Germany	UK
	US
	Sweden
	Russia
	Japan
	Italy
	China
China	Serbia
	North Macedonia
	Italy
	Germany

punctual one country is, it is revealed that Serbia, North Macedonia and Germany are significantly different from the rest of the countries included in the research. What is more, not many countries share similarities regarding this factor compared with the rest of the countries in the research. Germany is extremely professional, but moderately cold, while Sweden is moderately casual, but extremely cold. Japan is extremely casual, and moderately cold, which is a lot warmer than Sweden, and just a bit warmer than Germany. China is less casual than Japan but more casual than Sweden, and warmer than all previously analyzed countries: Germany, Sweden and Japan. Italy is the least professional country and moderately warm, North Macedonia is very professional – although less professional than Germany, which is in that group, and moderately warm. Serbia is extremely professional, more than North

Macedonia, but less than Germany, and moderately warm. Russia is the least casual of all countries, almost professional, and it is moderately warm. The US is the warmest country of all and moderately casual, more casual than Russia, while the UK is more casual than the US, but less warm than the US. Out of all countries, Germany is the most professional, while Japan is the most casual; thus, the least professional of all, while Sweden is the coldest, and the US is the warmest country.

As far as previous research on the topic of communication across cultures is concerned, it always revolves around Hofstede, his definition of culture and the distinction of cultural dimensions. That is what Grèzes [47] does – he cites Hofstede's work from 2001 [18] and, among other definitions, maintains that different cultures rely on different values, and the culture is not innate but acquired by the subjects. Rew et al. [48] define cultural awareness as "learning to work with people from diverse cultural backgrounds, using interpersonal communication, relationship skills, and behavioral flexibility." This aspect is very important at both personal and management level since both our everyday, non-work activities and business dealings are shaped by our culture, which impacts the way we communicate.

When talking about communication styles, especially about the direct one, Park et.al. [49] claim that people in different cultures have different preferences in the way they communicate with others. Compared to Koreans, Americans have been found to be more likely to rate direct statements as effective in making a request [50, 51]. Hong Kong Chinese migrants in the Australian workplace noted that Australians were more direct in communication than they were [52], while Russians and Japanese used more indirect communication strategies than Americans did when negotiating with others as Adair et al. [53] say. Similar to this, Indians preferred indirect communication more strongly than Americans [54].

Gudykunst et al [55] note that when comparing Koreans with Americans no cultural differences were evident in indirect communication. When making a request, both Koreans and Americans rated direct statements as the least likely strategy to use [51]. In [56], a study with Koreans is discussed, which showed that open and clear communication had a positive influence on organizational commitment and job satisfaction. As far as the Chinese are concerned, research shows that they preferred direct persuasion appeals [57], and a direct communication style in business communication [58].

However, according to Park et.al. [49], a culture-level value such as individualism–collectivism is probably not the only reason for variation in direct communication style preferences. Individuals within the same culture have varying reasons for direct communication style preferences. For example, differences in personality, self-esteem, and/or stress make people use particular communication styles consistently regardless of the referent groups such as partners, friends, and coworkers [59]. The relationship between individual-level independent variables and direct communication style may not be the same across different cultures. Possibly, cultures can differ in the reasons important for being direct when communicating with others. For example, politeness can be a reason for not being direct when communicating with others in one culture, but expressing relational closeness can be a reason for being direct in another culture [60, 61]. In [62], Kim et al. observed Australians' and Koreans' communication styles in their intercultural exchanges and found that Australians believed explicit and direct messages facilitated effective communication while Koreans thought that unconstrained and explicit communication in e-mails could threaten face and be impolite to others, thus being ineffective.

Learning about the typical communication styles of the researched countries, and positioning each country in terms of its professional/casual and warm/cold factors, the study will hopefully inform the readers how to adequately approach these cultures, how to correctly interpret their

communication, how to address them and ensure their messages are properly understood, that is, give us all better insight into the communication style we should adopt when communicating with a certain country's national.

We tried to conduct thorough research and approach the subject matter from as many angles as possible, but we are aware that there may be some limitations. One limitation, which may not be the only, is the fact that we have not included any countries from the African continent, that is, there are six European countries, two Asian countries, one country spanning on both Europe and Asia, and one American country. Further research can be done with African countries, and since that variety of countries will enable us to make comparison and contrast among the different continents, the results will have far bigger implications on the countries' communication styles on a global, world level. When cross-cultural communication takes place, there are potential barriers: attitude, perception, stereotypes, interpretation, and culture shock. Yet, successful cross-cultural communicators are those who achieve communicative competence. And in order to gain competence, one should be aware of the impact of national culture, which is deeply rooted in how we "see things, say things and do things".

We hope that this article is significant since it proposes an additional dimension, which is as frequent and solid among cultures as it is deeply rooted in each culture. Therefore, the article recommends that the countries ought to both comprehend their national culture and utilize it as a "tool" for understanding other cultures as well.

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APPENDIX A

Table 9. Questionnaire utilized to investigate the communication styles.

Section 1: Respondents' demographic data
O1. Please choose the age group you belong to:
Q2. Please choose your gender:
Q3. Please choose your native country:
Q4. Please mark your level of education:
Section 2: Non-verbal aspects of communication
Q5. I use my hands and arms to gesture while talking to people.
Q6. I touch others on the shoulder or arm while talking to them.
Q7. I maintain eye contact with people when I talk to them.
Q8. I have a bland facial expression when I talk to people.
Q9. I move closer to people when I talk to them.
Q10. I tend to be on time for any appointment I have.
Q11. I look over or away from others while talking to them.
Q12. I avoid touching people when I talk to them.
Q13. I avoid gesturing while I am talking to people.
Q14. I frown or smile while talking to people.
Q15. I try not to sit or stand close to people when I talk with them.
Q16. Time is not what I pay most attention to.
Section 3: Verbal aspects of communication
Q17. I speak loudly whenever I get into conversation.
Q18. I tend to give lengthy explanations to make sure the interlocutor understands me.
Q19. I give feedback within 24 hours.
Q20. I tend to keep my messages clear.
Q21. Instead of sugarcoating, I prefer telling people directly what I mean.
Q22. In communication, I value emotional language and connection.
Q23. I am quiet when talking with people.
Q24. I give myself time and reply within 3 to 5 days.
Q25. I 'dress' my expression and subtly address people.
Q26. Clarity of the message is not the first thing I go to.
Q27. I tend to keep my expression short.

Q28. Regardless of the message I need to convey, I try to be impersonal.

APPENDIX B

ANOVA for Factor 1 (Warm vs Cold).

Table 10. Leven test of homogeneity of variances of Factor 1 (Warm vs Cold).

Levene Statistic	df1	df2	Sig.
3,793	9	638	0,125

Table 11. Tukey HSD post-hoc analysis of Factor 1 (Warm vs Cold) (continued on p.491).

(I) Country	(J) Country	Mean Difference (I-J)	Std. Error	Sig.
	US	-0,039	0,094	1,000
	Sweden	0,843	0,102	0,000***
	Serbia	0,005	0,105	1,000
	Russia	0,110	0,104	0,989
UK	North Macedonia	0,132	0,086	0,881
	Japan	0,414	0,137	0,080
	Italy	0,087	0,103	0,998
	Germany	0,442	0,101	0,001***
	China	0,333	0,094	0,015**
	UK	0,039	0,094	1,000
	Sweden	0,882	0,098	0,000***
	Serbia	0,043	0,102	1,000
	Russia	0,148	0,101	0,905
USA	North Macedonia	0,171	0,083	0,552
	Japan	0,453	0,135	0,029**
	Italy	0,126	0,100	0,962
	Germany	0,480	0,098	0,000***
	China	0,372	0,090	0,002***
	UK	-0,843	0,102	0,000***
	USA	-0,882	0,098	0,000***
	Serbia	-0,839	0,110	0,000***
	Russia	-0,734	0,109	0,000***
Sweden	North Macedonia	-0,712	0,091	0,000***
	Japan	-0,429	0,141	0,072
	Italy	-0,756	0,107	0,000***
	Germany	-0,402	0,105	0,006***
	China	-0,510	0,098	0,000***
	UK	-0,005	0,105	1,000
	USA	-0,043	0,102	1,000
	Sweden	0,839	0,110	0,000***
	Russia	0,105	0,112	0,995
Serbia	North Macedonia	0,127	0,096	0,946
	Japan	0,409	0,143	0,121
	Italy	0.083	0,111	0,999
	Germany	0.437	0,109	0.003***
	China	0.329	0,102	0,045**
	UK	-0,110	0,104	0,989
	USA	-0,148	0,101	0,905
. .	Sweden	0,734	0,109	0,000***
Russia	Serbia	-0,105	0,112	0,995
	North Macedonia	0,022	0,094	1,000

	P =	~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~	(********	···· ··· ··· ··· ··· ··· ··· ··· ··· ·
	Italy	-0,022	0,110	1,000
Russia	Germany	0,332	0,108	0,065
	China	0,224	0,101	0,451
	UK	-0,132	0,086	0,881
	USA	-0,171	0,083	0,552
	Sweden	0,712	0.091	0,000***
	Serbia	-0,127	0,096	0,946
North	Russia	-0,022	0,094	1,000
Macedonia	Japan	0.282	0.130	0.478
	Italy	-0.045	0.093	1.000
	Germany	0.310	0.090	0.023**
	China	0.201	0.083	0.305
	UK	-0.414	0.137	0.080
	USA	-0.453	0.135	0.029**
	Sweden	0.429	0.141	0.072
	Serbia	-0.409	0.143	0.121
Japan	Russia	-0.304	0.143	0.503
Jupun	North Macedonia	-0.282	0.130	0.478
	Italy	-0.327	0.142	0.387
	Germany	0.027	0.140	1,000
	China	-0.081	0.135	1,000
	LIK	-0.087	0,103	0.998
	USA	-0.126	0,100	0.962
	Sweden	0.756	0,107	0.000***
	Serbia	-0.083	0.111	0,000
Italy	Russia	0.022	0,110	1,000
itary	North Macedonia	0.045	0.093	1,000
	Ianan	0.327	0.142	0.387
	Germany	0.354	0.107	0.032**
	China	0.246	0,100	0.294
	LIK	-0.442	0,101	0.001***
	USA	-0.480	0.098	0.000***
	Sweden	0.402	0,090	0.006***
	Serbia	-0.437	0,109	0.003***
Germany	Russia	-0.332	0.108	0.065*
Germany	North Macedonia	-0.310	0,090	0.023**
	Ianan	-0.027	0.140	1 000
	Italy	-0.354	0.107	0.032**
	China	-0.108	0.098	0.984
	LIK	_0 333	0,094	0.015**
		_0.372	0,094	0.002***
	Swadan	0,510	0,000	0,002
	Sweden	0,310	0,098	0,000****
China	Buggio	-0,329	0,102	0,045***
Cinita	Kussia North Magadaria	-0,224	0,101	0,451
	Inorui Macedonia	-0,201	0,085	0,303
	Japan	0.246	0,135	0.204
	Compose	-0,240	0,100	0.094
1	Germany	0,108	0,098	0,984

 Table 11. Tukey HSD post-hoc analysis of Factor 1 (Warm vs Cold) (continuation from p.490).

***the mean difference is significant at the 1 % **the mean difference is significant at the 5 %

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	40,885	9	4,543	13,933	0,000***
Within Groups	208,019	638	0,326		
Total	248,904	647			

Table 12. Anova analysis for Factor 1 (Warm vs Cold).

***statistically significant at 1 %

APPENDIX C

Table 13. Leven test of homogeneity of variances of Factor 2 (Professional vs Casual).

Levene Statistic	df1	df2	Sig.
1,195	9	638	0,295

Table 14. Anova analysis for Factor 2 (Professional vs Casual)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	59,966	9	6,663	20,025	0,000***
Within Groups	212,277	638	0,333		
Total	272,243	647			

*** statistically significant at 1 %

Table 15. Tukey HSD post-hoc analysis of Factor 2 (Professional vs Casual) (continued on pp.493-494).

(I) Country	(J) Country	Mean Difference (I-J)	Std. Error	Sig.
	US	-0,079	0,095	0,998
	Sweden	0,105	0,103	0,991
	Serbia	-0,593	0,107	0,000***
	Russia	-0,153	0,105	0,909
UK	North Macedonia	-0,580	0,087	0,000***
	Japan	0,248	0,139	0,743
	Italy	-0,269	0,104	0,230
	Germany	-0,615	0,102	0,000***
	China	0,161	0,095	0,795
	UK	0,079	0,095	0,998
	Sweden	0,185	0,099	0,698
	Serbia	-0,513	0,103	0,000***
	Russia	-0,074	0,102	0,999
US	North Macedonia	-0,501	0,083	0,000***
	Japan	0,328	0,136	0,327
	Italy	-0,189	0,101	0,687
	Germany	-0,536	0,099	0,000***
	China	0,241	0,091	0,202
	UK	-0,105	0,103	0,991
	US	-0,185	0,099	0,698
	Serbia	-0,698	0,111	0,000***
Sweden	Russia	-0,259	0,110	0,352
	North Macedonia	-0,685	0,092	0,000***
	Japan	0,143	0,142	0,992
	Italy	-0,374	0,109	0,021**

$10 \text{ m} \text{ p} \cdot 1 2, 00 \text{ m}$				
G 1	Germany	-0,721	0,106	0,000***
Sweden	China	0,056	0,099	1,000
	UK	0,593	0,107	0,000***
	US	0,513	0,103	0,000***
	Sweden	0,698	0,111	0,000***
	Russia	0,439	0,113	0,004***
Serbia	North Macedonia	0,013	0,097	1,000
	Japan	0,841	0,145	0,000***
	Italy	0,324	0,112	0,111
	Germany	-0,023	0,110	1,000
	China	0,754	0,103	0,000***
	UK	0,153	0,105	0,909
	US	0,074	0,102	0,999
	Sweden	0,259	0,110	0,352
	Serbia	-0,439	0,113	0,004***
Russia	North Macedonia	-0,427	0,095	0,000***
	Japan	0,402	0,144	0,143
	Italy	-0,115	0,111	0,990
	Germany	-0,462	0,109	0,001***
	China	0,315	0,102	0,066*
	UK	0,580	0,087	0,000***
	US	0,501	0,083	0,000***
	Sweden	0,685	0,092	0,000***
Nouth	Serbia	-0,013	0,097	1,000
Macadonia	Russia	0,427	0,095	0,000***
Iviaceuolila	Japan	0,828	0,131	0,000***
	Italy	0,311	0,094	0,033**
	Germany	-0,035	0,091	1,000
	China	0,741	0,083	0,000***
	UK	-0,248	0,139	0,743
	US	-0,328	0,136	0,327
	Sweden	-0,143	0,142	0,992
	Serbia	-0,841	0,145	0,000***
Japan	Russia	-0,402	0,144	0,143
	North Macedonia	-0,828	0,131	0,000***
	Italy	-0,517	0,143	0,012**
	Germany	-0,864	0,141	0,000***
	China	-0,087	0,136	1,000
	UK	0,269	0,104	0,230
	US	0,189	0,101	0,687
	Sweden	0,374	0,109	0,021**
	Serbia	-0,324	0,112	0,111
Italy	Russia	0,115	0,111	0,990
	North Macedonia	-0,311	0,094	0,033**
	Japan	0,517	0,143	0,012**
	Germany	-0,347	0,108	0,044**
	China	0,430	0,101	0,001***

Table 15. Tukey HSD post-hoc analysis of Factor 2 (Professional vs Casual) (continuation from p.492, continued on p.494).

11	/			
	UK	0,615	0,102	0,000***
	US	0,536	0,099	0,000***
	Sweden	0,721	0,106	0,000***
	Serbia	0,023	0,110	1,000
Germany	Russia	0,462	0,109	0,001***
	North Macedonia	0,035	0,091	1,000
	Japan	0,864	0,141	0,000***
	Italy 0,34		0,108	0,044**
	China	0,777	0,099	0,000***
	UK	-0,161	0,095	0,795
	US	-0,241	0,091	0,202
	Sweden	-0,056	0,099	1,000
	Serbia	-0,754	0,103	0,000***
China	Russia	-0,315	0,102	0,066*
	North Macedonia	-0,741	0,083	0,000***
	Japan	0,087	0,136	1,000
	Italy	-0,430	0,101	0,001***
	Germany	-0,777	0,099	0,000***

Table 15. Tukey HSD post-hoc analysis of Factor 2 (Professional vs Casual) (continuation from pp.492-493).

***the mean difference is significant at the 1 % **the mean difference is significant at the 5 %

INTERDISCIPLINARY APPROACH TO WINE PREFERENCES: CASE OF NORTH CROATIA

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ABSTRACT

The wine market in the world is well developed, and the countries at the very top of production are making great efforts to maintain their leading position. Traditional cultures and autochthonous sorts are especially valued, and many tourists are willing to pay well for this uniqueness and quality, which is why wine tourism has been developing more and more in the last 20 years. Thus, the consumption of wine is combined with the gastronomy, hospitality, viticulture and nature of an area and thus creates a certain harmony. This article aims to investigate the preferences of wine consumers in the area of North Croatia. Due to complexity of human behaviour, consumer preferences have an interdisciplinary dimension which must are considered in this article. Research results show the profile and preferences of wine consumers in North Croatia. Both of the research propositions are confirmed with the chi-square test. The article briefly presents the history and development of wine production, the main characteristics of wine consumers and wine consumption. It analyses the import and export of wine to the Croatian market. Also, the current state and trends of the wine market worldwide and in Croatia are described. Results are relevant for the providers of tourism services in North Croatia.

KEY WORDS

wine market analysis, wine consumers, wine preferences, North Croatia wine consumer preferences

CLASSIFICATION

JEL: D12

INTRODUCTION

Tourist demand is prone to various factors, among which innovation [1], community engagement [2] and quality of products and services [3] strongly impact the repeat visit [4]. The production and consumption of wine have a long history in almost all parts of the world, including Croatia. Regardless of the number of autochthonous and protected species, a large number of producers and self-sufficient stocks of wine, viticulture and winemaking in Croatia still strive for development and better recognition on the world market. Viticulture and winemaking are particularly popular and present in Europe. Still, the fact is that the number of vineyard areas in Europe has been gradually decreasing over the past few years. A big role in this is played by unfavourable weather and economic conditions and the price-quality ratio on the market, which is not always credible. Several state institutions monitor Viticulture in Croatia, and the production process is accompanied by law and legal acts. The Winegrower's Register is also important, in which all producers who produce certain quantities of wine must be registered. Wine distribution occurs through channels such as retail stores, restaurants and hotels, and door-to-door sales, but numerous wineries in Croatia provide the greatest experience and pleasure. Consumers and their attitudes are most important to manufacturers, as in all other industries. Consumer preferences can greatly influence the production, distribution and development of accompanying content related to wine consumption, such as the development of wine tourism. North Croatia is perceived as a rich viticulture and winemaking region where wine consumption is present in almost every household, and wine production for own needs is also often present.

This article aims to investigate the preferences of wine consumers in the area of North Croatia, especially their habits of buying and consuming wine. North Croatia is a well-known wine-production region of Croatia. Wine consumer preferences have been the research topic in many leading wine-producing regions and countries [5-7]. This article fills the void of such research for the region of North Croatia. Following this aim, the research questions formed in this article are

RQ1: What is the profile of wine consumers in North Croatia?

RQ₂: What are the preferences of wine consumers in North Croatia?

Two research presumptions are stated:

- RP1: Age affects the frequency of wine consumption and
- **RP**₂: Wine consumers in North Croatia prefer white wines.

Consumer behaviour has five interdisciplinary dimensions: economic, psychology, sociology, sociology and cultural anthropology. This complexity of human behaviour forms preferences in a way that affects decision-making. Concepts and insights from different areas that impact preferences make way for an integral view of research results. The emphasis of the research is also on consumer preferences regarding wine characteristics. Following the footsteps of previous research [8-10], traditional wine attributes are explored. In addition, this article analyses the state and trends in the wine market. The wine market consists of producers on the supply side and consumers on the demand side. Therefore, the production and consumption of wine in Croatia and the world are presented in detail. Data for the empirical part of the work are collected through an online survey.

The article consists of four sections. A theoretical framework with an analysis of the wine market follows the introductory part. Empirical research is presented in the third section, and the article's main conclusions are presented in the fourth section.

WINE MARKET

Wine is an alcoholic beverage that has changed significantly throughout history and gradually developed its taste, quality and production process. Many well-known poets, philosophers, writers and rulers mentioned the numerous benefits and undesirable consequences of excessive wine consumption. It is often mentioned in old religious and historical books, which is why it can be concluded that wine production and consumption is one of humankind's oldest crafts. The following will present the current situation and trends in the wine market in the world and Croatia. Although it is open and subject to competition, it can be argued that it is outside the stronger influence of changes in the world market.

LEADING WINE PRODUCERS IN THE WORLD

Vine berries can be exploited in several ways, i.e. growing vines does not have to be intended only for wine production but can be sold as dried or fresh fruit. In this article, the focus is on the cultivation of vines for the production of wine. Table 1 shows how vineyard areas, production and consumption of wine, import and export of wine are distributed by continent, and the number of types of wine on each continent is also shown. In 2019, Europe had the largest number of areas under vineyards, with 3 702 167 hectares out of a total of 7 341 771 hectares in the world, followed by Asia, America, Africa and finally Australia with Oceania. Comparing the amounts of wine consumption with their production capacities. Nevertheless, America and Asia achieve a negative balance when observing the amount of exports and imports, while the other continents achieve greater exports than imports of wine. As for production, Europe has the greatest variety of wine varieties with 4 050 types of wine, followed by Asia (1399), Australia and Oceania (551) and Africa (167) [11].

Continent /area	Vineyard surface, ha	Production of wine, 1000 hL	Wine sorts	Export, 1000 hL	Import, 1000 hL	Consumption, 1000 hL
Africa	366 755	11 197	167	4 749	3 743	7 976
America	1032 165	55 411	1399	16 817	19 589	55 353
Asia	2 055 379	12 854	1943	1397	11 351	23 932
Europe	3 702 167	163 287	4 0 5 0	74 233	70 517	143 384
Australia & Oceania	185 305	14 944	551	10 139	1528	6 840
World	7 341 771	257 693	8 100	107 335	106 728	237 485

Among the 10 largest wine producers in the world in 2021 (Table 2) are the following countries: Italy, Spain, France, USA, Australia, Chile, Argentina, South Africa, Germany, and China [12]. From the data in the table, it is evident that all countries except the Republic of South Africa had a drop in production in 2019 compared to 2018, which is also visible at the level of world wine production. The situation improved in 2020, where Spain (21 %) and France (11 %) had the biggest positive growth, while Argentina (-17 %) and China (-16 %) had the biggest decline. The fact that Italy, France and Spain produced 52 % of the total wine produced in the world in 2020 also speaks of the dominance of European countries in production. The situation changes again in 2021, when total production drops by 4 %, and the estimated production amount of 250,3 million hL is 7 % less than the average production of the last 20 years. The leading country in wine production remains Italy with a drop of -9,36 % and the biggest drop in production was France (-26,7 %), which is why it fell in the ranking, i.e. Spain managed to take 2nd place despite the drop of -14 % place in wine production. The decline in production in the leading European countries is attributed to unfavourable weather conditions, mostly frost during April and hail in the summer months. On the other hand, the southern hemisphere countries are recording a large growth in production, especially Australia and Chile, which, with a growth of about 30 %, looking at the year 2020, dropped Argentina from 5th to 7th place [13].

	Amount, million hL			L	change	total world
Country	2018.	2019.	2020.	2021.	2020-2021, %	production 2021, %
1. Italy	54,8	47,533	49,1	44,5	-9,36	17,78
2. Spain	44,9	33,676	40,7	35,0	-14	13,98
3. France	49,2	42,193	46,7	34,2	-26,7	13,66
4. USA	26,1	25,562	22,8	24,1	5,7	9,63
5. Australia	12,7	11,970	10,9	14,2	30,28	5,67
6. Chile	12,9	11,939	10,3	13,4	30,01	5,35
7. Argentina	14,5	13,019	10,8	12,5	15,74	4,99
8. South African Republic	9,5	9,705	10,4	10,6	-1,85	4,23
9. Germany	10,3	8,218	8,4	8,8	4,76	3,51
10. China	9,3	7,824	6,6	no data for 2021		
World	294	258	260	250,3	4 %	_

Table 2. 10 largest producers of wine in the world (source: OIV).

According to the analysis of the data in Tables 1 and 2, it can be concluded that the world wine market is very dynamic. The largest producers of wine are traditionally on the European continent, and trends in production largely depend on weather conditions in certain years.

WINE PRODUCTION IN CROATIA

The grapevine is an important crop for agriculture and the economy of Croatia. Vine-growing areas in Croatia are divided into zones, regions, subregions and vineyards. According to the Ordinance on geographical areas of grape growing [14], Croatia can be divided into 4 wine regions: Slavonia and Podunavlje, Hilly Croatia, Istria and Kvarner, and Dalmatia.

According to statistics maintained by the International Organization for Viticulture and Winery (OIV), the area of vineyards in Europe, including Croatia, is gradually decreasing every year. This trend is most affected by climate change, economic problems and global crises [15].

Wine production in the Republic of Croatia tends to improve quality, as evidenced by the fact that 60 % of the wine produced in Croatia is categorized as quality [16]. According to data from [17], 27.095 entities were registered, of which 25 840 are individuals, 564 crafts and 691 legal entities, producing wine on 18 126,36 hectares.

When talking about the largest producers of wine in the whole of Croatia, 10 producers stand out. The largest wine producers in Croatia are listed in Table 3. Most of the large producers come from the wine-growing regions of Slavonia and Podunavlje, and the largest wine producer in Croatia is Belje Plus d.o.o. with a total vineyard area of 613,59 hectares. Given that the 10 largest wine producers in Croatia occupy only 19,2 % of the total vineyard area, it

Company	Region	Surface under vineyards, ha	percentage of total vineyard surface, %
Belje Plus d.o.o.	Slavonija and Podunavlje	613,59	3,39
Agrolaguna d.d.	Istra and Kvarner	547,48	3,02
Kutjevo d.d.	Slavonija and Podunavlje	441,72	2,44
Erdutski vinogradi d.o.o.	Slavonija and Podunavlje	409,47	2,26
lločki podrumi d.d.	Slavonija and Podunavlje	351,53	1,94
Badel 1862 d.d.	Slavonija and Podunavlje	330,15	1,82
Đakovačka vina d.d.	Slavonija and Podunavlje	248,97	1,37
Dalmacijavino Split d.o.o.	Dalmacija	190,91	1,05
PP Orahovica d.o.o.	Slavonija and Podunavlje	177,38	0,98
Osilovac d.o.o.	Slavonija and Podunavlje	168,94	0,93
Total		3 480,13	19,2

Table 3. Ten largest producers of wine in Croatia. Author's work according to Ceiling Celić

 and Rulebook on geographical areas of vine cultivation (NN 76/19, attachment 1.)

is evident that wine production does not depend only on a few large companies but on a large number of smaller producers [14, 17].

The most famous producers in North Croatia include Agromeđimurje d.d. from Čakovec, Varaždinka d.d. from Varaždin, Petrač d.o.o. from Krapinske Toplice, Bojan Štampar and Alojz Novak, and numerous producers from Štrigova [18].

Table 4 shows data on production, the area under vineyards and the number of entities in North Croatia. The total number of registered entities is 9 047, of which 8 789 are individuals, 145 crafts and 113 legal entities. Comparing the amount of land under vineyards and the number of entities, it is evident that the majority are small wine producers who do not have a large area at their disposal. This is supported by the fact that 33,39 % of all registered entities that produce only 10,14 % of wine in Croatia are located in North Croatia.

Table 4. Producers and vineyard surfaces in North Croatia. Author's work according to data from Winery Register for the year 2021

County/Area	Production, hL	Surface, ha	Number
Međimurje	19 781,05	485,80	422
Varaždin	7 634,36	422,09	1687
Krapinsko – zagorska	7 016,95	655,84	3 231
Koprivničko–križevačka	3 640,80	401,38	1 376
Zagrebačka	28 847,26	727,48	2 331
TOTAL	66 920,42	2 692,59	9 047
percentage of total RH	10,14 %	14,85 %	3,39 %

According to the data [12], quality wine (76,44 %) is mostly produced wine in Croatia, followed by premium wine (9,88 %), sorted wine without a protected designation of origin (PDO) (7,1 %),

wine without PDO (6,33 %) and other wines (0,26 %). As for North Croatia, quality wine is produced the most (45,63 %), followed by sorted wine without PDO (28,93 %), wine without PDO (18,35 %), premium wine (6,32 %), other wines (0,77 %). Zagreb county produces the most wine, followed by Međimurje, Varaždin, Krapina and finally Koprivnica-Križevačka counties. Although Zagreb County produces the largest share of premium wines in North Croatia (40,81 %), other wines, quality wines and sorted wines are produced to a greater extent in this area. Regarding producing quality wines, Međimurje County stands out, where wines are marked as quality in 79,4 % of cases [19].

The leading sortes produced in Croatia are Graševina, Malvasia Istria and Plavac mali crni. The production of Graševina stands out in particular, amounting to 254 996,52 hL (41,43 % compared to other sortes in Croatia), followed by Plavac mali crni with 129 649,23 hL (21,07 %) and Istria Malvasia with 54 649,23 hL (8,79 %) [12]. In North Croatia, graševina, rajnski rizling, chardonnay, moslavac, škrlet, kraljevina, white and pinot gris are mostly produced [20]. From the above, it can be concluded that quality wines produced in Croatia can compete on the world market.

CONSUMPTION OF WINE

Wine consumers can be divided into several groups depending on their basic characteristics and reasons for consuming wine [21]: (i) Conservative wine connoisseurs and consumers; (ii) Wine consumers focused on the image of wine and eager for wine knowledge; (iii) Basic wine consumers; (iv) Experimental wine consumers with great wine knowledge; and (v) Social wine consumers focused on pleasure and entertainment.

When talking about the general consumption of alcohol, the highest consumers in Europe are the Czech Republic (14,3 L/pp), Latvia (13,2 L/pp), Moldova (12,9 L/pp), Germany (12,8 L/pp) and Lithuania (12,8 L/pp). Croatia is in 35th place with a consumption of 8,7 litres of alcohol per person, and neighbouring countries Montenegro, Slovenia, Hungary and Serbia are higher on the list. Interestingly, Italy is in 38th place with a consumption of 8 litres per person, even though it is the leading country in the world's wine production [22].

According to data from Eurostat for 2019, 38,3 % of Croats did not consume alcohol in the last 12 months, which is quite a large percentage compared to the EU level (26,2 %), and only Serbia has a higher percentage (50,7 %) and Turkey (85,1 %). Croats mostly consume alcohol several times a month (21 %), followed by several times a week (17,9 %) and daily (10,2 %), while 12,6 % of Croats consume alcohol less than once a month [23].

World wine consumption in 2020 is estimated at 234 million hl, which represents a decrease of 3 % compared to 2019. It is also important to note that this is the lowest recorded level of wine consumption since 2002. Considering the crisis caused by COVID-19 in 2020, the wine sector did not have worse results than other sectors [12].

Regarding wine consumption, the countries with the highest wine consumption and those with the highest wine consumption per person differ. The largest quantities of wine are consumed in the USA, followed by France, Italy, Germany and the UK. On the other hand, Portugal has the highest consumption of wine per person, followed by Italy, France, Switzerland and Austria. According to data from the National Bureau of Statistics, in 2018, wine consumption in Croatia was 22 litres per person.

Table 5 lists the largest consumers of wine in the world in 2020.

Wine production in a year		Wine production i	Wine production in a year per person		
Amount, hL	Country	Amount, L/pp	Country		
33,0	USA	51,9	Portugal		
24,7	France	46,6	Italy		
24,5	Italy	46	France		
19,8	Germany	35,7	Switzerland		
13,3	UK	29,9	Austria		
12,4	China	27,8	Australia		
10,3	Russia	27,6	Argentina		
9,6	Spain	27,5	Germany		
9,4	Argentina	27	Sweden		
5,7	Australia	24,2	Netherland		

Table 5. Ten largest wine consumers per person in the year 2020. Author's work according to OIV.

A few years ago, a decrease in the amount of wine consumed per household member was recorded, which does not necessarily indicate a decrease in wine preference, but is possibly a consequence of the economic crisis. According to the results of the Standardized European survey on alcohol carried out in 2015 as part of the EU Joint Action on Reducing Alcohol Related Harm – RARHA, it was determined that beer is consumed to a greater extent in Croatia (56%) compared to wine (34%) [24]. From a generational point of view, the largest consumers of wine are considered to be the so-called Baby Boomers (born from 1945 to 1964) and Generation Y (born from 1977 to 2000). One of the most important goals of Croatian winemaking is to win over younger consumers, given that these generations often reach for other alcoholic beverages such as beer and spirits [21].

Observing the foreign trade exchange of wine from 2017 to 2020, imports were much higher than exports, but imports and exports are decreasing yearly. The balance for all observed years is negative; for 2020, this loss amounted to \notin 14 792 902. In 2020, most wines were exported to Bosnia and Herzegovina, Germany, the United States of America, Serbia and the Netherlands. Total exports in 2020 provided earnings of \notin 12 574 332. The highest price per litre was achieved for export to the Netherlands, amounting to \notin 15,04/l. Most wine was imported from North Macedonia, France, Italy, Kosovo, Bosnia, and Herzegovina. The total import cost in 2020 was \notin 27 494 651. The highest price of imported wine per litre was also achieved in the exchange with the Netherlands and amounted to \notin 14,48/l [25].

It is necessary to point out that the common organization of the wine market of the European Union, to which the wine market of Croatia belongs, differs from other common market organizations by its complexity, as well as the fact that it includes not only price and market interventions, but also the control of grape production, wine production, oenological practices and procedures, rules related to the labelling and protection of wine as well as rules covering the path of grape and wine products on the market, from the producer to the final consumer. The diversity and wealth of ecological conditions ensure the possibility of growing many grape sorts in all wine-growing areas of the Republic of Croatia, which means market development and an increased number of competitors in the Croatian market.

WINE PREFERENCES ACCORDING TO THE OCCASION OF PURCHASE

Wine is an alcoholic drink, i.e. the product of incomplete or complete alcohol fermentation of fresh grapes or their juice. Namely, wine contains different concentrations of alcohol (from 9 to 15 vol %), and it also contains a certain number of mineral ingredients, mainly magnesium and sodium salts mostly bound to organic acids (tartaric acid), which are easily broken down

in the body and which give wine alkaline properties [26]. Wine contains about 400 ingredients, but their nutritional value is quite low. Wine is also rich in group B vitamins, especially B2 and nicotinic acid B3, and the nutritional value of one litre of wine is 600-700 calories. Sweet wines can range up to 1400 calories. The eternal topic is the pairing of food and wine, which is discussed by wine connoisseurs, oenologists, sommeliers, food and wine lovers, that is, everyone who drinks wine. This extremely popular theme opens up various possibilities for cooperation between wineries and local restaurants, then wineries and local food producers (for example, pieces of bacon and/or sausage, hard cheese or mushrooms that go perfectly with wine). Also, this is an opportunity for tourism workers to organize and promote local original dishes and create a unique tourist gastro - oenological experience. Wine and food combine, offering a compelling combination of tastes and experiences and an important part of many people's lifestyles. Food and wine are often the main attractions at festivals and events, and on many other occasions, they are a necessary addition to entertainment or work. Food and wine lovers are the main drivers of trips where facilities offer food and wine. Food and wine lovers mostly tend to belong to such social worlds and seek experiences that shape and affirm their personal and social identity. In this context, events manifest inclusion in the social world, play multiple roles related to identity and offer benefits that are highly valued by "insiders". Some events can achieve "iconic" status in their appeal to special interest groups, rising above all others thanks to their uniqueness and symbolic value. Moreover, of course, many go to wine and food events for the simple pleasures of taste, fun and fellowship.

Teaching consumers and gradually creating a "wine culture" is desirable. This approach aims to move away from the consumption of wine as an alcoholic product and the criticism that we promote alcoholism. By learning and creating a wine culture in the consumption of wine, we expand the horizons of possible drinkers and those who enjoy a good drop. Like any other, true wine culture is acquired over time and mainly implies certain knowledge about the vine, wine production, and the classification of wine (by quality, colour, CO2 content, and sugar). It is also desirable knowledge about serving wine. Still, the most delicate element of wine culture is the pairing of wine and food.

When it comes to wine lovers or connoisseurs, wine consumers can be grouped into three basic profiles:

- wine expert who has extensive knowledge about wines and visits wineries to buy, taste and learn about wines,
- a wine lover who loves wines, has experience in tastings and is eager to deepen his knowledge,
- casual wine tourists or wine enthusiasts with a low to moderate interest in wine are motivated to visit the region for non-wine reasons, and wineries are seen as "just another attraction". He is satisfied with his basic wine knowledge.

Trends such as local and expert food tours, street food and markets, cooking classes, home cooking, and meal sharing are expected to remain highly influential in culinary tourism. Regions must embrace their culinary history and include gastronomy in their tourist offer. In particular, countries with a rich culinary tradition should focus on developing culinary tourism and incentivize local companies to invest in this tourism segment.

Today, it is widely recognized that it is no longer enough to sell a tourist product only with a quality offer; it is also necessary to encourage an unforgettable experience. For this strategy to be successful, the conditions must be enabled to deliver superior visitor-focused food and wine experiences through consistent improvement and innovation. To achieve this, it is important to understand the four components that almost every tourist experience can be divided into:

- the product, food and wine must be authentic and "match",
- the service must be at a high level,

- the story must be recognizable,
- the narration must have a unique character.

Major consumers of wine are the generation of millennials who expect wine to meet high ethical standards. Growth of disposable income, the maturing of the market for authentic products, which means more experienced wine consumers, and willingness to experiment translate into greater demand for wine experiences among older consumer groups. Especially among the millennial consumer generation, there is a great interest in experimenting with wines from different cultures. The survey results by [27] support the view that globalization and the subsequent cultural transition from the West to the East make wine consumers more openminded about wine and more willing to try new, exotic products. Although traditional decisionmaking models can explain the behaviour of wine consumers' behaviour, wine consumers' behaviour has some specificities related to wine as a product of choice and its properties. Choosing a wine is a multifaceted decision that involves different behaviours [28]. It is a complex process involving many factors influencing wine consumers' choices [29-31]. Many models have been specifically developed to emphasize differences in behaviour in specific contexts and the influencing factors in this respect [32]. These models tend to explain wine choice behaviour from different perspectives, and in the next section, food choice models are introduced to explain the factors influencing the behaviour.

Article [33] was one of the first researchers to develop a model of consumer behaviour specifically for food consumption. The same model can be applied to the choice and selection of wine. This model divides the wine-buying decision process into four steps. The first stage is "need recognition" when consumers encounter discrepancies between their desired and actual existence. This condition can cause three different situations. The first situation is when the type of wine is no longer available. The second is when customers are not satisfied with the existing wine. The third is when there is a desire to experience a new product, a new wine, to stimulate their activation. The second stage is the search for information that is influenced by the previous experiences of the consumer's customers. The last stage is the evaluation of alternatives. Since there are many different wine products with different properties, colours, and dryness, which can meet consumers' expectations when choosing different alternatives, evaluation and purchase criteria arise.

This assessment is based on wine quality, price, brand/reputation, freshness and warranty, country of origin, and year of harvest. So, for example, gastronomic tourists who research the wine of the country where they are staying for the first time mostly do so in restaurants. By reading a wine list translated into their language, or often in English, they discover the specific wines and dishes of the country where they are staying. This reading is triggering and can be misleading: only knowledge of the local area and long-standing knowledge of wine tradition and culture can impart structural knowledge about wine and lay the foundations for true understanding. Knowledge is slowly built up by handling and enjoying the ingredients of wine. It is, therefore, a detour through fields, vineyards and grape picking, visiting markets and performing successive critical tests that lead to gastronomy. Each type of wine requires skills and cultural knowledge to take full advantage of it. For this to be possible, the tourist must be helped, advised and guided.

RESEARCH OF WINE CONSUMER PREFERENCES IN NORTHERN CROATIA

This section discusses the research questions, goals, and propositions that represent the basis for the research part of the work. The second part of the section presents the research results and limitations, as well as recommendations for further research.

RESEARCH METHODOLOGY

Figure 1 presents the summary of the methodology used in this research.



Figure 1. Research design.

The research part of the work includes processing and presenting the results of an online survey. The questions in the survey were compiled following the stated objectives of the research, based on a theoretical overview and previous research on this or a similar topic. The survey contains open and closed questions and consists of a total of 21 questions, of which 1 question is a filter question (separates people who do not consume wine from people who do; only one respondent was excluded from the study on that basis), 6 questions refer to the demographic characteristics of the respondents, and 14 questions refer to the examination of consume preferences and attitudes.

The target sample is adults living in North Croatia, which, according to the new statistical division of Croatia (National Classification of Statistical Regions 2021, NN 125/19, Article 3), includes the following 5 counties: Međimurje, Varaždin, Krapinsko-Zagorska, Koprivničko-Križevačka i Zagrebačka. The sample type is convenient, given that the survey questionnaire created via Google Forms was conducted via the author's Facebook page and was published in several Facebook groups (Volim gemišt, Anketalica, Studentski dom Stjepan Radić – "Sava"). The research propositions were tested by performing the chi-square test [34].

RESULTS

In this section, the results of the survey conducted in the period from May 31, 2022, to June 13, 2022 will be presented. A total of 338 respondents participated in the survey. All respondents are over 18 years old, come from North Croatia and have tasted wine at least once. The respondents were grouped into people who consume wine and those who do not. The largest number of respondents (65,4%) are between 18 and 30 years old, followed by 31 to 44 years (25,4), 45 to 60 years (8,3%) and the fewest respondents (0,9%) are 61 or older. The majority of respondents (68,6%) are male. Most respondents come from Varaždin County (45,9%), the least from Međimurje (7%), and most of them, 69%, live in rural areas. The majority of respondents have a secondary education (59,2%), followed by a university education (39,6%) and a basic education (1,2%). The majority of respondents (70,1%) are employed or self-employed, 27,2% of respondents are pupils or students, and a smaller percentage are unemployed (1,2%) and retired people (1,2%). The data are presented in Table 6.

Variable	Modalities	No. of respondents	percentage, %
	18-30	18-30 221	
_	31-44	86	25,4
Age	45-60	28	8,3
	61 or higher	3	0,9
	Male	232	68,6
Sex	Female	106	31,4
	Rural	234	69,2
Urban/rural area	Urban	104	30,8
	Međimurje	24	7,1
	Varaždin	155	45,9
	Krapinsko-zagorska	38	11,2
County	Koprivničko- križevačka	46	13,6
	Zagrebačka	75	22,2
	Elementary	4	1,2
Education	Middle	200	59,2
	Higher	134	39,6
	Employed or self- employed	237	70,1
Work status*	Unemployed	4	1,2
	Student	92	27,2
	Retired	4	1,2
Total		338	100 %

Table 6. Demographic attributes of respondents. Invalid answers are excluded from the table.

When examining wine consumption habits among various age cohorts, an interesting narrative unfolds in Figure 2. A significant majority of individuals from 18 to 30 report infrequent consumption of alcoholic beverages, often limited to a few occasions per year or on a monthly basis. However, in an almost equivalent proportion, still high number of individuals partake in the consumption of wine on many occasions during the week. Transitioning to the demographic encompassing those aged 31 to 44 years, a notable shift in the narrative becomes apparent. Most of these individuals derive enjoyment from consuming wine on multiple occasions during the week, while a smaller group distinguishes itself by partaking in wine consumption on an intermittent basis. As individuals go into the older age bracket, most partake in the consumption of wine on various occasions during the week. However, the number of everyday users is restricted to just five individuals.

According to this article's first research proposition, $\mathbf{RP_1}$, the frequency of wine consumption depends on the consumer's age. The hypothesis will be tested with the chi-square test of independence. In this case, the chi-square test proves the interdependence of two variables, i.e., the frequency of wine consumption and the consumer's age.

The value of χ^2 is 15,148 and is greater than the theoretical value of 9,488 (with a significance level of 5 %), indicating the acceptance of **RP**₁: Age affects the frequency of wine consumption. The collected data indicate the conclusion that older individuals consume wine more often, which is in line with the features of wine consumer preferences described in the third section.

Table 7 presents wine consumer preferences. Results show that the most common reason for consuming wine in North Croatia is to enjoy the taste (39,1%), followed by fun (30,4%) and company (17,5%). In contrast, other reasons, such as health, stress, work and boredom, are in

250 —			
200 —			
150 —			
100 —			
50 —			
0	18 to 30 years	31 to 44 years	45 to 60 years
□Every day	24	13	5
□ Several times a week	97	46	20
☑ Very rarely / few times a year/ month	98	26	3

a smaller ratio. Thus, the consumers of this area can be classified as social wine consumers focused on pleasure and entertainment.

Figure 2. Re	elationship between	age of responder	nts and frequency of	wine consumption.
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Table 7. Wine consumer preference.

Variable	Modalities	percentage, %
Bassana far wina	Taste	39,1
	Fun	30,4
consumption	Company	17,5
	Cottage/wine cellar	70,7
	Friends and family	66
	Home	65,1
Place of consumption	Caffe	49
Place of consumption	Restaurant	26,6
	Outdoor	23,6
	Work	8,7
	Elsewhere	1,5
	Beer	75
Alcohol preference	Spirits	21,1
	Beer and spirits	3,9
Domostic/foreign wine	Domestic	85,1
Domestic/Toreign wine	Foreign	0,6
preference	Indifferent	14,3
	Production at home	45,7
	Store	18,8
	Friends and family	11,3
Purchase	Winery	11
	Family farm	6,7
	Restaurant	1,5
	Do not buy	4,5

The majority of respondents consume wine in a cottage or wine cellar (70,7 %), followed by consumption with friends and relatives (66 %), consumption at home (65,1 %), consumption in a cafe (49 %), consumption in a restaurant (26,6 %) and outdoor consumption (23,6 %). As many as 8,7 % of consumers consume wine at work, while 1,5 % consume wine elsewhere. Wine is the primary alcoholic beverage of 75 % of consumers, while the other 25 % prefer some other type of alcoholic beverage.

Consumers for whom wine is not their primary alcoholic beverage mostly prefer beer (75 %), followed by spirits (21,1 %), and 3,9 % of consumers prefer both beer and spirits more than wine. The majority of consumers prefer domestic wine (85,1 %). Only 0,6 % of consumers prefer foreign wine, while 14,3 % do not care about the origin of the wine.

A large part of consumers produces their wine (45,7%), and the rest of consumers most often buy wine in a store (18,8\%), from friends or relatives (11,3\%), in a winery (11\%), at family farms (6,7\%) and in a restaurant (1,5\%). On the other hand, 4,5\% of consumers do not buy wine.

Interestingly, the largest % of respondents (24,2 %) do not buy wine and only drink it when someone offers it. This group potentially includes people who produce wine and, for this reason, do not buy wine, but on the other hand, it is evident that a certain number of wine producers also buy wine.

The following varieties are among the 10 most consumed sorts in North Croatia: Graševina, Muscat, Rhine Riesling, Green Sylvan, Sauvignon, White Pinot, Chardonnay, Cuvee and Noja. A large amount of mixed white wine is also consumed.

The percentage of preference for white wine (81,5 %) indicates that wine consumers in North Croatia prefer white wines, as stated by the hypothesis (Figure 3). The value of χ^2 is 557,45, which is significantly higher than the theoretical value of 7,815. Therefore, it can be concluded that there is a statistical feature of differences in wine colour preferences. This can be explained by the wine tradition of North Croatia, which was influenced by the stormy past, and white wine sorts traditionally predominate in vineyards. White wine is preferred by consumers in North Croatia due to its crisp taste and the fact that white wine "goes well" with traditional dishes such as turkey with bacon or blood sausage, as well as various side dishes from baked beans and potatoes, very spicy, to smoked or dried cheese. The minerality of white wines brings refreshment during the summer months. Among the characteristics of the wine (Table 8), the most important for consumers is the quality, the average importance of which is 4,1, followed by the wine sort with a rating of 3,4. At the same time, the producer (2,9), favourable price (2,8) and packaging (2,78) have approximately the same importance (Table 8).



Figure 3. Preference of wine among respondents from North Croatia.

Table 8. Wine characteristics rating.

Variable	Modalities	Average rating (from 1 to 5)
	Quality	4,1
Wine characteristics	Sort	3,4
whe characteristics	Produces	2,9
Importance	Price	2,8
	Packaging	2,78

Comparing the price and quality of wine, most consumers (70 %) believe that a higher price is not an indicator of better quality of wine. This can be confirmed by the fact that quality is the most important characteristic for consumers when buying wine, and they think they do not have to pay large sums of money to get that quality.

Following the previous analysis of preferences, some of the attitudes of wine consumers are presented in Table 9. Consumers rate themselves mostly as good wine connoisseurs (44,8 %) and very good wine connoisseurs (32,5 %). To a slightly lesser extent, they rate themselves as excellent wine connoisseurs (11,3 %) and poor wine connoisseurs (10,1 %), while only 1,2 % of consumers believe they do not know wine. Wine supply in the Croatian market is satisfactory for 42,1 % of consumers; 17,6 % are very satisfied, while 35,5 % are indifferent. Although they are satisfied with the range of wine sorts, most consumers believe Croatian wines are not promoted enough (61,2 %). Only 15,8 % of consumers think that wines are promoted enough, while 23 % of respondents do not know.

Variable	Modalities	percentage, %
	Excellent	11,3
	Very good	32,5
Knowledge of wine	Good	44,8
	Poor	10,1
	No knowledge	1,2
	Very satisfied	42,1
	Satisfied	17,6
Wine supply satisfaction	Indifferent	35,5
	Not satisfied	3,6
	Not at all satisfied	1,2
	Enough	15,8
Wine promotion	Do not know	23,0
	Not enough	61,2

 Table 9. Wine consumer attitudes.

DISCUSSION

It is a positive fact that in 2021, 76,44 % of the wine produced in Croatia is categorized as highquality, which provides a good basis for further development. Considering the ratio of physical entities and legal entities among wine producers, it is evident that wine production in Croatia rests on smaller producers who mostly operate locally. This is why the wine market in Croatia is quite diverse regarding indigenous wine varieties and producers, depending on which part of Croatia it is. Interestingly, 33,39 % of all registered entities are located in North Croatia, but they produce only 10,14 % of wine in Croatia. Croatia produces self-sufficient amounts of wine, but the wine balance is negative, which makes us aware that it is necessary to go to foreign markets to a greater extent. The highest price for a litre of wine is achieved in exchange with the Netherlands, where Croats sell wine for \in 15,04 and buy wine for \in 14,48. On the other hand, the price of an average bottle of wine in Croatia is around \notin 5, which, compared to neighbouring countries, is the average price of wine for this climate.

Two research questions were set in this article: What is the profile of wine consumers in North Croatia? What are the preferences of wine consumers in North Croatia? By studying the profile and the preferences of wine consumers in North Croatia, it is evident that wine is consumed for social reasons, leisure and entertainment, most often with friends or family in their own home or cottage. The frequency of wine consumption varies between once a week and once a month, and a statistical test established the connection between the frequency of consumption

and the consumer's age, where younger people consume wine less often than older people. Wine is the primary alcoholic drink for 75 % of consumers, and the most common substitute for wine is beer. Quality is valued most in wine, while wine packaging is least valued. As much as 85 % of consumers prefer domestic wines. An equal number of consumers buy wines in the lower and higher price groups, with many not buying wine because they produce it. Other forms of wine distribution, such as in-store purchases, door-to-door sales, and wineries, are the most common. Most respondents are satisfied with the offer of wine on the Croatian market and believe that quality wines do not necessarily have to be expensive. Still, they also believe that Croatian wines are not promoted enough. In addition to the research questions, two research propositions were formed: \mathbf{RP}_1 – Age affects the frequency of wine consumption, and \mathbf{RP}_2 – Wine consumers in North Croatia prefer white wines. The research confirmed both research propositions.

CONCLUSION

SUMMARY OF RESEARCH

Consuming wine is not only for fun and relaxation; it is an essential part of the economy and part of a culture maintained for several thousand years. It is believed that wine production originated in Mesopotamia and that traders brought the culture of producing vines to the rest of the world. The entire process of wine production and consumption has changed significantly throughout history regarding the development of new technologies and agricultural procedures, which only contributed to the spread of this culture and the development of new varieties. Numerous types and varieties of wine provide a wide range of products that can satisfy the basic needs of the most demanding consumers. It is known that certain wines are more appreciated through the ageing process, which can also be applied to consumers who, upon reaching maturity, begin to appreciate the quality and variety of wines more. Traditional viticulture, developed in a certain area for many years, is especially appreciated, like the viticulture of many European countries. Italy, Spain and France are the world's leading wine producers. Viticulture as an agricultural activity depends significantly on weather conditions and economic crises, which is why, in the last few years, there has been a decrease in wine production. There is also a legal framework that, through various ministries, agencies and institutions, provides certain quality control, records on the status of imports and exports and wine stocks, determination of average prices and many other control functions. Of particular note is the vineyard register, which gathers information on wine production in Croatia.

This article aimed to examine wine consumers' preferences in North Croatia. Consumer preferences are influenced by various factors, including economic, psychological, sociological and cultural, that need to be addressed. Thus, an interdisciplinary approach was used in forming this research. The research results indicate that wine consumers in North Croatia are middleaged or older and prefer white wines. Consumers prefer domestic wines, and the most important characteristic is the quality of the wine, while consumption is most often in one's own home or cottage. Knowledge of consumer preferences is the foundation for successful marketing activities essential to entering and maintaining the market. There are also some specific features of wine marketing, given that it is an alcoholic drink whose excessive consumption can lead to serious side effects. Therefore, it is sometimes difficult to choose the right way of communicating with consumers and creating appropriate and attractive advertising. The promotion of wine is hampered by the legal framework that strictly dictates that wine must not be associated with sociological successes and must not be presented as a positive solution to personal problems. Nevertheless, the wine industry finds other ways to promote wines and their producers through various wine manifestations, fairs and numerous exhibitions, where producers get direct promotion. Such manifestations mostly occur locally, where smaller producers who have ambitions to expand the market can also participate.

The interest and need for wine tourism certainly exist. Visits to wineries and wine events should be adapted to today's busy life. Sometimes, consumers do not have the opportunity to set aside a whole day for a tour of the wine roads. Still, they will be happy to make time for an evening trip to a nearby winery or an event that offers them the perfect combination of gastronomy and oenology. Croatia is a diverse country, and each area can offer something unique and indigenous. Therefore, it is necessary to create content that faithfully and briefly shows a certain area's tradition and culture of winemaking and viticulture while combining it with gastronomy and catering, which will further attract tourists. It is important to create a positive atmosphere and make it known that enjoying wine does not have to be expensive and inaccessible. Wine tasting is not intended only for top connoisseurs; communication with them can create a broader picture and greater wine knowledge.

RESEARCH LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

It is worth pointing out a possible limitation of this research. One limitation is using a convenience sample that is potentially not representative of the area. This primarily refers to the age group and county of the respondents, i.e. the largest number of respondents are in the age group of 18 to 30 years, and most of the respondents are from Varaždin County. Certain parts of the wine market have not been researched at the national level, such as the attendance of Croatian wineries, which can be a suggestion for further research to create a better quality tourist offer.

Based on the research results, future research propositions emerged, which take into account that tourism is a system that needs management practices forming a system, e.g. between food and wine consumption [35]. In a world where tradition seamlessly intertwines with innovation, the age-old practice of wine consumption offers many untapped opportunities. The culture and economy surrounding wine have proven resilient, surviving and adapting through thousands of years of changing landscapes, technologies, and tastes.

As our research has shown, the evolution of wine production has always been closely linked to technological advances and improved agricultural procedures. This suggests that modern viticulture can benefit significantly from adopting innovative agricultural technologies, possibly leveraging advancements like precision agriculture, drones for vineyard health assessment, or even AI-driven predictive analytics to optimize grape yield and quality.

Given the breadth and variety of wines available, there is an immense potential for creating tailored consumer experiences. Augmented reality is a tool becoming prevalent in several business sectors; tourism is one of them [36]. Imagine augmented reality wine labels that narrate the rich history of the vineyard or smartphone applications that provide real-time sommelier advice based on individual taste profiles. Such innovations could amplify the appreciation of wine, especially for the more mature consumer demographic that has grown to value the nuances of different wine varieties. Europe's traditional vineyards, such as North Croatia, could embrace such innovations as a marketing tool and a means to preserve their rich heritage. By digitizing centuries-old viticulture techniques and stories, they can be preserved for future generations, ensuring the continuity of knowledge and practices and making them suitable for easy sharing over social media [37, 38].

However, the challenges posed by unpredictable weather patterns and economic fluctuations cannot be ignored. Herein lies an opportunity for innovations in sustainable viticulture. Techniques like drought-resistant grape cultivation or environmentally controlled indoor

vineyards might be the answer to ensuring consistent wine production, even in adverse conditions. In the case of pandemics, various innovations, such as private dining restaurants, were invented [39], which still can have relevance in nowadays post-pandemic world.

Lastly, with the importance of legal frameworks and institutions such as Croatia's vineyard register, there is room for digital transformation. Blockchain technology [40], for instance, could ensure the traceability and authenticity of every wine bottle, providing consumers with assurance about the product's origin and quality.

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OPTIMISING INVESTMENT DECISIONS IN R&D INTENSIVE PRIVATE MICRO-ENTITIES USING GAME THEORY

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ABSTRACT

In this article, three small private R&D intensive European entities have been used in a case study involving game theory combined with content analysis in an attempt to identify an optimal investment strategy. A game theory matrix is constructed for each entity based on previous exposure of investors to the entities' capital sources. The basic concept is that the investment exposure's size is affected by the capitalisation of internally generated intangible assets; in other words, investors consider capitalisation of internally as a positive signal regarding the future economic benefits associated with the intangible asset, and as a result, they adjust their investment positions accordingly. The matrices aim to identify an optimal investment strategy in high-intensity R&D private micro entities.

The game theory matrices are constructed using publicly available empirical data extracted from the financial statements of three R&D intensive private micro-entities. The game theory matrix attempts to estimate the effect of the managerial discretionary choice to capitalise or expense the development cost of internally generated intangible assets; the risk appetite of investors could be affected by the capital-isation signalling. The investment strategies are classified based on their risk in three categories. High risk is represented by equity; medium risk is represented by long-term debt, and low risk is represented by short-term debt.

The results of the game theory matrices indicate that if a potential investor were to select an investment strategy after the end of the investigated time frame, end of 2015 for one entity and 2016 for the other two, the dominant strategy would be a medium risk through long-term debt for one company and low risk for the other two. These dominant strategies are then evaluated ex-post by reviewing the financial positions of the entities according to the most recent financial statements and additional relevant documentation.

KEY WORDS

intangibles, investment, strategy, matrices, R&D, capitalisation

CLASSIFICATION

JEL: G32, M21

INTRODUCTION

Research and development expenses are essential when innovating; however, the global accounting standards fail to capture the full value of R&D, thus resulting in an understatement of their value in the financial statements [1]. On the other hand, the income statement can provide all the necessary information regarding internally generated intangibles without compromising the quality of the information while at the same time mitigating any risks deriving from asset capitalisation [2].

Some researchers seem to support the capitalisation approach, while others support conservatism, expressed through the expenditure of development-related costs [2, 3]. Indeed, capitalisation reduces information asymmetry, encourages innovation, reduces debt issuance cost and mitigates under-investment [3-6].

All these positive attributes of internally generated assets' capitalisation rely on genuine signalling, which is based on the managerial discretionary choice to capitalise on development costs. This article aims to investigate if simple game theory matrices can assist in navigating investment decisions in cases of R&D intensive private entities. The case of private entities is investigated, considering that financial data is more limited than publicly traded entities. Also, the primary factor affecting the players' decision is development cost capitalisation and its embedded signalling of project success or underlying managerial earnings manipulation [7].

The structure of the article is as follows: The next chapter describes the methodology used to construct the matrices. The second chapter explains and presents the basis of the calculations involved. The third chapter presents the entities chosen as case study subjects. Their profiles are presented along with information regarding the nature of their business and affiliations; their business and managerial ties are directly related to their eligibility as case study subjects. The fourth chapter contains the results; two tables are created for each entity. One table contains the data extracted from the financial statements in a format that can be used to create a game theory matrix. The second table per entity is the game theory matrix itself, accompanied by the solution of the game and its interpretation. At the chapter's end, another table summarises the results and contrasts them with the entities' current status to identify the results' accuracy. The final chapter contains the conclusion and a discussion regarding the article's contribution and the limitations of the game matrices.

Capitalisation of R&D expenses is contingent upon the likelihood of future economic benefits materialising, with a threshold of over 50 % probability, according to the Australian Accounting Standards Board [8]. However, measuring the inputs and outputs of intangible assets presents challenges for managers, making it difficult to match expenditures to outcomes [8] accurately. Based on the probability of future economic benefits, the discretionary decision to capitalise on development costs carries risks such as earnings management, misrepresentation, personal financial gain for managers, and potential delays in disciplinary action [7-10].

These factors indicate that the managerial decision regarding the probability of future economic benefits is a potential point of failure, which can be addressed using the income statement. R&D expenditures can be expensed while accompanied by voluntary non-financial disclosures in the financial statement notes [2, 11].

This article aims to determine the most rational investment strategy for three entities engaged in R&D activities using game theory. Empirical data is utilised, and the evaluation of investment decisions is retrospective, based on events that have already occurred within the investigated time frame. The optimal strategy is identified by considering a reasonable level of R&D progress and the management's decision to capitalise on the intangible asset after completing the research phase. For example, if an investor is considering investing in an R&D- intensive private micro-entity in the 8th year of project development, provided that the management has chosen to capitalise the intangible asset and the research phase is finalised, the three strategies from the investors' perspective are categorised as low risk, medium risk, and high risk, represented by short-term debt, long-term debt, and equity, respectively. On the other hand, management faces a binary decision: to capitalise on the development cost or to expense it.

The entity's management aims to secure capital with favourable terms, while investors seek to maximise their profits while considering the associated risks. Although the management and investors are not in direct competition, their agendas may differ regarding the success or failure of an R&D project.

The case study focuses on private micro-entities in the U.K. operating in the industry sector of "other research and experimental development on natural sciences and engineering", categorised under SIC 72190.

A relevant research study examined the value relevance of R&D expenses in the U.S. and internationally [1]. The study concluded that current financial standards do not accurately capture the value of R&D-related activities. The results varied across time and industries, but the main finding was that "intangible capital intensity is related to changes in the value relevance of earnings and book value". This finding explained their global sample's cross-sectional variation in stock prices from 1994 to 2019. The study also confirmed a decline in the combined value relevance of earnings and book value for companies with high intangible intensity, both in the U.S. and internationally. In contrast, no such decline was observed for companies in the low-intangible-intensity group.

Regarding the financing of R&D and the creation of intangible assets, one view suggests that when the values of assets are not transparent to the external environment, debt financing is preferable, and equity issuance is only done when necessary. However, the asymmetric information associated with asset development can increase investment risk, leading to higher debt issuance costs. As a result, equity may be issued to avoid these elevated costs [5]. It is worth noting that without the capitalisation of intangible assets, there would be no option to use internally generated patents as collateral [10]. However, using intangible assets as collateral entails a certain level of risk, as the number of patents owned or successful patent applications does not necessarily indicate their value [11].

Another team of researchers suggests that entities choose to finance their intangible asset development projects with equity rather than debt due to the high informational opaqueness associated with these projects, which results in higher debt issuance costs. According to their findings, for every \$1 spent on R&D, \$0,8 is financed through equity issuance and \$0,26 through short and long-term debt [5]. Regarding information asymmetries in R&D projects, it is argued that managers have better knowledge about the project outputs than external stakeholders [12]. Additionally, it is noted that under International Financial Reporting Standards (IFRS), managers have the discretionary right to decide whether to capitalise or expense development costs based on their estimation of the probability of future economic benefits. This practice can lead to earnings management, as managers may choose to capitalise expenses to show higher earnings to shareholders or expense them to take advantage of tax benefits. As a result, investors may disregard the valuation of R&D after implementing IFRS. When transitioning from a mandatory expense or capitalisation framework to IFRS, the impact on value relevance is more significant in the presence of robust investor protection regulations. Institutional factors play a crucial role in value relevance, and convergence to a common financial reporting framework alone is insufficient. High-patent entities with successful innovations prefer disclosing patent information rather than asset capitalisation, especially when their legal environment provides adequate intellectual property protection [13]. Investor

protection and intellectual property protection contribute to greater information dissemination, making information available to stakeholders beyond just the managers.

METHODOLOGY

In the case study, three small private R&D intensive European entities were analysed using game theory and content analysis to determine an optimal investment strategy. A game theory matrix was constructed for each entity based on investors' previous exposure to the entities' capital sources.

The main concept underlying the matrix is that the capitalisation of intangible assets influences the size of exposure. Investors perceive the capitalisation of intangible assets as a positive signal indicating potential future economic benefits associated with developing these assets. Consequently, investors adjust their investment positions based on this signal.

The game theory matrix aims to assess the impact of managerial discretion in choosing whether to capitalise or expense the development costs of internally generated intangible assets. The capitalisation decision can affect investors' risk appetite and their investment strategies. The investment strategies are categorised into three risk levels: high risk, represented by equity; medium risk, represented by long-term debt; and low risk, represented by short-term debt.

The game theory matrix is structured as a 3×2 matrix, with the two columns representing the treatment methods for development costs (capitalisation or expense) and the rows representing the three different investment strategies classified by risk. The values within the matrix are the averages of equity, long-term debt, and short-term debt corresponding to the expenditure under each treatment method (expense or capitalisation).

The average equity under capitalisation is expressed as

$$e_{cap}^{-} = \frac{\sum e_{capi}}{n_{cap}},\tag{1}$$

where $\bar{e_{cap}}$ is the average equity under capitalisation, $\sum e_{capi}$. The sum of equity for the years where intangible assets are recorded on the balance sheet and n_{cap} is the number of years with capitalised intangible assets.

The average long-term debt under capitalisation is expressed as

$$L_{cap} = \frac{\sum L_{capi}}{n_{cap}},\tag{2}$$

where L_{cap} is the average long-term debt under capitalisation, $\sum L_{capi}$ the sum of long-term debt for the years where intangible assets are recorded on the balance sheet, and n_{cap} is the number of years with capitalised intangible assets.

The average short-term debt under capitalisation is expressed as

$$S_{cap}^{-} = \frac{\sum S_{capi}}{n_{cap}},\tag{3}$$

where S_{cap} is the average short-term debt under capitalisation, $\sum S_{capi}$ the sum of short-term debt for the years where intangible assets are recorded on the balance sheet, and n_{cap} is the number of years with capitalised intangible assets.

The relevant averages are calculated if the development expenditures are expensed or the capitalised intangible asset is eliminated from the balance sheet for any reason, such as impairment.

The average equity under expensing is expressed as

$$e_{ex}^- = \frac{\sum e_{exi}}{n_{ex}},\tag{4}$$

where e_{ex}^{-} is the average equity under expensing, $\sum e_{exi}$ the sum of equity for the years where intangible assets are not recorded on the balance sheet, and n_{ex} is the number of years without capitalised intangible assets.

The average long-term debt under expensing is expressed as

$$L_{ex}^{-} = \frac{\sum L_{exi}}{n_{ex}},\tag{5}$$

where L_{ex} is the average long-term debt under expensing, $\sum L_{exi}$ the sum of long-term debt for the years where intangible assets are not recorded on the balance sheet, and n_{ex} is the number of years without capitalised intangible assets on the balance sheet.

The average short-term debt under expensing is expressed as

$$S_{ex}^{-} = \frac{\sum S_{ex,i}}{n_{ex}},\tag{6}$$

where S_{ex} is the average short-term debt under expensing, $\sum S_{ex,i}$ the sum of short-term debt for the years where intangible assets are not recorded on the balance sheet and n_{ex} is the number of years without capitalised intangible assets on the balance sheet.

The six numbers in the matrix are considered projections of investors' reactions to the capitalisation or expensing of intangible assets. Averages were chosen as the metric because they consider the invested amounts during the years when alternative valuation methods for intangible assets were implemented. Using averages ensures that if the signalling effect caused by intangible asset capitalisation does not significantly impact equity, the average equity during the years of expensing will not differ from the average equity during capitalisation.

This case study aims to determine the most sensible investment strategy using game theory for entities primarily involved in R&D activities. The analysis is based on empirical data, and investors' decisions are evaluated retrospectively based on past events. The optimal strategy for similar situations can be identified by examining these events, assuming that the project has progressed beyond the research phase. The three investment strategies from the investors' perspective are categorised as low, medium, and high, represented by short-term, long-term, and equity, respectively. On the other hand, management faces a binary decision of whether to capitalise or expense the development costs.

The case study focuses on understanding how investors should react to the managerial decision of expensing or capitalising intangible asset development costs. The three entities selected for the case study have common individuals exerting significant control throughout a substantial portion of the period under consideration. Therefore, a multiple case study approach, primarily exploratory, has been chosen to determine if game theory can provide an optimal investment strategy.

The three entities participating in the case study are R&D-intensive companies classified under SIC code 72190 ("Other research and experimental development on natural sciences and engineering"). These entities are private limited companies whose financial statements are abbreviated and unaudited, prepared following the financial reporting standard for small entities, FRS 105. [14]. The publicly available information for these entities, particularly for unsophisticated investors, is limited and opaque. Hence, if the case study produces reliable results, similar game theory matrices could be useful for guiding investment strategies.

While it is desirable for the solutions of the game theory matrices to be similar to confirm a replication pattern, it is important to consider the contextual factors at play. The results of the case study may have the potential for generalisation [15]. However, it is crucial not to overlook the specific context in which the case study occurs. This includes factors such as the type of

entities involved, the nature of internally generated intangible assets, and the specific restrictions or concessions applied to the game theory matrix.

Assumptions and concessions are essential for the game theory matrix to function effectively. These assumptions and concessions set the rules and framework for the matrix. They provide a structure within which the decision-making process can be analysed. The specific assumptions and concessions made in the case study should be clearly stated to ensure transparency and understanding of the game theory analysis. By acknowledging the following assumptions and concessions, the limitations and scope of the case study can be properly assessed.

First, due to the entity's activity, investing in it involves a high amount of uncertainty and, consequently, risk; the directors of the company state in the notes to the financial statements that "the company is supported by its creditors who are aware that the company may not be able to pay its debts until the benefit of its research and development crystallises". This, on its own, is an admittance that conducting R&D is the main driver of the company's value and income generation source. Thus R&D is the most important factor determining the entity's financial performance, overshadowing every other asset.

Secondly, these are private companies, unlisted by default, so the investor protection framework regarding regulated market participants is not applicable.

Thirdly, the game matrices focus on the investors' strategy decision regarding the risk they are willing to assume under two different intangible asset value reporting schemes, expense or capitalisation. No other factors affect their decision since the company's primary objective is, by definition, its activity to generate intangibles through R&D; any other factor is secondary and irrelevant to the game's solution. Given that the primary objective of the companies is to generate intangible assets through their R&D activities, the game matrices prioritise this specific aspect and its associated reporting methods. The matrices do not explicitly consider other factors that may affect investment decisions, such as the companies' financial performance, market conditions, or industry dynamics. By isolating the decision to expense or capitalise the development costs of intangible assets, the game matrices provide a simplified representation of the investment strategy. This allows for a focused analysis of the implications of the reporting schemes on the investors' risk appetite and decision-making process without the interference of other potentially less relevant factors.

Fourthly, the investor profile is unknown, and as such, the game's solution will provide a dominant strategy or a mixed strategy irrelevant to the investor profile; the only information available from the annual return is that some of the shareholders are also directors of the company which is to be expected in a private company. The mixed strategy can combine only two investment strategies since, by definition, mixed strategies can only be calculated on a 2×2 matrix if needed.

Fifthly, the following investment options, equity, long-term, or short-term debt, are available to any interested investor. Practically, commercial banks and such institutions avoid direct investments in equity because they usually prefer debt, which involves collateral or at least the right to charge assets of any kind. Also, there might be regulatory constraints. However, although direct equity exposure is uncommon, commercial banks can gain exposure to equity investment through affiliated firms such as venture capital or investment funds.

Lastly, the three investment options are classified according to their risk in descending order; equity is the high-risk strategy, long-term debt is the medium-risk strategy, and short-term debt is the low-risk strategy. Such a classification is consistent with mainstream investment theory, which considers volatility and yield as risk indicators [16].

Through this case study, the development cost capitalisation can be observed during a timeline to identify how the investors' behaviour is affected by the signalling in terms of investment strategy selection.

The drawback of the case study is the inability to expand the game matrices' results beyond the restrictive context where they are set [15]. Also, a certain amount of operational time frame is required to construct and implement the game theory matrices, so apparently, this method cannot provide useful insights in the case of startups or before the completion of the research phase. In other words, the fact that the case study evolves around a specific population is an inherent limitation of the case study method. Also, the fifth concession regarding the availability of all three investment options seems borderline biased regarding equity. However, there is no indication from the shares allotment filled with the UK companies' houses that equity is not an option for potential investors [17].

The game theory matrices' case study also contains elements of content analysis. The financial statements and additional related documentation, such as annual return statements, return of share allotments, confirmation statements, and Patent-scope-related documentation, have been studied to extract data, but also additional information that would assist in revealing certain managerial attitudes. The content analysis has been mostly descriptive and was used mainly to identify the persons with significant control over the three case study entities and, if possible, the nature of intangible assets developed by the entities and the relevant timeline. It was essential to demonstrate that the same standard industrial classification and similar or familiar managerial mentality and culture bind the three entities. That common managerial way of thinking would create the necessary conditions, evolving into a behavioural decision pattern regarding the capitalisation of internally generated intangible assets' development costs and not a mere coincidence.

The content analysis was used to establish the existence of linkages or partnerships among the three observed entities based on the criteria of capital participation and ownership. Furthermore, content analysis was used to identify changes in managerial positions and important events such as notices of capital increase or even notices of gazette strike-offs. Additionally, through content analysis, the nature of developed patents could be identified along with their intellectual property standing level, meaning whether patent grants have been awarded or not and the nature of these patents.

Practically, the content analysis expanded to far more entities than just the three included in the case study. This action was optional but instrumental in portraying the business environment and managerial liaisons among companies with extensive R&D activities. Although additional linked entities were found with the corresponding standard industrial classification code SIC 72190-Other research and experimental development on natural sciences and engineering, no capitalised development costs, so they were excluded from the case study population.

CASE STUDY SUBJECTS' PROFILES

In this section, the profiles of the 3 companies will be presented along with additional information regarding the companies' ownership and group formations based on linkages and partnerships.

The first entity is Hudol Thermal Ltd, the company was incorporated in 2002, and the game matrix was constructed using the financial statements from 2002 until 2015; its corresponding standard industrial classification code is SIC 72190 (Other research and experimental development on natural sciences and engineering). Company statements are abbreviated,

unaudited and prepared per the financial reporting standard for small entities FRS 105 [14, 17]. The standard was amended in 2002, 2008 and 2016 within the relevant time frame, requiring the expense of all costs related to internally generated intangible assets according to the most recent amendment. However, capitalisation was allowed and implemented between 2007, 2008 and 2011 to 2015.

The second entity is Hudol Thermal Ltd, and the company was incorporated in 2003, initially under the name Celtus Ltd., until 2006, when it was renamed Hudol Thermal Ltd. The game matrix was constructed using the financial statements from 2005 until 2016; its corresponding standard industrial classification code is SIC 72190 (Other research and experimental development in natural sciences and engineering). Company statements are abbreviated, unaudited and prepared following the financial reporting standard for small entities FRS 105 [14, 17]. The standard was amended in 2002, 2008 and 2016 within the relevant time frame, requiring the expense of all costs related to internally generated intangible assets according to the most recent amendment. However, capitalisation was allowed and implemented from 2008, 2009 and 2011 to 2016. The years before 2005 have not been included since the entity seems to have been in limbo or inactive during 2003 and 2004.

The third entity is Dyfodol Energy Ltd, and the company was incorporated in 2004, initially under the name Alurec Ltd., until 2005, when it was renamed to Dyfodol Energy Ltd. The game matrix was constructed using the financial statements from 2007 until 2016, and its corresponding standard industrial classification code is SIC 72190 (Other research and experimental development on natural sciences and engineering). Company statements are abbreviated, unaudited and prepared following the financial reporting standard for small entities FRS 105 [14, 17]. The standard was amended in 2002, 2008 and 2016 within the relevant time frame, requiring the expense of all costs related to internally generated intangible assets according to the most recent amendment. However, the capitalisation was allowed and implemented during the years 2008 to 2015 included. The years after 2016 have not been included in any case study companies since, technically, after the latest amendment of the FRS 105, the managerial discretionary choice of development cost capitalisation would not be available.

The three companies are linked through indirect ownership; two natural persons seem to hold combined percentages of voting rights in all three companies above 25 % and up to 60 %; these percentages are not stable throughout the studied time frame; share ownership is constantly shifting. However, a relatively safe assumption, deriving from the shares' allotment reports, would be that these two individuals acting jointly can exercise significant influence and control on all three entities during much of the investigated period. This fact demonstrates, to a certain extent, that the managerial mentality is the same in all three entities. It is important to note that both these directors are scientists according to the annual return statements; one is a chemist, and the other an engineer. These facts are significant because, as directors, these individuals seem to have the ability as scientists to adequately evaluate the progress of the entities' projects and thus the probability of any future economic benefits flow and technical feasibility insights. The decision to capitalise on internally generated intangible assets is subject to the same managerial judgement and critical thinking; in other words, the future economic benefit probability is estimated under an identical way of thinking in all three companies. As a result, the amount of optimism or pessimism around projects has a common baseline. Investors face the same management in all three companies regarding signalling success through development cost capitalisation. All three companies are operating within the same industry and are R&D intensive; undeniably, research and development is their primary value driver. From a legal standpoint, Hudol Thermal Ltd received a compulsory strike-off notice in 2022, which was later discontinued; from its most recent financial statements, the entity has undergone restructuring and appears dormant in 2021. Subsequently, this entity alone is functioning now under different management.

Although there are no disclosures in the notes to the financial statements regarding the nature of the intangible assets capitalised, patent-scope is used to identify the nature of the assets [17]. Two out of the three entities have successfully published a patent in more than one jurisdiction, and in one of these cases, a patent grant has been obtained in more than one jurisdiction; Hudol Thermal Ltd seems to be the only one without a record on patent-scope.

RESULTS

In this section, the game theory matrix solution will be applied to the three entities to identify if there is a consistency in the results regarding optimal strategies. There is a trade-off between practicality regarding the matrices' construction and efficiency, which is interpreted as prediction capability.

The first hypothesis is that a dominant investment strategy exists in the case study and is formulated as follows.

H₁: The solution of the game matrix will provide a dominant investment strategy, either high risk, medium risk or low risk.

If the first hypothesis is rejected, the matrix will be transfigured into a 2×2 matrix, and the second hypothesis will come into play.

H₂: The solution of the matrix will provide a mixed strategy, which will be a combination of high-risk and mid-low-risk investment allocation.

The first step will be the data presentation; the data from the financial statements have been extracted and formatted to be utilised to construct the game theory matrices.

Table 1 contains the raw data in a suitable format for constructing the game matrix.

The averages of invested funds per funding source category have been calculated for the years during which development costs were expensed and for the years during which development costs were capitalised, accordingly. Those sums are, by solving for formula (1) 30 951, formula (2) 155 392, formula (3) 96 792,33, about the capitalisation method and on the other hand, formula (4) 9 765,38, formula (5) 84 823,88, formula (6) 67 617 for the expense method. At first glance, it is obvious that the entity is funded mainly by long-term debt, followed by shortterm debt and equity for most of the period under investigation. The debt-to-equity ratio skyrocketed during the initial years of the project when costs were mostly expensed, probably because of early-stage research. On the contrary, equity raises are significant when capitalisation comes into effect later, and then equity is stabilised during the last three years of the relevant time frame. The point here is exactly the narrative shift expressed through development cost capitalisation while exiting the research expense-only stage. On average, it is obvious that during the capitalisation era, the entity manages to raise significantly more funds from equity. At the same time, long-term debt is rising as if a signal was emitted calling investors to enter a "risk on" mode. The origin of the amassed long-term debt is not entirely certain; it could be new loans, restructuring short-term loans, or an increase from restructured default payments. The standard deviation is significantly higher than the average in the case of equity and long-term debt during the expense era, indicating a rather noticeable volatility diversity.
CAPITALISATION VEAD			LONG TERM	SHORT TERM	DEBT/E			
INDICATOR	ILAN	EQUIT, a	DEBT, £	DEBT, \pounds	QUITY			
EX	2002	230,00	32.681,00	33.738,00	288,78			
EX	2003	230,00	32.681,00	11.328,00	191,34			
EX	2004	230,00	32.681,00	43.740,00	332,27			
EX	2005	230,00	23.837,00	80.057,00	451,71			
EX	2006	17.050,00	29.037,00	87.756,00	6,85			
CAP	2007	20.051,00	29.037,00	92.519,00	6,06			
EX	2008	20.051,00	85.079,00	105.181,00	9,49			
EX	2009	20.051,00	200.511,00	114.307,00	15,70			
EX	2010	20.051,00	242.084,00	64.829,00	15,31			
CAP	2011	20.051,00	229.629,00	52.490,00	14,07			
CAP	2012	20.051,00	181.866,00	112.422,00	14,68			
CAP	2013	41.851,00	173.903,00	97.005,00	6,47			
CAP	2014	41.851,00	163.940,00	108.176,00	6,50			
CAP	2015	41.851,00	153.977,00	118.142,00	6,50			
Total time-frame av	erage	18.844,93	115.067,36	80.120,71	97,55			
EXPENDITURE ANNUAL AVERAGE		9.765,38	84.823,88	67.617,00	163,93			
CAPITALISATION ANNUAL AVERAGE		30.951,00	155.392,00	96.792,33	9,05			
STANDARD DEVIATI	ION EX	10117,49	86239,62	40480,73	174,63			
STANDARD DEVIATIO	ON CAP	11940,35	67223,98	23709,43	4,13			

Table 1. Extracted Formatted Data for Hudol Thermal Ltd

Note: The annual averages of the three investment options are calculated for each corresponding managerial decision regarding the capitalisation of development costs.

The financial statements do not provide detailed information regarding the nature of the capitalised assets on the balance sheet; under the header of intangible assets, the corresponding description is additions. The capitalised amounts are not large; they begin at 3 346£, reaching up to 29 355£. However, it is the signal caused by the capitalisation of the issue and not the capitalised amount necessarily. The nature of the intangible asset is identified using Patenscope. Fortunately, multiple publications were found, including two patent grants for the invention called "Gasification apparatus and method" designated WO/2004/078879 in the international application; so from a technical perspective, an intangible asset exists, although its financial success and future economic benefits are not guaranteed just by obtaining patent status [11, 18]. Initially, the New Zealand regional office granted the patent on 10/05/2007 and subsequently by the European Patent Office on 30/05/2012. The capitalised value corresponds to something protected by intellectual property rights; the issue now is how that capitalisation signal affects investors' strategies.

The game matrix presented in Table 2 is a 3×2 matrix where the two columns represent the development cost treatment methods and the rows represent the three different investment strategies classified by risk.

The averages that were presented in Table 1, calculated using formulas (1)-(6), are being used as values of the matrix in Table 2. The next step requires calculating the rows' maximum among minimum values and columns' minimum among maximum values. When the calculated two numbers are the same, the game has a saddle point indicating the existence of a dominant strategy; that would confirm the first hypothesis. If the game had no saddle point, it would be reconfigured as a 2×2 matrix to explore the second hypothesis. A more complex set of calculations would provide a mixed strategy based on

		DEVELOPMENT COST TREATMENT, £			
		EXPENSE	CAPITALISE	row maxi-min	
INVESTOR DECISION (PRIVATE, RETAIL- INVESTOR COMMERCIAL BANK ETC)	High risk (equity)	9.765,38	30.951,00	9.765,38	
	Medium risk (LT-debt)	[(84.823,88)]	155.392,00	[84.823,88]	
	Low risk (ST-debt)	67.617,00	96.792,33	67.617,00	
	column mini-max	(84.823,88)	155.392,00		
	Saddle point	Medium risk (LT-debt)			

Table 2. Game Matrix for Hudol Thermal Ltd..

Note: The saddle point pinpoints the prevailing strategy for the investors, which is medium risk, namely long-term debt possibilities.

In this game, a saddle point dictates a dominant strategy. As a result, investing in long-term debt is the dominant strategy for investors in this entity. The dominant strategy means investing in long-term debt is the best option for an investor, regardless of the intangible asset development cost accounting treatment selected by the entity's management. The first hypothesis is thus confirmed.

The same game matrix method will be applied now to Hudol Thermal Ltd, beginning with the data in Table 3.

CAPITALISATION INDICATOR	YEAR	EQUITY, £	LONG TERM DEBT, £	SHORT TERM DEBT, £	DEBT/ EQUITY
EX	2005	970,00	0,00	0,00	0,00
EX	2006	870,00	0,00	235,00	0,27
EX	2007	870,00	0,00	143.960,00	165,47
CAP	2008	1.740,00	0,00	532.406,00	305,98
CAP	2009	1.740,00	0,00	417.894,00	240,17
EX	2010	1.740,00	0,00	269.844,00	155,08
CAP	2011	1.740,00	0,00	273.473,00	157,17
CAP	2012	1.740,00	0,00	291.346,00	167,44
CAP	2013	1.740,00	0,00	259.861,00	149,35
CAP	2014	1.740,00	72.049,00	320.865,00	225,81
CAP	2015	1.740,00	49.248,00	826.886,00	503,53
CAP	2016	1.740,00	26.447,00	839.276,00	497,54
Total time-frame average		1.530,83	12.312,00	348.003,83	213,98
EX AVERAGE		1.112,50	£0,00	103.509,75	80,21
CAP AVERAGE		1.740,00	18.468,00	470.250,88	280,87
STDEV EX		420,98	0,00	129978,52	92,56
STDEV CA	P	0,00	28252,26	241211,58	145,07

Table 3. Extracted Formatted Data for Hudol Thermal Ltd.

Note: The annual averages of the three investment options are calculated for each corresponding managerial decision regarding the capitalisation of development costs.

The averages of invested funds per funding source category have been calculated using formulas (4)-(6) for the years during which development costs were expensed and formulas

(1)-(3) for the years during which development costs were capitalised, accordingly. At first glance, it is obvious that the entity is funded mainly by short-term debt, followed by long-term debt and lastly, equity. The debt-to-equity ratio rose significantly in 2007 and stays elevated; it peaked in 2015 and showed signs of major debt accumulation; the debt relief in 2016 is rather insignificant. On the contrary, equity raises are significant when capitalisation comes into effect later on and remains stable until the end of the relevant time frame, just as in Hudol's case presented previously. Once again, the shift in narrative is expressed through development cost capitalisation after the end of the research expense-only stage. During the capitalisation era, the entity managed to raise a significantly larger amount of funds from equity, although it was still relatively small compared to other sources of capital. Long-term debt only started to increase in the last three years of the period under study. This could be a debt restructuring attempt rather than an increase in risk undertaken by the investors. Unfortunately, there is no way to know for certain. However, capitalisation may also be relevant to debt restructuring if it provides collateral that could convince investors to postpone their claims. Therefore, the game theory matrix can still provide insights into the investors' strategies.

It is worth noting that the standard deviation is significantly higher than the average for longterm debt during the capitalisation era, indicating a noticeable diversity in terms of volatility. All other standard deviations suggest relatively low volatility. There is an important discrepancy in the financial statements of 2008 and 2009. They have been amended, and it appears that patents were misclassified as tangible assets with a depreciation straight-line method over 20 years. For the game matrix, these two years have been included in the capitalisation category since the asset was included in the balance sheet but misplaced. From 2011 onwards, patents and licenses have been correctly classified as intangibles.

Interestingly, no patent grants were awarded to Hudol Thermal Ltd or published by the entity in PatentScope [18]. This might indicate that the entity failed to deliver results or acquired licenses for inventions tied to its research but did not follow through with the research. However, this can only be speculation, and the absence of any records in PatentScope is not an encouraging sign regarding the research progress. The nature of the patents and licenses on the balance sheet remains unknown.

The corresponding matrix of Hudol Thermal Ltd is presented in the following table, designated in Table 4.

		DEVELOPMENT COST TREATMENT, £			
		EXPENSE	CAPITALISE	row maxi-min	
INVESTOR DECISION (PRIVATE, RETAIL- INVESTOR COMMERCIAL BANK ETC)	High risk (equity)	1.112,50	1.740,00	1.112,50	
	Medium risk (LT-debt)	0,00	18.468,00	0,00	
	Low risk (ST-debt)	[(103.509,75)]	470.250,88	[103.509,75]	
	column mini-max	(103.509,75)	470.250,88		
	Saddle point	Low risk (St-debt)			

Table 4. Game matrix solved for Hudol Thermal Ltd (Former Celtus Ltd.).

Note: The saddle point pinpoints the prevailing strategy for the investors, which is low-risk, namely short-term debt.

The averages that were presented in Table 3, calculated using formulas (1)-(6), are being used

as values of the matrix in Table 4, just as in the case study of Hudol Thermal Ltd.. The next step, as demonstrated in the first case, is calculating the rows' maximum among minimum values and the columns' minimum among maximum values. When the calculated two numbers are the same, the game has a saddle point indicating the existence of a dominant strategy; there is a saddle point in this case, meaning that a dominant strategy is present. Subsequently, investing in short-term debt is the dominant strategy for investors in this entity. The dominant strategy means that investing in short-term debt is the best option for an investor. Regardless of the intangible asset development cost accounting treatment selected by the entity's management, the matrix advises investors to assume a low-risk position. This result does not seem to contradict the overall feedback provided by Table 3; if more astute investors were to examine Table 3, they would observe that most investments are consistently placed on short-term debt over time. This suggests that the game matrix demonstrates a certain level of predictability, although it should be noted that it is based on historical data.

The next game theory matrix solution could provide additional information about how the matrices function and their implications.

Table 5 shows the corresponding data for the case of Dyfodol Energy Ltd., the last of the three entities.

CAPITALISATION INDICATOR	YEAR	EQUITY, £	LONG TERM DEBT, £	SHORT TERM DEBT, £	DEBT/ EQUITY
EX	2007	1.000,00	81.000,00	211.400,00	292,40
CAP	2008	1.000,00	136.347,00	220.982,00	357,33
CAP	2009	1.000,00	121.943,00	219.781,00	341,72
CAP	2010	1.000,00	106.202,00	225.860,00	332,06
CAP	2011	1.000,00	90.461,00	240.606,00	331,07
CAP	2012	1.000,00	74.719,00	239.260,00	313,98
CAP	2013	1.000,00	58.978,00	234.546,00	293,52
CAP	2014	1.000,00	43.237,00	253.775,00	297,01
CAP	2015	1.000,00	27.496,00	253.853,00	281,35
EX	2016	1.000,00	11.755,00	254.418,00	266,17
Total time-frame average		1.000,00	75.213,80	235.448,10	310,66
EX AVERAGE		1.000,00	46.377,50	232.909,00	279,29
CAP AVERAGE		1.000,00	82.422,88	236.082,88	318,51
STDEV EX		0,00	48963,61	30418,32	18,55
STDEV CAP		0,00	38286,92	13416,40	26,39

Table 5. Extracted Formatted Data for Dyfodol Energy Ltd. (Former Alurec Ltd.).

Note: The annual averages of the three investment options are calculated for each corresponding managerial decision regarding the capitalisation of development costs.

As in the previous cases, the averages of invested funds per funding source category have been calculated for the years during which development costs were expensed and for the years during which development costs were capitalised. At first glance, it is obvious that the entity is funded mainly by short-term debt, followed by long-term debt and lastly, equity, just as in the previous case. The debt-to-equity ratio was elevated in 2007, indicating extreme leverage and remains elevated. Generally speaking, this entity appears overleveraged throughout the investigated period. On the contrary, equity remains stable until the end of the relevant time frame at a nominal value of just 1000 British pounds. The shift in narrative represented by the capitalisation of development costs after transitioning from the research expense-only stage does not seem to impact equity investments significantly. However, during the capitalisation

era, the entity can secure more funds through long-term debt, while short-term debt remains the primary funding source. This suggests that investors maintain a cautious approach towards the entity regardless of the capitalisation signalling. Therefore, the game theory matrix should indicate a more cautious investment strategy in this case, based on the data presented in Table 5. The standard deviation for long-term debt during the expensed cost era is slightly higher than the average, which is expected given that the expense data set only includes two years (the initial and the last year). On the other hand, the standard deviations for other investment options suggest relatively low volatility.

Intangible assets are recorded on the balance sheet as additions. However, according to the patent scope, there is a patent application and publication by the entity under the details of GB2458690 for treating waste plastics material, published on 30/04/2008 [18]. It is worth noting that this coincides with the capitalisation year. Further analysis of the application suggests that the patent has been published but not yet granted, and the international patent application seems to have been withdrawn. Although a published patent is not officially granted, it can still be monetised through licensing, albeit at a lower price than a granted patent. This indicates that there are still potential economic benefits associated with the published patent.

The next game theory matrix solution could provide additional information regarding the matrices' functionality. Table 6 below is the game matrix for Dyfodol Energy Ltd., the last of the three entities.

		DEVELOPMENT COST TREATMENT, \pounds			
		EXPENSE	CAPITALISE	row maxi-min	
INVESTOR DECISION (PRIVATE, RETAIL- INVESTOR COMMERCIAL BANK ETC)	High risk (equity)	1.000,00	1.000,00	1.000,00	
	Medium risk (LT-debt)	46.377,50	82.422,88	46.377,50	
	Low risk (ST-debt)	[(232.909,00)]	236.082,88	[232.909,00]	
	column mini-max	(232.909,00) 236.082,88			
	Saddle point	Low risk (St-debt)			

Table 6. Game matrix solved for Dyfodol Energy Ltd. (Former Alurec Ltd.).

Note: The saddle point pinpoints the prevailing strategy for the investors, which is low-risk, namely short-term debt.

Just as before, the averages calculated using formulas (1)-(6) presented in Table 5 are being used as values of the matrix in Table 6. Again, the next step is calculating the maximum among the minimum values of the rows and the minimum among the maximum values of the columns. The calculated two numbers are the same, meaning that the game has a saddle point indicating a dominant strategy. In the third and final case, investing in short-term debt is the dominant strategy for investors in this entity. This result confirms the cautious investor sentiment in the data presented in Table 5. As commented previously, the obvious strategy implemented by investors in Dyfodol Energy Ltd. was low-risk positioning interpreted as short-term debt. This further confirms that the game matrix utilises past data and projects an optimal strategy concurrent with what the data suggests and, most importantly, easily and practically for everyone to use regardless of their investing sophistication and prowess.

Table 7 is designed as a summarised result presentation which could assist in evaluating the

game theory matrices' method by viewing the entities ex-post the relevant time frame.

As mentioned before, a disadvantage of using these game matrices is that they are backwards looking for guidance and rely on past decisions of the involved players. In that sense, the size of the time-frame providing the necessary data is crucial and any future predictability needs to be considered with a caveat. However, it is necessary to state that in situations involving R&D, the process is lengthy, thus providing an adequate number of annual data for the construction of matrix.

Table 7 summarises the results in contrast to the most recent figures and information, meaning the most recent financial statements for every entity plus additional documentation available in the UK. Companies House and WIPO. Hudol Thermal Ltd. seems to be in the best financial position or situation compared to the other two affiliated entities. Although it is not what one might describe as a financially sound and healthy entity, it owns the most assets, and the debt-to-assets ratio is probably the lowest. Moreover, it has the most patent publications

		GAME	PRESENT-DAY FIGURES & INFORMATION		
CASE NUMBER	ENTITY DETAILS	MATRIX	CORPORATE STATUS	ASSETS (2021), £	DEBT/ ASSETS (2021), %
1	HUDOL LIMITED Private limited Company SIC 72190 - Other research and experimental development on natural sciences and engineering	Medium risk (LT- debt)	ACTIVE- NO P.S.C., HIGHEST VOTING POWER R.PS.W.	102.456,00	231,81
2	HUDOL THERMAL LIMITED (Former Celtus Ltd.) Private Ltd. Company SIC 72190 - Other research and experimental development on natural sciences and engineering	Low risk (St-debt)	ACTIVE- COMPULSORY STRIKE-OFF NOTICE 2018 (DISCONTINUED- DORMANT ACCOUNTS 2021- P.S.C. R.J.LENTITY SHARES TRANSFERRED- LINKS TO THE OTHER CASE STUDY ENTITIES SEVERED	1500,00	0,00
3	DYFODOL ENERGY LIMITED (Former Alurec Ltd.) Private Ltd. Company SIC 72190 - Other research and experimental development on natural sciences and engineering	Low risk (St-debt)	ACTIVE – P.S.C. R.P. CONFIRMED IN 2017	16.513,00	1412,32

 Table 7. Summarised results.

Note: Conclusions are drawn based on the most recent data provided by the UK Companies House.

in different jurisdictions and actual patent grants. The lowest debt-to-assets ratio belongs to Hudol Thermal Ltd.; however, this entity has undergone an ownership change and, second of

all, a debt haircut, probably due to the acquisition and restructuring. This scenario is not speculation, and it can be easily deducted by looking at the most recent financial statements combined with the additional documentation available at the UK Companies House [17]. The accounts of 2021 are dormant, and the persons with significant control have changed due to share transfers; however, the relevant documents of 2021 show a decrease in assets combined with a significant debt write-off. All these events occurred after an initial warning of a compulsory strike-off of the entity, which was discontinued. All these facts, paired with the transfer of ownership, justify the assumption that a debt restructuring has occurred; thus, the assets-to-debt ratio is not representative of the entity's situation. The creditors, most likely, were only partially and not fully compensated for their risk, at best. Also, this is the only entity out of the three with no intellectual property rights on intangible assets. Under these circumstances, the debt-to-assets ratio of Hudol Thermal Ltd. is probably the most decent out of the three, although quite high at 231,81 %. Considering that the game theory matrix's investment strategy indication for Hudol Thermal Ltd. was the riskiest of the three entities, it is not irrational to claim that the guidance was correct within the broader context of all the cases. The best investment strategy for the other two entities was short-term debt. As was already mentioned previously, if Hudol Thermal Ltd. underwent a debt restructuring, then those exposed to short-term debt had the best chances to sustain minimum damages; it should be noted that this entity was the one with no patent publication or grant; in comparison with the other two entities, Hudol Thermal Ltd was the least productive in terms of intellectual property.

On the other hand, the most productive in terms of patent publications and grants is Hudol Thermal Ltd., the only one where medium risk is indicated as the optimal strategy. In the case of Dyfodol Energy Ltd., the assets are relatively insignificant, just £16 513,00. Additionally, the debt to assets ratio at 1412,32 % indicates an unsustainable situation unless nothing short of a miracle occurs, such as a new investor stepping in or a major scientific breakthrough is achieved, or the patent status changes from publication to grant, boosting capital inflows. Taking into account all of the previous ex-post, the game matrices' were successful in indicating the most appropriate risk strategy in all three cases, and most importantly, no equity investment was suggested, which would have meant a catastrophic failure not only for investors but also for the presented methodology and related case study. A further application is necessary to reconfirm the advisory capabilities of the game theory matrices; however, this case study has concluded in an initial positive resolution.

CONCLUSIONS AND POTENTIAL CONTRIBUTIONS

The main contribution of this case study is that by outlining a dominant strategy in situations where investment is characterised by a combination of high-risk R&D intensity, data scarcity and information asymmetry, the sincerity of the managerial decision of capitalisation or expense, can be identified. These matrices can be used as a compass to navigate through a project's "liminal" stage between research and development, which hinges on the signalling properties of development cost capitalisation. What the matrices try to accomplish is filtering the information in the financial statements following a simple procedure and transforming it into a game theory table which provides an optimal investment strategy without having to analyse the financial statements in a sophisticated manner.

From a theoretical perspective, just as past performance does not guarantee future returns, past decisions are not necessarily correct under every circumstance; thus, they do not warrant predictive accuracy. In these case studies, the matrices relied on the previous investment decisions of investors to project the average investor reaction to development cost capitalisation. Prudent investing necessitates using multiple data analysis instruments such as various indexes and moving averages, a meticulous study of white articles, and even market

sentiment. Such a rigorous investigation is challenging to inexperienced investors, especially when data are scarce, as presented in this article and when dealing with private entities in general.

Additionally, investments in R&D-intensive internally generated intangible assets are, by definition, risky. The uncertainty around these kinds of projects is associated with technical feasibility issues and legal framework concerns, namely intellectual property rights protection. Since capitalisation of development costs is perceived as an indication of potential success, the game theory matrix presented attempts to capture the investors' reaction to the underlying signal of scientific breakthrough.

The significance of capitalisation in this case study arises from the nature of the entities' SIC (Standard Industrial Classification) code, which indicates their primary focus on research and experimental development in natural sciences and engineering. As R&D is the core driver of value creation for these entities, capitalisation becomes crucial in signalling their commitment and potential for successful innovation.

As a result, the development costs' capitalisation or the absence of it should reasonably affect how much risk investors are willing to assume. Indeed, the suggested game theory instrument presented here could not generically hold water for every industry type, nor is it intended to. Its purpose is to provide consultation and assistance in formulating investment strategies regarding private micro-entities operating in high-intangible-intensity industries.

The strategies focus on development cost capitalisation while disregarding other factors. This does not mean that other factors do not exist. However, they are not as important; the only exception could be earnings. Although earnings are important, most startups rarely post earnings in their financial statements before a major breakthrough in the projects under development. In the case of the presented entities, the earnings are from non-existent to trivial; this is an anticipated fact that contributes even more to the significance of development cost capitalisation. The absence of earnings during the early stages is not an isolated event, and it is common for startups in high-intangible intensity sectors which rely on extensive R&D spending.

A significant amount of information asymmetry is involved that affects the result of the game matrix. However, this is an expected trade-off between predictive accuracy and practicality associated with the simplicity of the matrix's construction. The fundamental principle is that a non-sophisticated retail investor can rely on past decisions of institutional and accredited investors equipped with the resources and knowledge to make better-informed decisions regarding the investment in a high-risk private entity. Thus, the quality of the due diligence conducted on the private entity's R&D potential by sophisticated investors determines the quality of the matrix's solution indicating the suggested dominant strategy.

Admittedly, the underlying information asymmetry is troubling; however, the lack of more cost-efficient instruments and the game theory matrix's practicality, which translates into a dominant strategy after a simple data input, qualifies the game theory matrix as a practical estimating tool when it comes to investing in R&D intensive private entities.

In practice, constructing the game theory matrix does not require significant effort, complex calculations, or extremely time-consuming data extraction. Most importantly, as demonstrated here, even abbreviated financial statements are adequate for the task. Ideally, an AI-generated pre-trained transformer in the future could use the matrices to form an opinion regarding investment strategies after "reading" the financial statements.

As always, an investor should not rely solely on any instrument or indicator; instead, the potential investor should do as much research as possible before assuming any risk. In this broad research context, the game theory matrices presented in this case study could be one of the tools used to define the optimal investment strategy, given that such a strategy exists. By

considering all the parameters affecting the investment strategy, potential investors could customise the matrix's suggested strategy according to their risk profile and available funds, making it more prudent or aggressive.

The results of the game theory matrices in the case study presented in this article rely on the game's preset parameters explained in the methodology section. Specifically, the rule set mentioned in the methodology section describes the assumptions about the game matrix. Equity seems to be the best option where development costs are mostly treated as expenses and disclosures are limited [5]. This happens mainly because debt issuance costs are high, and there is nothing valuable enough to serve as collateral when disclosures are limited and internally generated intangible assets are not capitalised. The debt issuance cost factor is not addressed directly by the game matrix, and it is considered a factor in the managerial decision regarding the capitalisation or expense of development costs. However, as mentioned in the fifth rule of the game, all three investment options are available to investors. The game matrix recognises the investor side as the predominant force in the fundraising process.

This is probably a main limitation for the investigated cases presented here. However, Table 1 shows a noticeable influence on investors by the signalling caused by the capitalisation of development costs. Of course, given that the matrix does not consider other factors that could have influenced investors' risk appetite, as well as debt accumulation and restructuring, it requires further confirmation. These other factors are additional limitations which could be addressed to a certain degree by conducting similar game theory experiments using entities within the same industry sector and, ideally, partner or linked entities which probably have similar managerial principles.

The second limitation is that a significant number of years into research and development must pass before using the game matrix; unfortunately, during early stages where the uncertainty is highest, the matrix cannot be used until the initial year of capitalisation. In terms of efficiency, it is not an effective tool from the beginning of the research stage. However, there is no signalling during that stage, so interpreting signalling is unnecessary.

In summary, the capitalisation signalling impact on investors can be interpreted using the game matrices, which are simple and easy to construct with limited publicly available data. The results can indicate an optimal investment strategy in private R&D intensive entities based on risk. However, it is important to acknowledge the limitations, such as the necessary constraints and concessions for the matrices' functionality and the inability to construct them without entering a development cost capitalisation phase.

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MANUSCRIPT PREPARATION GUIDELINES

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ABSTRACT Concisely and clearly written, approx. 250 words.

KEY WORDS Not more than 5 key words, as accurate and precise as possible.

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Use Arial font for titles: 14pt bold capital letters for titles of sections, 12pt bold capitals for titles of subsections and 12pt bold letters for those of sub-subsections. Include 12pt space before these titles.

Include figures and tables in the preferred position in text. Alternatively, put them in different locations, but state where a particular figure or table should be included. Enumerate them separately using Arabic numerals, strictly following the order they are introduced in the text. Reference figures and tables completely, e.g., "as is shown in Figure 1, y depends on x …", or in shortened form using parentheses, e.g., "the y dependence on x shows (Fig. 1) that…", or "… shows (Figs. 1-3) that …".

Enumerate formulas consecutively using Arabic numerals. In text, refer to a formula by noting its number in parentheses, e.g. expression (1). Use regular font to write names of functions, particular symbols and indices (i.e. sin and not *sin*, differential as d not as *d*, imaginary unit as i and not as *i*, base of natural logarithms as e and not as *e*, x_n and not x_n). Use italics for symbols introduced, e.g. f(x). Use brackets and parentheses, e.g. {[()]}. Use bold letters for vectors and matrices. Put 3pt of space above and below the formulas.

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References are listed at the end of the article in order of appearance in the text, in formats described below. Data for printed and electronic references is required. Quote references using brackets, e.g. [1], and include multiple references in a single bracket, e.g. [1-3], or [1, 3]. If a part of the reference is used, separate it with semi-colon, e.g. [3; p.4], [3; pp.4-8], [3; p.4, 5; Ch.3]. Mention all authors if there are not more than five of them, starting with surname, and followed with initial(s), as shown below. In other cases mention only the first author and refer to others using et al. If there are two or more authors, separate the last one with the word "and"; for other separations use semicolon. Indicate the titles of all articles, books and other material in italics. Indicate if language is not English. For other data use 11pt font. If both printed version and the Internet source exist, mention them in separate lines. For printed journal articles include journal title, volume, issue (in parentheses), starting and ending page, and year of publication. For other materials include all data enabling one to locate the source. Use the following forms:

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