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Research Article

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Quantifying Entrepreneurial Orientation in ICT Firms: a composite index approach with implications for Digital Transformation in Healthcare

Emmanouil Karakostas[1], **Dimitra Balaska**[1], **Dimitrios Karaferis**[1*], **and Yannis Pollalis**[1]

[1]Department of Economic Science, University of Piraeus, e-mail: info@unipi.gr, 185 34 Piraeus, Greece

[*]**Corresponding author:** Dimitrios Karaferis, MSc, PhD, Postdoctoral Researcher, Department of Economic Science, University of Piraeus, e-mail: karafedis@yahoo.gr, 185 34 Piraeus, Greece.

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Abstract

Purpose *This study develops a composite index for quantifying Entrepreneurial Orientation (EO) in Information and Communication Technology (ICT) firms, utilizing objective financial data. At the same time, it investigates the relationship between Entrepreneurial Orientation and business competitiveness, highlighting its importance for the development of technological innovations that support digital transformation, including in the healthcare sector.*

Methodology *This study develops a composite index to quantify Entrepreneurial Orientation in Information and Communication Technology firms, utilizing objective financial data. At the same time, it investigates the relationship between Entrepreneurial Orientation and business competitiveness, highlighting its importance for the development of technological innovations that support digital transformation, including in the healthcare sector.*

Findings *The results show that firms with a higher level of entrepreneurial orientation perform better in terms of their competitiveness. Furthermore, it is found that the individual dimensions of EO do not contribute equally to the final index, a fact which highlights the heterogeneity characteristic of firms in the ICT sector. The index shows a positive correlation with changes in gross profit, suggesting that Entrepreneurial Orientation is linked to the creation of economic value and the enhancement of competitiveness.*

Originality *The study proposes an alternative and more objective approach to measuring Entrepreneurial Orientation, based on financial data rather than questionnaires. At the same time, it highlights the potential role of ICT firms in developing digital innovations that support the digital transformation of healthcare, providing a useful framework for future research in the field of digital health.*

Keywords*: Entrepreneurial Orientation; Composite Index; CRITIC; ICT; Competitiveness; Digital Transformation; e-Health; Digital Health.*

Abbreviations:
AI: Artificial Intelligence; **CRITIC:** Criteria Importance Through Intercriteria Correlation; **EHR:** Electronic Health Record; **e-Health:** Electronic Health; **EO:** Entrepreneurial Orientation; **ICT:** Information and Communication Technology; **IoMT**: Internet of Medical Things; **MCDM:** Multi-Criteria Decision Making; **mHealth:** Mobile Health; **ROA:** Return on Assets

1. Introduction

Information and Communication Technologies (ICT) are now part of many people's daily lives. In a globalized, digitized and constantly evolving world, the ICT sector is of particular importance. As Schiersch et al. [1] point out, ICT products are vital to global trade, as they are now essential components in the production of all types of goods. According to Liu et al. [2], the foundation of a company's competitiveness will lie in its digital transformation. The digital revolution is of vital importance because it can significantly increase productivity [3]. These technological developments not only affect businesses in the ICT sector, but also largely shape the way in which strategic sectors of the economy, such as healthcare, education and industry, are being transformed.

Digital transformation in the healthcare sector is driven by ICT, ranging from data analytics and cloud computing to connected devices and digital platforms. Nowadays, healthcare organizations are called upon to adapt to the new technological landscape and adopt innovative digital solutions, such as electronic health records, telemedicine, clinical decision support systems, and the digitization of medical imaging and health data management applications. Consequently, the digital transformation of healthcare is significantly influenced by ICT. Healthcare companies that invest in innovation adapt quickly to change and contribute to digital transformation. From this perspective, Entrepreneurial Orientation (EO) is not only about enhancing a company's competitiveness, but also about its ability to generate and disseminate innovations that support the transition to more modern and effective healthcare systems. According to Becker and Schmid [4], a company's technological, human, intellectual and financial resources are key prerequisites for the successful implementation of digital transformation. At the same time, businesses are required to constantly adapt to changes in the external environment and respond effectively to challenges such as economic crises or health threats [5]. This need is even more acute in the healthcare sector, where the successful integration of digital technologies depends to a large extent on the ability of organizations and businesses to innovate, adapt and respond to the ever-changing demands of the environment.

EO contributes to businesses' ability to capitalize on opportunities, manage uncertainty effectively and achieve higher levels of performance. Organizations characterized by a high level of EO are more willing to adopt and utilize innovative digital technologies. The international literature indicates that organizations which make effective use of IT exhibit higher levels of productivity and create new jobs. Furthermore, the relationship between entrepreneurial orientation and organizational performance has been extensively examined. Kuivalainen et al., Wach et al., Martin and Javalgi, Javalgi and Todd, Brouthers et al., Deligianni et al. and Karami and Tang demonstrate that EO enhances international competitiveness and the overall performance of firms [6–11]. EO is a strategic approach that describes how a firm seeks out and capitalizes on new opportunities through behaviors related to innovation, proactivity, risk-taking, competitive aggressiveness and autonomy [12]. Miller's original approach comprised three key dimensions: innovation, proactivity and risk-taking [13]. Later, Lumpkin and Dess expanded the theoretical framework by adding autonomy and competitive aggressiveness, in order to more fully capture the scope of entrepreneurial orientation [14]. For more than three decades, EO has been one of the most widely studied topics in the literature on entrepreneurship and strategic management [15]. EO characterizes a firm's strategic stance, reflecting the degree of innovation, risk-taking, competitive aggressiveness, and independent and proactive behavior [16]. Another key dimension is proactivity, that is, a firm's ability to anticipate future developments and capitalize on new market opportunities in a timely manner [17]. Proactive firms do not merely adapt to change, but often act as pioneers, shaping developments themselves and offering solutions to customers' needs before their competitors do [18]. Competitive aggressiveness refers to the intensity with which a firm seeks to strengthen its market position and gain the upper hand over its competitors through dynamic strategies and rapid responses to changes in the environment [19, 20]. Finally, autonomy refers to the degree of freedom that individuals or groups within an organization have to take the initiative, develop creative ideas and capitalize on business opportunities that contribute to organizational growth [21]. EO enhances the competitiveness of businesses, as it equips them with the necessary capabilities to identify, capitalize on and respond promptly to the opportunities and challenges of the constantly changing business environment. Businesses with a high level of EO develop strong innovative capabilities, which enhance the continuous renewal of products and services and contribute to the creation of a sustainable competitive advantage [22].

This study seeks to contribute to the existing literature by proposing a composite index for measuring EO in ICT firms using firm-level financial information. Rather than relying exclusively on managers' perceptions, the proposed approach is based on observable economic data and provides an alternative way of assessing entrepreneurial behavior. In addition, the study examines whether higher levels of EO are associated with stronger competitive performance in technology-intensive firms. At the same time, it offers a framework that may help explain how technological capabilities and entrepreneurial activities support digital transformation in different sectors, including healthcare. The role of EO is particularly relevant in the context of digital health. The development and diffusion of technologies such as telemedicine, health information systems, artificial intelligence applications and digital health platforms largely depend on ICT firms that are capable of adapting to technological change and introducing innovative solutions. Consequently, examining EO in these firms may help explain which factors support the adoption of digital technologies in healthcare.

2. Development of Hypotheses

The international literature has shown that organizations with a high level of EO are better able to adapt to technological developments, capitalize on market opportunities and maintain a competitive advantage [12, 23]. However, EO is traditionally measured through questionnaires and subjective assessments by executives, which primarily reflect their perceptions and intentions rather than their actual business behavior. Recent studies highlight the need to develop more objective methods for measuring EO, based on observable data at company level [24]. Particularly in technology-intensive sectors, such as ICT, entrepreneurial behavior is reflected in strategic economic decisions, such as investment in innovation, development expenditure and the allocation of resources under conditions of uncertainty. Consequently, financial indicators can provide an objective basis for measuring the dimensions of EO.

ICT firms operate in an environment of rapid technological change and intense competition, where business behavior is expected to be reflected in their financial performance. Provided that EO is captured through objective financial indicators, which reflect actual business decisions, it is expected to be positively associated with firms' competitive performance. As such, the following hypothesis is proposed:

H1: *Firms with higher Entrepreneurial Orientation, as measured by the composite EO index, exhibit superior competitive performance.*

Although EO is often treated as a unidimensional construct, its individual dimensions, such as innovativeness, proactiveness, and risk-taking, may vary across firms and industries [14]. In the ICT sector, firms do not always follow the same strategic priorities. Some companies devote substantial resources to innovation while adopting a cautious approach to financial risk. Others focus more strongly on expansion strategies, despite investing less intensively in research and development activities. This variation suggests that the dimensions of EO are not equally important across firms and may influence business behavior to different degrees. The composite index developed in this study makes it possible to capture these differences by assigning weights to the individual indicators according to the information they provide. As a result, the various dimensions of EO are expected to have different levels of influence on the overall EO score. Although healthcare organizations are not directly included in the sample, the findings may also be relevant to the broader digital health environment. ICT firms with higher EO are often involved in the development of telemedicine solutions, health information systems and data-driven clinical applications. This leads to the second hypothesis:

H2: *The dimensions of Entrepreneurial Orientation contribute unequally to the overall entrepreneurial intensity among ICT firms.*

Most questionnaire-based measures of EO depend on managers' perceptions and self-assessments, which are not always free from bias. Responses may be affected by personal judgement, social desirability, or other subjective factors. By contrast, financial and investment decisions reflect actions that firms actually undertake under specific market conditions and resource constraints. In technology-intensive industries, entrepreneurial intentions are expected to be translated into

tangible investments and financial commitments before they can influence performance. For this reason, objective financial indicators may provide a more realistic picture of entrepreneurial behavior. They can complement perception-based measures and offer additional evidence for assessing Entrepreneurial Orientation. Accordingly, the following hypothesis is proposed:

H3: *Objective financial indicators can provide an alternative approach to capturing realized Entrepreneurial Orientation in technology-intensive firms.*

3. Methodology and Data

This study is based on a quantitative approach. A composite index will be used. Nardo et al. define a composite index. In particular, they say: *"... a composite indicator is the mathematical combination of individual indicators representing different dimensions of a concept, the description of which is the objective of the analysis ...*" [25]. According to Freudenberg, composite indices are a methodologically established tool for comparing the performance of nations at various levels [26]. Examples of studies using composite indices include those by Huggins, Lovell et al., Munda, Griliches, Forni et al., Cribari-Neto et al. and Färe et al. [27–33]. The OECD Handbook on the Construction of Composite Indices serves as a primary reference point for the development of composite indices and provides relevant methodological guidance [34]. The use of composite indicators has both supporters and critics. One of the main criticisms, according to Smith, is that the overall composite score depends heavily on the weights assigned to each performance component. Furthermore, some individual indicators may suffer from poor-quality data and, in some cases, there may be inconsistencies between the data for the individual indicators [35] . However, there are several arguments in favor of using composite indicators. Firstly, they provide a means of assessing performance; secondly, they enhance accountability; thirdly, they encourage the development of improved systematic approaches and higher-quality data; and finally, they offer a comprehensive "big picture" perspective on complex phenomena.

In actuality, a weighted linear aggregation of a set of variables is called a composite index (CI). The following formula is a general one:

$$CI = \sum_{i=1}^{N} w_i X_i$$

where w_i is the weight of variable X_i and X_i is the normalized variable.

Mazziotta and Pareto argue that there is no standardized procedure for constructing a composite index. However, they describe a composite index framework in three basic steps (normalization, weighting and aggregation) [36]. Zeng et al. cite 51 individual studies using CIs across 17 sectors at the firm level [37]. Examples include the Sustainability Performance Index [38], the Total Performance Index [39], the Corporate Performance Index [40] and the Multidimensional Innovation Index [41].

3.1. Data

For this study, the period 2022–2024 was selected, and eight firms were examined that operate either directly in the ICT sector or in technologically related activities. Eight firms were selected because they operate in areas associated with digital innovation and technological development. The sample includes both core ICT enterprises, such as IT, software and consultancy firms, and enterprises operating in broader technological fields, such as connectivity, sensors, environmental monitoring and visualization technologies. The inclusion of both categories is considered useful, as these firms are involved in technological innovation processes and adopt strategies related to entrepreneurial orientation. The selection of a relatively limited number of firms for this study is considered appropriate, as the main objective is not to generalize the results statistically to the entire population, but to develop and apply a composite index for measuring the EO. This is a methodological and exploratory approach, in which the emphasis is placed on evaluating the functionality and reliability of the proposed measurement framework. The selected companies are presented in Table 1.

Table 1: Companies that participate in source.

Company	Description	ICT
NNIT A/S	IT services	Core ICT
Vaisala Oyj	Environmental measurements	Technology-related, not core ICT
Barco NV	Visualization technology	Technology-related, not core ICT
Hexagon AB	Digital solutions	Technology-related, not core ICT
Bechtle AG	IT retail	Core ICT
SAP SE	Enterprise software	Core ICT
Accenture plc	Consulting services	Core ICT
TE Connectivity plc	Connectivity components	Technology-related, not core ICT

Source: Authors' elaboration

The relevant literature suggests that studies developing composite indices may be based on targeted samples, particularly when firm-level data are required and when the aim is to construct and test a new methodological approach [34, 37]. Given the exploratory nature of the study, priority was given to the availability and reliability of firm-level data rather than to increasing the sample size. The firms included in the sample operate in different segments of the broader ICT ecosystem, covering activities such as software development, IT services, digital applications, sensor technologies and connected systems solutions. Despite their individual differences, all the firms in the sample operate in a highly technology-intensive

environment and are required to adapt constantly to technological developments and market changes. In this context, it is considered that firms' strategic choices, such as investment in innovation, the allocation of available resources and the assumption of business risk, are reflected in their financial performance. For this reason, the use of financial data provides an objective basis for assessing the individual dimensions of EO, reducing reliance on subjective assessments derived from questionnaires. Based on the relevant literature and the availability of reliable data, financial indicators were selected that can capture key aspects of the EO, such as innovation, growth, the efficient use of resources, and the ability to take on and manage risks. These indicators are used as individual components in the construction of the composite EO index.

Table 2: The pillars of the Entrepreneurial Orientation and its Descriptive Statistics.

Companies	Innovativeness	Risk-taking	Proactiveness	Competitive Aggressiveness	Autonomy
NNIT A/S	9.82	0.15	1.00	25.85	1.35
Vaisala Oyj	24.81	0.19	0.43	55.30	2.24
Barco NV	32.87	0.19	0.36	39.85	1.66
Hexagon AB	23.27	0.16	0.32	65.60	2.91
Bechtle AG	44.48	0.17	0.65	17.50	1.21
SAP SE	29.80	3.13	0.07	72.60	3.64
Accenture plc	4.30	0.37	0.61	32.35	0.76
TE Connectivity plc	17.46	1.01	0.30	31.85	1.47
-Mean	23.35	0.67	0.46	42.61	1.90
-Std. Deviation	12.88	1.03	0.28	19.74	0.96
-Skewness	0.08	2.44	0.74	0.45	0.89
-Kurtosis	-0.22	6.12	0.94	-1.25	-0.03
-Minimum	4.30	0.15	0.07	17.50	0.76
-Maximum	44.48	3.13	1.00	72.60	3.64

Source: Authors' elaboration

According to the results presented in Table 2, the Min-Max normalization method is considered more suitable for the present study, as several of the variables exhibit a significant degree of asymmetry. In contrast, the z-score normalization method assumes that the data follow an approximately normal distribution, a condition that is not fully met in the case under consideration. Furthermore, prior to constructing the composite index, it is important to investigate the degree of correlation between the individual variables [42]. The existence of a high correlation between two or more indicators may lead to the over-representation of specific dimensions in the final composite indicator, affecting its weighting and overall interpretation. For this reason, examining correlations helps both to improve the reliability of the index and to facilitate the interpretation of the results. The table of correlations between the individual variables is presented in Table 3.

Table 3: The correlation among the sub-indicators.

	Innovativeness	Risk-taking	Proactiveness	Competitive Aggressiveness	Autonomy
Innovativeness	1.00				
Risk-taking	0.12	1.00			
Proactiveness	-0.34	-0.64	1.00		
Competitive Agressiveness	0.08	0.55	-0.74	1.00	
Autonomy	0.31	0.65	-0.71	0.93	1.00

Source: Authors' elaboration

Consequently, there is a lack of strong positive correlation between the variables. Instead, there is a low degree of both positive and negative correlation between the individual indicators. It is considered appropriate to apply multi-criteria analysis without requiring a high degree of correlation, as this allows for appropriate weighting [34]. Multivariate analysis is not strictly necessary and is often inappropriate when there is a limited amount of data available for constructing a composite index [43, 44].

3.2. Normalization Method

The normalization of raw data is an essential step in the creation of a composite index. The Min-Max normalization method is the normalization technique that will be applied in the index creation process. As stated by the OECD (2008): "*Min-Max normalizes the indices so that they have the same range [0,1] by subtracting the minimum value and dividing by the range of the index values* ...". The following is the Min-Max Normalization Equation method:

$$S_{ij} = \left[\frac{X_{ij} - \min_j X_{ij}}{\max_j X_{ij} - \min_j X_{ij}} \right]$$

where X_{ij} is the real measured value, S_{ij} is the standardized criteria value, Min is the smaller sample value, and Max is the larger sample value. If the indication is positive, the formula stated above is used. Min-Max Normalization maintains the relationship between the raw data and performs a linear adjustment on the original range of data. As Saisana and Saltelli point out, Min-Max rescales the data from 0 (lowest rank) to 1 (highest rank). The next section mentions the weighting method [45].

3.3. Weighting Method

The weighting process is one of the most important stages in the development of a composite index, as it determines the relative contribution of each individual variable to the final result. Various techniques for determining weights have been proposed in the international literature, which are categorized as subjective and objective. Subjective methods rely on the judgement of experts or decision-makers, whilst objective methods utilize the data itself to calculate the weights, thereby limiting the influence of personal assessments and potential biases. In this study, the Criteria Importance Through Intercriteria Correlation (CRITIC) method, proposed by Diakoulaki et al. and is widely used in multi-criteria analysis problems when no information is available regarding a decision-maker's preferences [46]. The basic rationale behind the CRITIC method is that the weight of each criterion depends on the information it provides to the overall system. This information is estimated on the basis of two characteristics: the variability of the criterion's values and the degree of correlation between it and the other criteria. Variability is reflected by the standard deviation, where higher values indicate greater discriminatory power. At the same time, the correlation between the criteria is used to assess the degree of overlap in the information they provide. Thus, criteria that exhibit high variability and relatively low correlation with the others are given greater weight in the final composite index. In this way, the CRITIC method contributes to the formation of a more objective and evidence-based weighting process. Two fundamental concepts of Multi-Criteria Decision Making (MCDM), a scientific field that combines knowledge from management, mathematics, computer science, the social sciences and economics [47], are quantified using the CRITIC method: (i) the degree of variation in the performance evaluations of the alternatives for each criterion and (ii) the conflict between criteria [46]. Given that criteria are often highly interrelated in real-world conditions, it is important to take these correlations into account when evaluating the weights of the criteria. Furthermore, the degree of variation between criteria and alternatives may reflect the volume of information associated with a given criterion. Consequently, the algorithms underpinning the CRITIC method are mathematically robust [48]. The weighting in this method is referred to as objective weighting. It depends on the degree of contrast for each criterion and the degree of conflict between the criteria, with the standard deviation and the correlation coefficient serving as bases, respectively. Below are the stages involved in applying the CRITIC approach. Firstly, it is assumed that there are m viable alternatives Ai (i = 1, 2, …, m) and n evaluation criteria, C_j (j = 1, 2,..., n). A decision table called X is created. It shows the performance of the viable alternatives across a range of parameters.

$$X = [x_{ij}]_{mxn} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (i = 1,2...,m \text{ and } j = 1,2,...,n)$$

The performance value of the *i*-th alternative on the *j*-th criterion is shown in x_{ij}. Equation below is used to normalize the decision matrix:

$$x_{ij}^{*} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \qquad i = 1, 2,...,m \text{ and } j = 1, 2,...,n$$

The standard deviation of each criterion and its relationship to other criteria are taken into account when assigning weights to them. Accordingly, the weight of the *j*-th criterion (w_j) can be found as follows:

$$w_j = \frac{C_j}{\sum_{j=1}^{n} C_j}$$

where the amount of information in the *j*-th criterion, as determined by C_j, is

$$C_j = \sigma_j \sum_{j'=1}^{n} (1 - r_{jj'})$$

the two criteria's correlation coefficient. Based on the analysis by Aznar Bellver et al. [49], it can be inferred that this method favors the criterion with a high standard deviation and little association with other criteria. A larger value of C_j indicates that more information may be gleaned from the provided criterion, which raises the criterion's relative importance in relation to the problem of decision-making. Ocampo, et al. have used the CRITIC method in order to construct a composite index. The following table displays the weights of the pillars [50].

Table 4: The weights of the Entrepreneurial Orientation pillars.

	Innovativeness	Risk-taking	Proactiveness	Competitive Agressiveness	Autonomy
Weightage	19.16	18.02	30.32	17.81	14.69

Source: Authors' elaboration

3.4. Aggregation Method

The process of aggregation is the final stage in creating a composite index. The weighted arithmetic mean is the aggregate technique used in this study. Undoubtedly, the weighted arithmetic mean is the most often used additive procedure [51]. One of the aggregation strategies employed, according to Mazziotta and Pareto, is the additive strategy, particularly the arithmetic mean [36]. The following formula [52] can be used to determine the weighted arithmetic mean (WM):

$$y_j = \sum_{i=1}^{d} w_i x_{ji}, \qquad j = 1, 2, \cdots, n$$

where w_i is the nominal weight given to the i-th variable X_i and x_{ji} is the normalized score of individual j (e.g., firm) based on the value X_{ji} of the ith raw variable i=1,..., d. The outcomes are shown in the next section.

4. Results

4.1. Sensitivity analysis

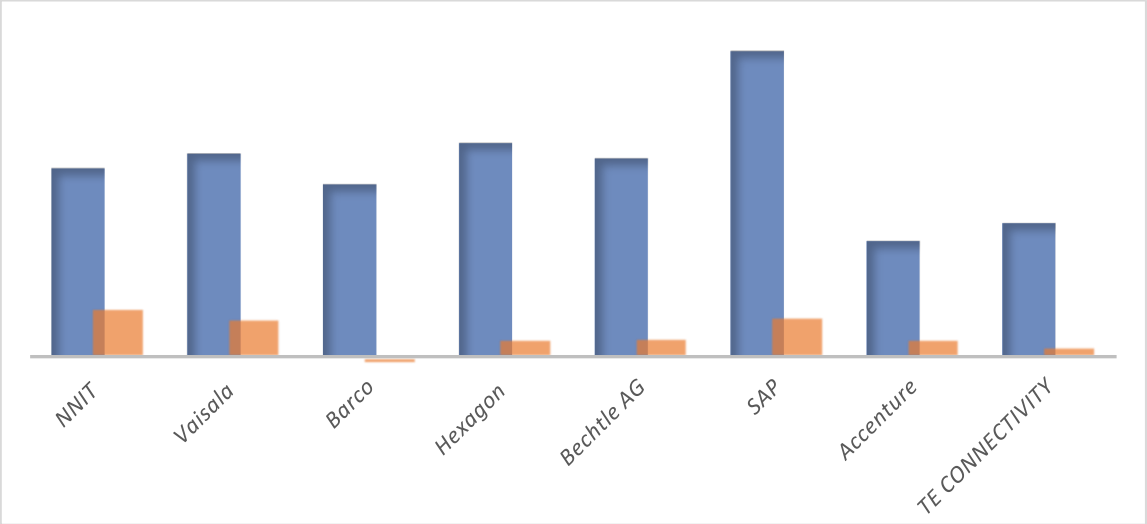
The primary objective of robustness analysis is to confirm the validity and reliability of a composite index (CI). One approach to achieving this is to recalculate the various stages of CI construction using alternative methods, such as different methodological frameworks [53]. Without robustness analysis, a CI may produce unclear or ambiguous results [54]. Uncertainty analysis is a suitable tool in this context, as it identifies the range of possible variations in the results of a composite index arising from changes in the stages of its construction, including weighting or concentration [55]. Robustness is assessed by applying alternative approaches at

different stages of the development of a composite index. For example, equal weighting may be used at the weighting stage, a simple average at the aggregation stage, and the Z-score method at the normalization stage. These approaches enable researchers to determine whether variations in methodology affect the values or scores of the composite index. The robustness analysis in this study did not reveal any significant changes in the ranking scores of the firms included in the CI. As such, the correlation coefficients between the modified index scores obtained from the different CI construction approaches are:
i) Index Scores (Equal weighting - Weighting method) = 0.96,
ii) Index Scores (Simple average – Aggregation method) = 0.95, and iii) Index Scores (Z-score – Normalization method) = 0.82.

4.2. Presentation of the Composite Index

The estimation of the Index scores for the selected companies for the years 2022-2024 is: NNIT A/S = 38.7, Vaisala Oyj = 41.7, Barco NV = 35.4, Hexagon AB = 43.9, Bechtle AG = 40.7, SAP SE = 62.7, Accenture plc = 23.7, TE Connectivity plc = 27.4. To examine the performance of the composite index developed in this study, we assess whether there is a correlation between the average values of the index for the period 2022–2024 and the corresponding percentage change in gross profit over the same period. According to Murphy et al., various measures can be used to assess a firm's performance within the context of EO, including size/liquidity, market share, productivity, revenue growth and profitability. Gross profit is a suitable and widely accepted indicator of a company's competitiveness, as it reflects a company's ability to create and capture value in the market [56].

Competitiveness refers to a firm's ability to outperform its competitors through innovation, differentiation or the more efficient utilization of available resources [57]. In this study, gross profit is used as an indicator of competitiveness, as it reflects the difference between revenue and the direct costs of producing goods or services. In this way, it provides a clear picture of a firm's ability to translate its strategic choices and organizational capabilities into financial results [58]. Firms with higher levels of gross profit are considered to have a stronger competitive position and a greater capacity to create value. The choice of gross profit as an indicator of competitiveness is also based on the fact that it is directly linked to the core operations of the firm and is less influenced by accounting practices compared to other financial indicators, such as net profit [56, 59]. Although competitiveness can be assessed using various financial or non-financial indicators, such as revenue growth, return on assets (ROA), market share or innovation activity, this study focuses on gross profit in order to maintain the clarity of the methodological approach. The main objective of the study is to develop and evaluate a composite EO index and to investigate its relationship with a key business performance indicator. Gross profit is considered suitable for this purpose, as it is directly linked to the creation of economic value and reflects the firm's competitive position in the market [60]. The correlation between the values of the composite EO index and the percentage change in gross profit is approximately 0.5. The following figure presents the index values and the corresponding changes in gross profit. Although this correlation does not establish a causal relationship, it suggests the existence of a positive link between the two variables. At the same time, it should be borne in mind that gross profit is also influenced by other factors, such as the composition of sales, pricing policy and the cost structure of each company.



Source: (Authors' estimation).

Figure 1. The Index Scores for the selected companies and the percent change in the Gross profit.

The results of the analysis provide evidence in support of the study's three research hypotheses. In particular, evidence consistent with H1, as the composite EO index shows a positive relationship with the firms' competitive performance. At the same time, Hypothesis 2 is confirmed, as the weighting process revealed different contributions from the individual dimensions of the EO, suggesting variations in business behavior amongst ICT firms. Finally, the findings also support Hypothesis 3, highlighting the possibility of capturing realized EO through objective financial data.

4.3. Implications of Entrepreneurial Orientation for Digital Transformation in Healthcare

The digital transformation of healthcare services represents not only technological innovation but also a complex reorganization of the structures, processes, and values of the healthcare system [61]. In recent years, the healthcare sector has faced significant challenges relating to the scarcity of available resources, rising costs of service provision and ongoing technological developments [62, 63]. From a techno-economic perspective, this transformation requires the restructuring of hospital

investment models. The adoption of cloud technologies, mobile health (mHealth), the Internet of Medical Things (IoMT), and big data analytics is reshaping infrastructure requirements and workforce capabilities. At the same time, the development of digital technologies, such as health information systems, telemedicine and artificial intelligence applications, is significantly transforming the way healthcare organizations operate and creating new demands for adaptation and innovation [64–66]. The key benefits and major challenges associated with digital transformation in healthcare services are summarized in following Table 5. These changes necessitate the development of organizational characteristics that enable the faster exploitation of new opportunities and a more effective response to environmental challenges. In this context, EO takes on particular significance, as it incorporates elements such as innovation, proactivity and risk-taking, which facilitate organizations' adaptation to changing conditions [14].

The literature suggests that organizations which adopt entrepreneurial practices are better able to develop new services, capitalize on technological advances and improve their organizational effectiveness [67]. In the healthcare sector, innovation is not only about developing new technologies and therapeutic approaches, but also about redesigning processes, services and management models that can improve the quality of care provided.

At the same time, the growing need for digital transformation makes it crucial for organizations to be able to adapt to an environment of constant change. The development of an entrepreneurial culture can enhance flexibility, creativity and the effective utilization of available resources, contributing to the successful implementation of innovative solutions in the healthcare sector. In this context, the study of entrepreneurial orientation takes on particular significance, not only for the business performance of ICT companies but also for understanding the factors that underpin the digital transformation of healthcare. Organizations characterized by high levels of innovation, foresight and organizational adaptability are more likely to contribute to the development of technological solutions that support the operation of more effective, flexible and sustainable healthcare systems. Despite the significant benefits arising from the adoption of digital technologies, their implementation in the healthcare sector is not without challenges [68]. The utilization of mHealth and e-Health solutions offers substantial advantages in terms of clinical performance, data interoperability, and the enhancement of patient-centered care. However, this transition is accompanied by multidimensional challenges, ranging from technical issues related to interoperability and information security to legal and ethical concerns associated with personal data management and public health governance [64].

Table 5: Benefits and Challenges of Digital Transformation in Healthcare Services.

Dimension	Benefits	Challenges	Indicative References
Clinical Effectiveness	Improved patient monitoring, reduction in readmissions, support for clinical decision-making	Low acceptance by healthcare professionals, lack of training in digital documentation	Adetunji et al. (2021); Karaferis et al. (2024) [69,70]
Interoperability	Ability to integrate multiple data sources (e.g., EHRs, mHealth applications)	Lack of common standards and platforms, difficulties in information exchange between different information systems	Alenoghena et al. (2022); Karaferis et al. (2025b) [66,71]
Security and Privacy	Implementation of PETs (Privacy-Enhancing Technologies), block chain, and AI auditing to strengthen trust	Cybersecurity vulnerabilities, complexity of compliance with GDPR and EHDS requirements	Capparelli & Ligio (2025), Agyie & Oinas-Kukkonen (2020) [72,73]
Policy and Regulation	Establishment of a framework for the use of AI applications based on the new AI Act regulation	Time-consuming compliance procedures, increased certification costs	Regulation (EU) 2024/1689 (2024), ScienceDirect (2024) [74]
Accessibility of Services	Facilitation of access for remote populations, reduction of inequalities in healthcare provision	Digital divide, limited infrastructure in rural or island regions	European Commission (2024) [75]

4.4. The Impact of Entrepreneurial Orientation on the Healthcare Sector

In a climate of rising competition and ongoing shifts in the industry, entrepreneurial orientation is vital for the successful management of organizations. Data-driven studies involving executives from small and medium-sized businesses validate this perspective. The results indicate that companies with a stronger entrepreneurial orientation display greater innovative behavior, operational flexibility, and market focus, elements that improve their financial and overall business outcomes [76]. Business growth in the private healthcare sector remains relatively slow. Government regulations and internal organizational rules often act as barriers to the development of business initiatives [77]. Conversely, factors such as market conditions, competitive pressures, financial incentives, and technological and social developments can act as drivers for undertaking such initiatives. At the same time, the autonomy of healthcare units plays an important role, as does the entrepreneurial and collaborative mindset of managers, decision-makers and staff.

Business ventures in the healthcare field typically focus on enhancing the quality and efficiency of the services delivered. Consequently, it is crucial to establish a supportive setting for entrepreneurship's growth, allowing the sector to progress innovatively [78].

At the organizational level, autonomy signifies an organization's capacity to make choices and operate independently of the current frameworks that regulate it. Autonomy allows a company to quickly react to shifts in market conditions, to evaluate new opportunities, to take advantage of them, and to formulate new strategies. At the individual level, autonomy signifies employees' capacity to perform tasks, make choices, and act independently on their own accord. Autonomy fosters innovation, dedication, and a sense of accountability, elements that aid in the recognition and advancement of new business strategies [79].

Consequently, the findings of the existing literature provide strong evidence that employee autonomy is a critical factor in fostering innovation in the healthcare sector. Through decision-making autonomy, the freedom to try out new ideas and collaboration, organizations can boost their employees' creativity and productivity, whilst improving the quality and responsiveness of the services they provide [80]. The relationship between autonomy and proactivity has also been studied extensively in healthcare organizations [81]. When healthcare professionals are able to make decisions and work in flexible environments, they tend to actively identify problems and develop solutions to improve the quality of services [82]. By giving staff the freedom to organize their work and express their views, organizations can harness their creativity and unique approaches to problem-solving. This helps to foster a culture of continuous improvement and organizational resilience, enabling healthcare organizations to respond effectively to the challenges of an ever-changing environment [83].

Previous research has also shown that autonomy contributes to the creation of an organizational culture where risk-taking is not only permitted but also encouraged in private healthcare organizations. By empowering healthcare professionals to make decisions and try out new ideas, management can create an environment of trust and safety, in which staff feel comfortable taking the initiative and experimenting with new practices [84]. It has been shown that healthcare workers are more willing to engage in activities that deviate from established practices when they have greater autonomy. This autonomy strengthens their willingness to take on new initiatives and implement innovative approaches [85]. At the same time, the trust shown by the organization towards its employees boosts their self-confidence and effectiveness, increasing their willingness to undertake activities involving a higher degree of risk [86].

5. Conclusion and discussion

This study developed a composite index for measuring EO in ICT firms, utilizing objective financial data. This approach aims to fill a gap in the relevant literature, where the measurement of EO is based primarily on questionnaires and subjective assessments by executives. Through the application of the Min-Max normalization and CRITIC weighting methods, it was possible to create a composite index that captures the key dimensions of EO in a systematic and comparable manner. The results of the analysis showed that firms with higher values of the EO index tend to perform better in terms of their competitiveness. The positive relationship observed between the composite index and the change in gross profit suggests that the characteristics comprising the EO, such as innovation, foresight, risk-taking, competitive aggressiveness and autonomy, are linked to firms' ability to create economic value and maintain a competitive advantage. At the same time, it was found that the individual dimensions of the EO do not contribute equally to the final index, a fact which highlights the heterogeneity that characterizes firms in the ICT sector. The study also contributes to the measurement of EO by using observable economic data as an alternative to traditional approaches. Rather than replacing existing measures, the proposed approach can complement them by providing information based on firms' actual financial data. The composite index also allows the selected firms to be compared within a common measurement framework.

The findings may also have implications for the digital transformation of healthcare. Many technologies used in healthcare, including health information systems, telemedicine, AI, electronic health records and data management platforms, are developed or supported by ICT firms. Firms with higher levels of EO may therefore be better positioned to develop innovative digital solutions that contribute to the modernization of healthcare services. In this context, the capacity to adapt to change, use emerging technologies and respond to new needs is relevant both to firm competitiveness and to the wider digital transformation of healthcare.

Limitations

The study nevertheless has important limitations. It examines only eight firms over the period 2022–2024, so the findings should not be generalized to the ICT sector as a whole. Furthermore, the proposed index was applied exclusively to ICT firms, and its application to other sectors of the economy was not examined. Future research could expand the sample, examine a longer time horizon and apply the same methodology to enterprises operating directly in the digital health sector. At the same time, it would be of particular interest to investigate the relationship between SMEs, technological innovation and the adoption of digital health technologies, in order to better understand the role of ICT companies in supporting the digital transformation of modern healthcare systems.

Author Contributions

Project administration: E.K.; writing-original draft preparation: E.K. and D.B.; writing-review and editing: D.B., D.K., Y.P.; validation: D.B., D.K., Y.P.; All authors have read and agreed to the published version of the manuscript.

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