

Digital and Sustainable Transition: Status of European Union Production of Transport Equipment Sector

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Abstract

The European Digital Decade (2030) strategy sets out guidelines for digitalisation in Europe, meaning that more than 90% of businesses have achieved at least their significant digitisation capacity. The European Commission is committed to implementing the European Green Deal to reduce its environmental impact. Production of the transport equipments sector will play an important role in Europe's green and digital transition, creating technologies that contribute to sustainable development and strengthen Europe. The limited and fragmented use of digital and sustainable technologies at the European Union level within the Production of the transport equipments sector is identified. The results of the publication show that the number of papers on digital practices is five times higher than the number of papers on sustainable practices. This article aims to develop guidelines that allow the Production of the transport equipments sector to accelerate the transition among the European Union member states. The author proposed a two-step approach to testing for the digital and sustainable transition of Production of the transport equipments sector. According to this method, the researcher of this study mainly analyzes and compares data from the European Union 27 Production of the transport equipments sectors, reflecting the performance activities among the manufacturing sector in general. The results show that 8 Production of the transport equipments sector digital and sustainable indicators are lower than the European Union average of the manufacturing sector. In addition, the proposed interdisciplinary ranking system is being developed to consider decision-making and progress in transitioning to a more digital and sustainable landscape. The study identifies areas needing more attention from Production of the transport equipments sector and policymakers and aligns the green and digital transitions.

1. Introduction

The European Union's policy agenda aims to prioritize the implementation of digital and sustainable transformation. The speedy transition is essential to achieving the United Nations Sustainable Development Goals (SDGs). The European Commission's priorities in implementing the Green Deal are key to achieving the European Green Deal (EU) goals. So far, little attention has been paid to the factors that support digital applications. Recent studies have shed light on the role of green technology in digitalisation, particularly addressing the sustainability challenges businesses face. Although much attention has been paid to digital and sustainable approaches, research in this area is generally fragmented, and there are serious gaps.

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The sustainable and digitized Europe approach emphasizes the importance of drivers of the European economy and those that are contributing to the transition. The EU's transport equipment manufacturing sector has about 45,700 companies and employs over 3.2 million workers. Therefore, it is necessary to conduct research in this area to accelerate the digital transformation of PTES and integrate it with solutions related to sustainable development. The results and implementation of this study will lay the foundation for addressing challenges related to digitalisation, sustainability, and environmental issues and will contribute to increasing the long-term competitiveness of PTES.

However, it remains unclear how the synergy of these two digital and sustainable changes will affect society and what changes will lead to the future. Research on these changes in PTES is robust, but researchers rarely address these issues. Therefore, analysis of business trends related to the transition of EU Impact Assessment and PTES analysis is a new and important area of management science research that forms the basis of this research. Therefore, the analysis of changes in competitive advantage through SDG and PTES assessments is becoming a new and important area of business research.

The study provides theoretical views that facilitate the digital and sustainable transition in PTES. The results of the research and its use forms a framework for digitalisation, sustainability, and social and environmental factors increasing the business competitiveness. In today's world, issues and concerns related to the environment, renewed energy, and sustainability are particularly important, and implementing this transition will improve digitalisation and sustainability. It is, therefore, in line with the Sustainable Development Goals, the European Green Deal, and other relevant programs.

In the case of PTES, changes can significantly increase competitiveness, but we lack knowledge about these changes and the factors that influence their results. These findings should help policymakers assess whether the EU is ready to move to digital and sustainable practices and whether it is ready to speed up implementation at PTES. The study will address challenges which increase the EU's ability to pursue and strengthen its commitment to sustainable digitalisation. In addition, the author hopes that the results of this research will be important to facilitate a smooth and rapid transition, which will be followed by knowledge of it.

This research results present the outcome of the analysis of digital and sustainable transition in PTES speeding processes in the 27 EU member states and establishes a validation process for assessing PTES trends in the green and digital transition.

The author conducted several pilot studies: 1) identified key factors that promote and delay the transition; 2) identified the gaps between the EU-27 states and benchmarked status in manufacturing sectors in the applications of digital and sustainable technologies and their practices; 3) developed a results-based research system to evaluate the progress of PTES.

This paper is divided into six parts. These are the first two results of a literature review. Chapter 2 summarizes the literature review results. Chapter 3 focuses on identifying factors increasing the competitive advantage of PTES. In the fourth chapter, the study presents the methods and methodology used for the research. Chapter 5 examines the differences between the EU-27 countries and benchmarks differences in countries. Chapter 6 provides the analysis system used for decision-making. Finally, the author presents investigations and conclusions.

2. Review of Literature

Sustainable digitalisation is an important part of the EU's agenda. Successful implementation of these reforms is critical reaching the UN Sustainable Development Goals (SDG). The EU report in 2022 highlights the link between digitalisation, sustainable transformation, and capacity building. The Europe Green Deal strives to achieve the neutrality of climate before 2050, with targets and strategies [1]. However, sustainability topic lacks attention in the context of digital transformation. Meanwhile, according to the Annual Report on enterprises in Europe 2022-2023, 1/3 of EU countries do not have systems/facilities in place to adapt early learning to sustainable needs [2]. The link between digital transition, sustainability, and metrics related to the company's current competitive advantage raises research questions.

Therefore, for the acceleration of the digitisation of PTES and integrate sustainability, it is important to explore its content and support and accelerate the digitisation and implementation of SDGs in the EU-27 member states. Current researches highlight the digitalisation aspects, especially the challenges businesses face towards sustainability [3-13]. It's important to remember that the focus is on digital transformation and sustainability, which is growing, but research in this field is limited. The recent papers have not conducted adequate research on changes and factors affecting PTES's competitive advantage, and very little research has been conducted in this area [14], [15], [16], [17]. In this study, green and digital transitions are joined, seeking to contribute to the economy, circular economy, and climate neutrality if digital technologies are used and managed properly. A successful transition for all requires identification of synergies in line with digital and green transformation and implementation of proactive and inclusive governance plans which support implementation of systems. The transformation of several actors requires the participation of all actors, and the production sector has an

important contribution to the EU economy, but it also has an important role in the transformation of both. At the same time, the public sector and civil society should work together to maximize the benefits of digitalisation and green processes and mitigate the negative impact of digitalisation and green processes.

PTES research in competition and innovation is becoming increasingly popular among researchers abroad and in Lithuania [18-21]. "A company's competitiveness can be defined as a company that achieves two goals in a sustainable manner, namely its ability to meet customer needs and benefit from long-term business growth." The growing interest is evident in researchers and experts [22]. Gao et al. (2022) focus on business opportunities that can be harnessed to drive change [23]. Recent studies highlight the essence of environmental digital technology in line with the sustainable development challenges faced by businesses [24], [25], [26]. In the analysis of recent studies, digital innovation and sustainability is an important topic [27], [12]. Clarative Analytics has published about 1,400 articles on digital and sustainable applications, but the studies are fragmented. The study examined PTES only partially, focusing on improving interdisciplinary classification and ignoring changes in PTES. If we look at specific research topics (digitalisation, sustainability, business change), we can see that recent research in this area aims to assess the impact of digitalisation on sustainability (environmental, social, etc.) [28], [29], [30], [31], [10], [25], [26], analysis of digital applications [16] and various organizations (32)]. The study looked at the relationship between these variables, the concept of change management in sustainable business development [33], sustainability, and digital innovation [34]. There have been researches on business transformation [35], [36], [37], [38] and business results from such applications [39-40].

Through digitalisation and sustainability applications, PTES can reduce its environmental impact. For example, in digital solutions such as waste and remote working, PTES reduces energy consumption and greenhouse gas emissions. Sustainability change can include other environmentally friendly practices, such as minimisation of waste, promoted recycling, and the use of renewed energy [41-45].

It is important to manage and implement structural changes in business [9]. PTES innovation management principles and techniques can be used to effectively make organisational change, followed with communication plan, trainings, and cultural aspects [43]. Digitalisation and sustainable change often requires transformation of organization culture which fosters different forms of employment and skills. PTES focuses on digital innovation and sustainability and often requires significant organizational change to accommodate innovations, new practices, and initiatives that require the management of organizational change. Structural change theory refers to the direction of planning, implementing, monitoring, and digital sustainability change in PTES. This includes analysing the change scope, forming the plan for managing change, engaging stakeholders, and responding to objectives. Digitalisation and sustainable transformation need continuous improvement and adoption [46]. PTES continues to learn and develop feedback, analysis, and adaptation systems. This enables PTES to engage in complex innovations and advance digital literacy and sustainability [47-48]. It helps focus on business challenges, recruit workforce, and deliver an environment supporting successful employment and further results.

The key to achieving competitive advantage is integrating national resources and the ability to use them. PTES should identify opportunities that business could benefit from a dual approach [50], such as professional staff, information resources, and technical infrastructure. By employing such resources, PTES could increase capabilities and business competitiveness. Physical and digital resources could help to reach competitiveness increase [51]. PTES companies could differentiate themselves from their competitors using unique to sustainability oriented digital tools. For example, country-based PTES, which uses innovative digital and sustainable solutions, can be at the forefront of other EU countries. Through digital transformation and sustainability, PTES can enhance innovation, rise operational efficiencies, and apply innovative business models [52-53].

The solution must be user-friendly and follow a simple approach that requires PTES to differentiate between workers and stakeholders. PTES should consider the specifics of the first implementation of environment oriented practices and build strategies supporting broader implementation by employees, suppliers, and other stakeholders. PTES stakeholders driving the adoption of digital technologies can facilitate knowledge exchange and encourage others to use them. PTES can provide valuable insights in identifying and driving digital transformation and sustainability. This exposure contributes to early departure and successful implementation of positive structural changes [54-59].

Regarding competitive advantage, PTES's digital transformation and sustainability will follow initiatives contributing to further success. While transformation requires timely investments, PTES can deliver long-term economic benefits [60]. Digital technology allows you to increase operational efficiency, simplify processes, increase productivity, reduce costs, and increase revenue. PTES can tailor its actions to consider digital transition's social and other aspects and its environmental benefits [61]. This approach helps PTES create commercial, social, and environmental value and promote further development [62]. PTES measures related to digital transformation and sustainability will ensure compliance with corporate social responsibility (CSR) requirements [63].

By understanding this knowledge, PTES can develop strategies that reflect business and environmental goals. In general, the following factors are taken into account:

- PTES role. The objective should be to become digital and sustainable through successful transition, including communications, resources, education, and organizational culture changes.
- Knowledge importance. Understanding and successfully implementing green and digital transformation projects requires knowledge and training to develop end-user skills and competencies, develop new digital and sustainability strategies, and drive changes in the sector.
- Evidence of solutions. Companies should support research and innovation activities to help develop user-friendly solutions that meet PTES requirements and facilitate the transition.

Due to the importance of the solution, it has been shown that several Industry 4.0 technologies can also be used to operate sustainably, reduce waste, and increase efficiency [64].

2.1 Bibliographic Study of The Transition at PTES

The author conduct bibliographic research in three stages, addressing related topics. In the first stage, revises the papers on digital transformation. The second stage examines written research in the field of sustainability. The third string is used to verify the PTES studies.

The process consists of three steps:

- VOS Viewer will be used to view articles included in the Web of Science 2023 database.
- Review of bibliographic correlations to identify complex concepts.
- The keywords research in the titles of the above mentioned papers and clusters formation.

By learning the keywords "digital business transformation", "sustainable business transformation" and "production of transport equipments", the author of the article created a directory map using the VOS Viewer (version 1.6.20) and created the above group. The author includes all open-source articles available in VOS Viewer. Starting in 2023, author will limit the materials they can submit. This includes all documents provided in 2023. The number of repeated published experiments does not exceed 50,000 publications during grouping.

VOS Viewer uses VOS mapping technology to check "matches". VOS Viewer links nodes to network groups. A cluster represents the group of nodes which are closely related. All nodes are directly linked to the cluster. The parse parameter indicates the number of cluster. To describe the directory network, VOS Viewer represents the category in which ads are associated with colors. Waltman et al. (2010) discuss connectivity technology used in the VOS Viewer. This approach requires an intelligent spatial traffic algorithm introduced by Waltmann et al. (2013) [65-68].

Complex bibliographic maps (see Figure 2) use models with unique characteristics. First, circles on the map are depicted to reflect different groups and mention closely related keywords. The lines in Figure 2 show the relationship between key words and connection strength. A length between keywords indicates the strength of each relationship.

The outputs of such bibliographic survey presented below are divided into three parts. Summarize the results of the terms used in the classification.

In this presentation, the author used only the results of several groups and did not use all the clusters generated with the above three keywords on digital, sustainable, and PTES topics.

The first part focuses on digitalisation (Figure 1) and introduces the keywords "digital tranformation" and "sustainable tranformation" belong to the third cluster. These keywords belong to the same group. However, these records are not related to PTES. This general term describes the combination of numerical concepts and practical concepts. References linked to SDGs also indicate references associated with this topic is intended to support the broad transition to the SDGs, but their content does not meet the needs of the SDGs.

The keywords "digital transformation" and "sustainable" belong to the 5th cluster; in addition, "sustainable development goals" belong to the 4th cluster in the sustainable business landscape. These keywords are shown in Figure 2. In the third part (Figure 3), which describes the PTES factor, the keywords "digital" and "sustainable" are not mentioned at all. However, the keyword "PTES" refers to the 3rd cluster. This suggests that the literature considers the roles of business in digital and sustainable transition, but not in PTES case. Such shows that it is not the most important question.

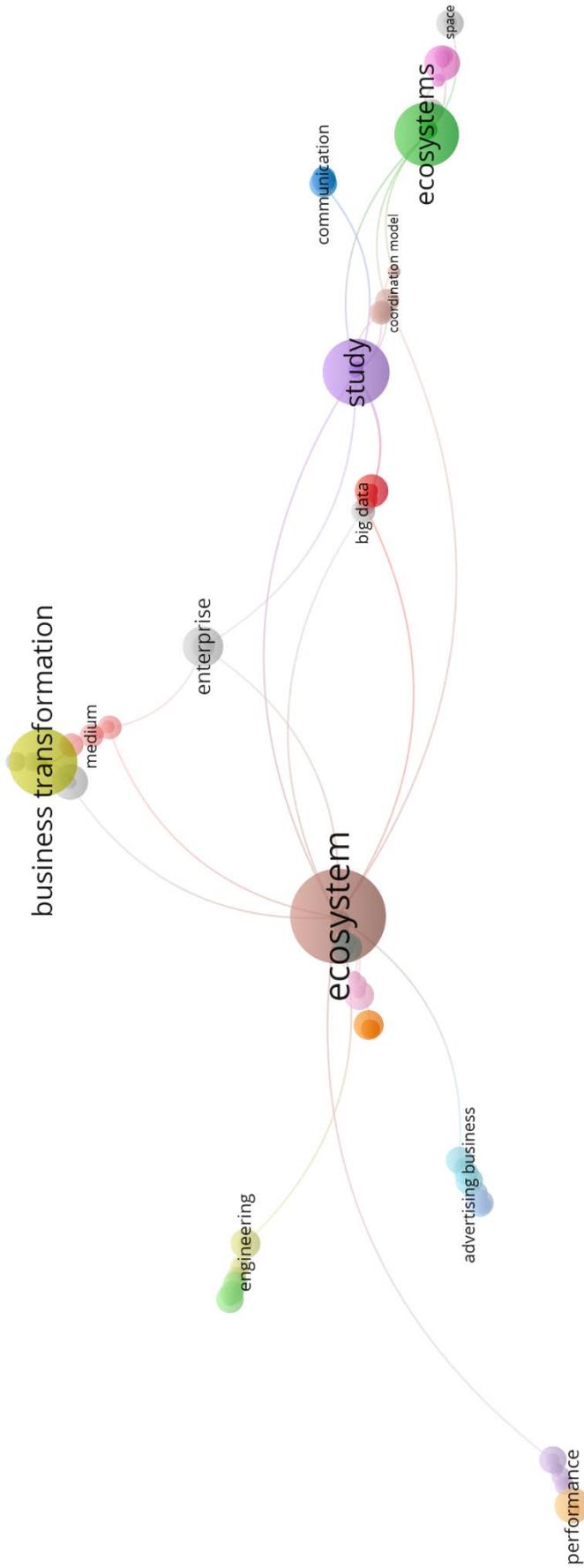


Fig. 1 Digital business transformation

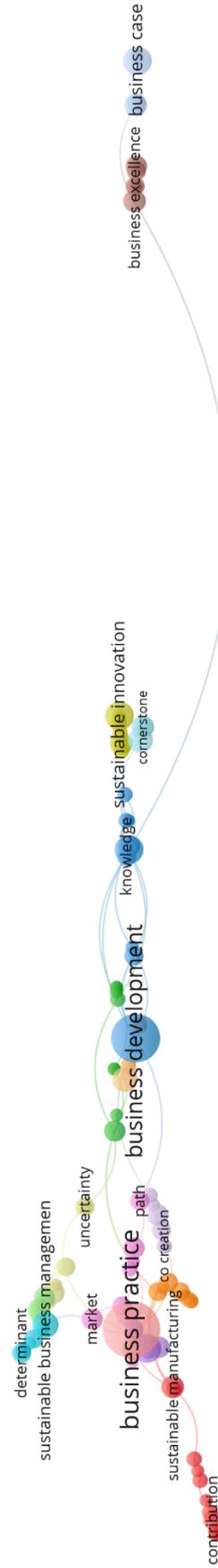


Fig. 2 Sustainable business transformation

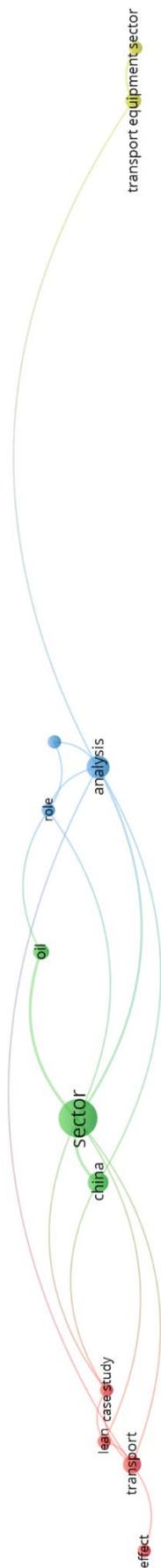


Fig. 3 Production of transport equipments

This study shows that there is a lack of papers that cover PTES case. In the Web of Science database, the author found just 22 papers on PTES. It is clear that there are gaps in research, and there is still no research to address this.

3. PTES Factors For The Competitive Advantage

Double ambivalence affects many factors that reflect PTES' competitive advantage. The relationship between these elements and the material is presented below.

Some factors have been identified that affect how the transformation will handle its competitive advantage. Thus, following the literature, mentioned series includes such elements:

- (a) Number of enterprises applying digital and sustainable technologies [69]
- (b) Productivity generated during the application of technologies [70]
- (c) Market share reached by products manufactured using green technology [71]
- (d) Primary investments [72]
- (e) Complexity of solutions implementation [73]
- (f) The number of digital and sustainability technologies used in the PTES [74], [75].

The first factor is the amount of digital and sustainable enterprises. How companies use digital and sustainability practices can be assessed through the Roger curve used for adopting innovations. The curve, drawn by Rogers, depicts the companies being innovate over time. By applying this curve buyers are divided into five parts: innovators, adopters, majority, lagging majority, and late implementers.

- Innovators (2.5%). Modern societies were among the first adopting digital and sustainable solutions. These companies experiment with innovative digital and sustainable projects and take some risk.
- Adopters (13.5%). Adopters follow guidelines used to evaluate innovation. They track the successes and failures of entrepreneurs and take more efforts to calculate risk. These firms could integrate digital solutions in a timely manner into existing business models.
- The majority (34%). Digital and sustainable technologies are increasingly being tried and tested, and more and more businesses are adopting them. These companies must avoid certain risks and demonstrate the benefits of these improvements.
- The lagging majority (34%) lagged behind. Other firms are described by postponing change. Digital and sustainable solutions should only be applied when this is a general rule or market-imposed. At this stage, implementation includes modernizing current systems and business practices and complying with industry environmental standards.
- Late implementers (16%). Lagarde is a modern world that is adopting digital and sustainable technologies. They oppose changes and could only take it if these firms have issues or if their safety is under risk. Today's businesses can use essential digital tools and powerful tools to meet the needs of managers and customers.

The number of firms mentioned by Roger varies by sector, region, and other conditions. However, when digital and sustainable practices become increasingly important to technological developments, awareness, and growing market pressures is more visible. Companies need to thrive on these changes and strive to be competitive and sustainable in a constantly changing business environment over the long term.

Another factor is the productivity of resources. Asset productivity refers to how efficiently a company uses resources while minimizing environmental impact through digital innovation and sustainable practices. The integration of digital and sustainable applications will increase productivity. Robot-based technologies improve manufacturing process; automatisaion-based solutions could work on task and reduce costs and minimise the size of errors. IoT allows in real time you follow the devices and processes. Simplify your business by supporting with insights on energy usage, performance of technologies and activities. Data mining helps revise big volume of data to find inefficiencies and figure out opportunities. Transition usually requires advanced energy management and technologies dedicated fro that. This reduces the impact of energy consumption on the environment. Sustainable business practices aim to reduce waste and CO2 emissions and ensure ethical governance. In this way, resources are saved throughout the supply chain.

The market share shows that consumers tend to focus on more to environment oriented solutions. When firms adopting technologies which minimise the impact of production process on environment, these companies will reach increase in market share.

While digitalisation and sustainable transformation have many advantages, they can lead to challenges and disadvantages. It is important to identify and address these issues to counteract the impact of the change.

Therefore, the primary investments are important. The investments for using new technologies is high. The financial aspect can be challenging, especially for businesses having limited resources.

In addition, a technical complexity is the last challenge. The integration of new systems into working infrastructure could be challenging and destructive. To solve these issues extra investments could be needed.

When considering these practices, it is important to consider the number of companies adopting digital and sustainability application in PTES. In EU-27, the digital focus is still low; only 22.5% of companies have high digital intensity and apply nine or more than nine digital technologies. Only 13% of firms with high digital intensity apply measures that affect energy consumption [75].

The positive or negative of the coefficient is defined as follows (see Table 1): (the second column).

Table 1 List of criteria formed by author

Key elements	Positive(+) / Negative(-)
Number of enterprises applying digital and sustainable technologies	+
Productivity generated during the application of technologies	+
Market share reached by products manufactured using green technology	+
Primary investments	-
Complexity of solutions implementation	-
The number of digital and sustainability technologies used in the PTES	+

Switching to the application of advanced technologies, which are digital and sustainable, could require informing consumers about the environmental benefits of products manufactured using green technologies, which could influence purchasing decisions and increase market share.

In addition, using green digital technologies helps reduce costs and increase the long-term competitiveness of businesses. Customers receive revenue at competitive prices, which further increases their market share.

The factors listed in this chapter can be used to improve the decision-making system by considering positive and negative influences on the transition speedup.

4. Methods and Methodology

The author revises the literature and examines the quantitative methods they use in other authors' studies. The authors explored this topic using various techniques, including research on the most common ones in a paper published by Burinskiene et al. (2022) [76].

Table 2 summarizes the studies. The author notes that, according to the quantitative methods described above, some methods are sometimes mentioned in the work of other researchers. At the same time, the AHP method allows you to define parameters that can help you determine the situation.

Table 2 Quantitative method and model prioritised in PTES studies

Groups of methods	Focusing on	Method	References
Mathematics Programming methods	Single objective	Linear programming	[77]
	Multi objective	Multi-objective integer linear programming	[78]
		Non-linear analysis	[79]
		Time series	Multiple regression
Causal model	Causality identification	Causal effect modeling	[81]
	Heuristic approach methods	Diagram of causal systems	[82]
		Heuristic approach	Fuzzy logic
Analytical models	Metaheuristic	Genetic Algorithm	[84]
		Multiple-criteria decision support methods	AHP
	Systematic models	COPRAS	[86]
		DEMATEL	[87]
		TOPSIS	[88]
		Delphi method	[89]
AI-based methods	Language models	Network model	[90]
		Large language models	-

Herein: AHP - Hierarchical analysis process; DEMATEL - a complex method for creating and analyzing structural rules that takes into account the causal relationship between complex factors; COPRAS - Complex

PROportion Assessment multi-criteria method; TOPSIS – the latest technology for events seems to be the best solution.

Table 2 shows the different methods are commonly applied by the authors. [74] and [80] papers write about the impact of digital innovation on enterprise's economic performance and attempt to establish a link between digital innovation and its efficiency.

Table 2 provides terminology for uploading using these methods. In 2022, a linear design approach was launched that promotes digital innovation for sustainability by integrating innovation, insights, and efficiency while promoting green behavior. [78] research uses universal integer applications to create supporting industrial integrated circuit systems 4.0. [79] paper are non-linear analytics that bring digital enterprise's activity closer to a higher threshold. This paper has proposed a method of modulating the causal relationship between digital transformations to stabilize them. [83] uses the ambiguous logic of enterprise. [84] The paper analyses the application of genetic algorithms to enterprise asset management. [85] paper, among other standard approaches, develops comprehensive monitoring solutions and achieves more sustainable enterprise activity. [86] paper identifies industry cases [86]. The authors of [87] paper announced an uncertainty analysis of improved social outcomes for enterprises through digitization, among others. [88] the paper examines how enterprise improves reliability. [89] paper uses Delphi's methods to explore the emergence of sustainable (and accurate) digital maturity in the business ecosystem and identify best practices, barriers, and systems for digital innovation. [90] the paper identifies network models that support enterprise digitisation.

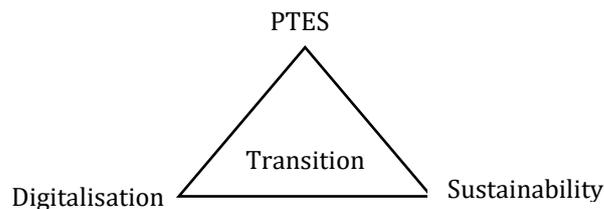


Fig. 4 Exploring the main triangle for research

Table 2 shows how the COPRAS method may be suitable for further research to assess industry 4.0 deployment. COPRAS integrates positive and negative criteria, as stated in section 2.

Using different assumptions, the author uses statistical analysis and COPRAS' decision-making methods to examine differences between countries. The author is developing a system incorporating the expert method using decision-making. These rules apply to the points mentioned below.

The article's content belongs to the keyword triangle (digitalisation, sustainability, PTES) on either side of the triangle, and the only words that connect all other keywords are the triangle – number and privilege (Figure 4).

According to Figure 4, this transition can be defined as the transition to a new level of value creation for PTES. In other words, digitization means that digital technologies can give companies a greater competitive advantage in their business processes. Both are associated with sustainable development. Sustainability is economic, environmental and social. In this study, the author will focus on environmental protection that meets the needs of nature and contributes to the conservation of social resources in the future.

The author of the paper [92] described a large-scale transition process and presented the conversion effect in the spirit of intentional change. At the bottom of the triangle is the keyword PTES, indicating that private companies perform production of transport equipment activity.

The author conducted the study in the following stages (according Table 3):

1. First, Eurostat data is analysed to show progress through digitization indicators in all EU countries, with a particular focus on the environment.
2. Second, the author introduces a multifaceted decision-making system that uses a collaborative approach to assess PTES progress in different countries.

The first phase of research is presented in Chapter 5, and the results of the second phase are presented in Chapter 6.

Table 3 The methodology stages are used to research the application of digital and environmental technologies in PTES

Level	Objective	Application	Assess compliance with national implementation policies
Step 1			
Status of PTES in applications of technologies	Analyze the current situation and results.	Analyze and compare statistical data from companies of different sizes and countries.	Develop green ICT activities, achieve environmental performance, and integrate sustainability into business policies.
Step 2			
Decision-making method application	Create an evaluation system based on decision-making based on various assumptions.	COPRAS identifies and evaluates criteria by experts and calculates the coefficient of similarities in experts' opinions.	Identify a two-way strategy that politicians can use to develop PTES.

The results of this study are presented below.

5. Statistical Analysis of PTES Development

Eurostat (2023) provides information on various aspects of information technology and the environment. After analysis of data, ICT, environmental practices, and digital sustainability became clear to FEPE. Here is a list of the main functions of the company:

- Eurostat data on the use of ICT in the EU sectors provides an overview of the extent of digitization. The prevalence of ICT in PTES may reflect a strong trend towards sustainability.
- Eurostat's data on adopting green practices in ICT shows how PTES integrates sustainability into its digital programs. This also includes the introduction of green technologies.
- The ICT integration and sustainability level can be considered when tracking Eurostat data on PTES environmental reporting practices. Digital tools play an important role in collecting, analyzing, and disseminating information about the performance of environmental activities.

The author closely examines various aspects of digitalization and sustainability to understand the relationship between Eurostat data and EU digital and sustainable production of transport equipment. In regards, to this study, researchers and policymakers can use this knowledge to develop strategies to promote the ICT potential, integration, and sustainable practices of the EU PTES sector.

The author examines 26 indices collected from Eurostat's database, reflecting the trajectory of implemented digital and sustainable solutions in 2022.

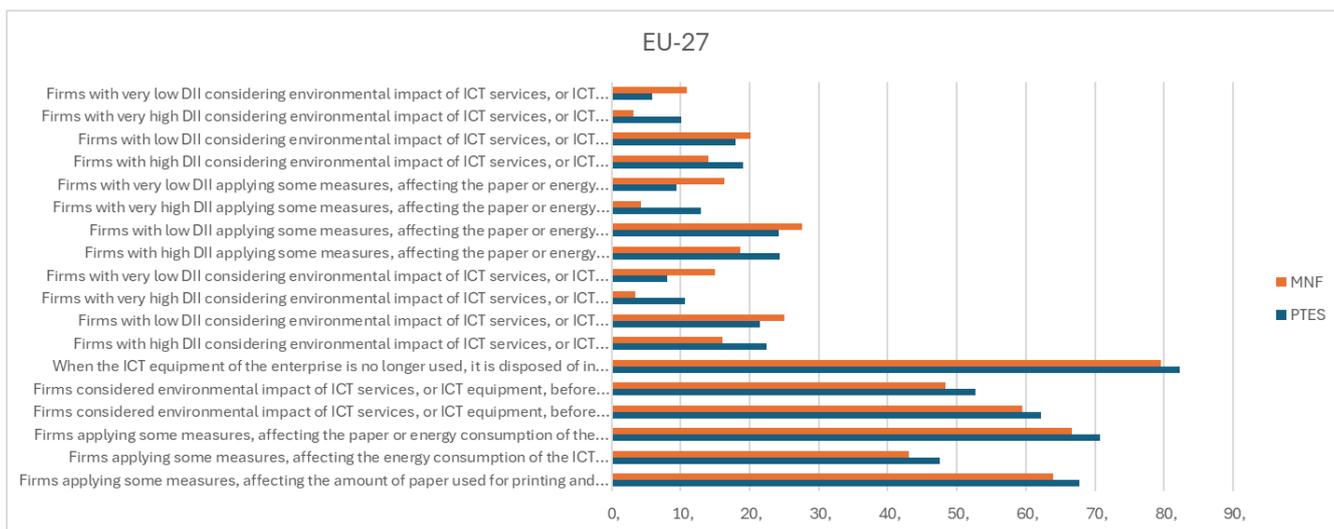


Fig. 5 Intensity level of digitalisation in PTES compared to general manufacturing (MNF)

Figure 5 shows that the application of ICT tools used is the most sparkling. It presents the comparison of PTES with all types of manufacturing (MNF) companies.

The author compared PTES results with other manufacturing companies based on 22 positive indicators, four of which were negative, which means that the worse the situation, the more valuable it is. The author drew a map showing the use of digital technologies in each country and found, on average, 22 positive indicators (see Figure 6).

As a result, PTES indicators outperformed manufacturing (MNF) sector values in 13 indicators used to assess environmental impact before selecting ICT services or assets. In all four negative KPIs, PTES's position is better in the general manufacturing (MNF) sector. In positive KPIs, PTES has better values in such most significant differences, showing indicators as ICT equipment when it is no longer used in the enterprise, it is sold, returned to a leasing enterprise, or donated. Firms with very high digital intensity levels apply some measures affecting the paper or energy consumption of the ICT equipment; Firms with very high digital intensity levels consider the environmental impact of ICT services or ICT equipment before selecting them and others.

PTES firms with very high digital intensity levels outperformed manufacturing (MNF) sector firms in applying some measures that affect the paper or energy consumption of the ICT equipment.

However, PTES firms with very low digital intensity levels are lagging behind manufacturing (MNF) sector firms in considering the environmental impact of ICT services or ICT equipment before selecting them and in applying some measures affecting the paper or energy consumption of the ICT equipment.

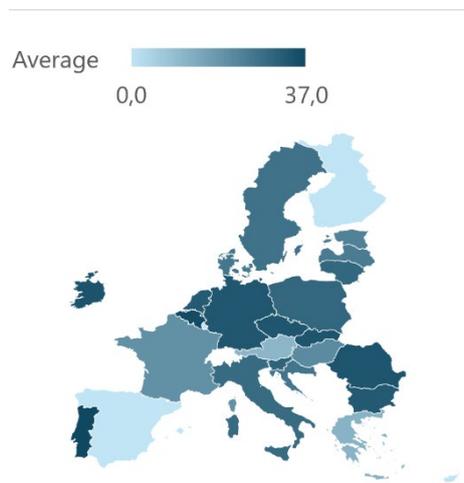


Fig. 6 Use of digital technology in EU-27, 2022 (PTES companies with ten or more employees)

Using the statistics, the author created two short-term averages with 18 positive indicators. According to Eurostat, PTES firms with more than 10 employees in Portugal and Belgium are the most active among the EU-27 countries in applying digital and environmental measures (see Figure 6).

There are four negative indicators: companies failing to affect the amount of paper used for printing and copying, companies failing to act to affect the energy consumption of ICT equipment, and companies failing to consider the impact of ICT services and sorting equipment (see above). Companies that stop using ICT equipment will not be exempt from e-waste collection and recycling. Greece, Croatia, and Hungary have the highest number of negative indicators.

6. A Decision-Making Analysis System With Many Criteria

First, the author defines a system that classifies beer methods according to factors affecting the competitive advantage of PTES due to the transition to digital and sustainable practices.

The multi-criteria decision-making system is an organizational approach to evaluation and prioritization options based on different criteria (using Appendix 1). The following criteria are defined to evaluate the digital and sustainable transition of PTES, including positive and negative impacts:

- 1) Many PTES turn to digital and renewable energy sources.

This criterion describes how PTES can adopt digital and sustainable practices. They positively impact ecosystems and bring economic, social, and environmental benefits.

- 2) The flow of resources gained during migration will double.

Resource productivity measures resource efficiency in the context of digitalisation and sustainable change. This positive effect is that PTES maximizes resources, reduces waste, and increases productivity.

3) Market share of products manufactured using green technology.

This criterion measures the success of enterprises selling products manufactured using green technology. The increase in market share positively impacts customer empathy, competitiveness, and the environment.

4) Initial investment (negative).

Innovative investments are needed for digitalisation and sustainable transformation, especially management technology standards with limited financial resources.

5) Technically complex (negative).

These challenges stem from the technological complexity of integrating and managing new digital technologies. Increased technical complexity can lead to installation problems, failures, and operational risks.

6) The number of digital and sustainable technologies using PTES.

This criterion assesses the diversity and diversity of digital and sustainability technologies used in PTES. The higher the number, the more complex and effective the changes will benefit more industries.

The impact assessment system will allow stakeholders to systematically assess and prioritize R&D based on their digital and sustainable transition process performance. Policymakers fully understand the impact of these changes and provide a strategic approach to making informed decisions about aid, investment and development projects.

The system is determined in four stages:

1. Calculation of the mass coefficient.
2. Check the consistency of expert advice.
3. Normalization of coefficient values.
4. Keep up the evaluation.

The application of decision-making methods to a given criterion depends on the calculation of the weighting of the criteria. Measure each criterion according to its relative meaning. If the main goal is to succeed and improve the market, it will be more difficult due to increasing market share, changing PTES data, etc. Select the default rating on this scale and calculate the weight value for each criterion. Provide a source of metrics describing overall performance in all conditions.

Experts often recommend weight management. At least seven experts are working on a case study. PTES and ICT professionals are encouraged to prioritise policy standards.

The concordance coefficient is calculated in such a way as to ensure consistency of expert opinions (see Appendix 1 for details). The author performed a sensitivity analysis to understand the consistency of expert opinions. This will help you identify and reinforce factors that have a greater impact on the stability of your decision-making.

The values of PTES should be considered according to each criterion, and their weight should be evaluated. According to the COPRAS method, the problem is the different parameters of the matrix. In this example, the table contains six coefficients (rows) and n alternatives (columns) (see Appendix 2). The calculation results will be presented in the reference value matrix outlined in Appendix 3. Normalize results to ensure comparison of conditions. This means that results become a general criterion favoring a fair comparison.

The underlying system can prioritize talent accordingly. You get the final result, for example, priority (scores of all other options). It is evaluated based on the severity of the results. Digital and sustainable transitions are expected to bring positive results in improving PTES.

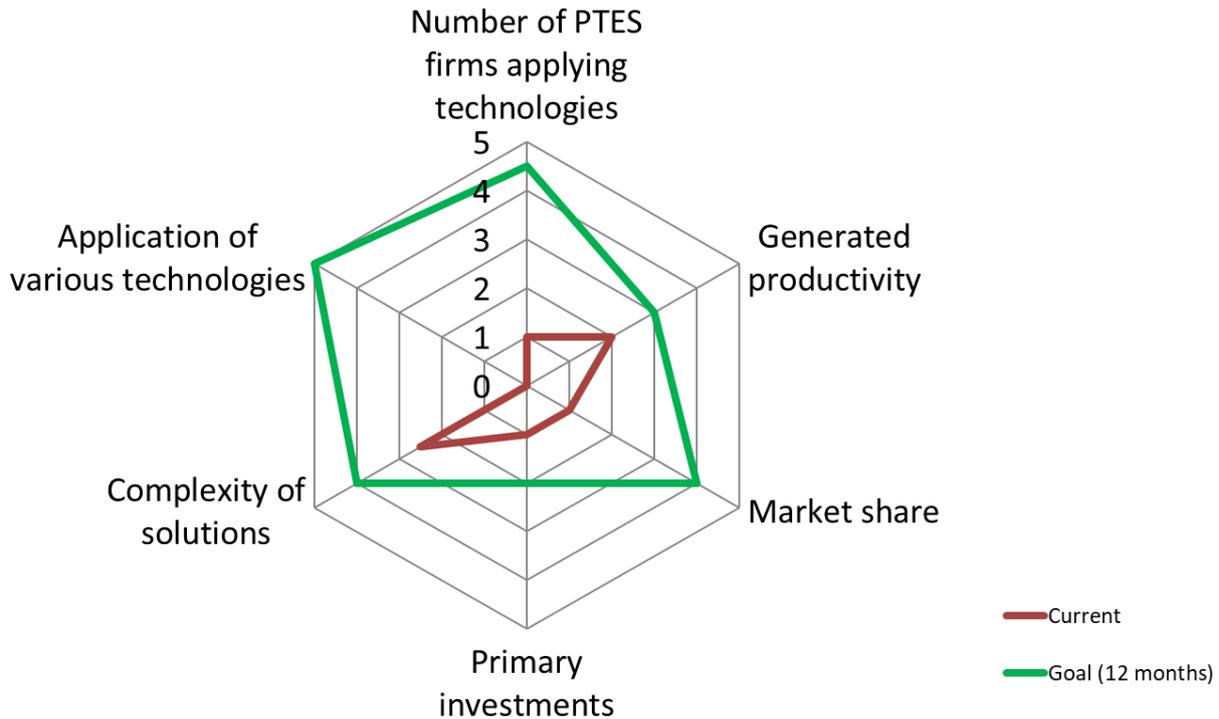


Fig. 7 A decision-making analysis system with multiple criteria

Where 0 = False, 1 = no information, 2 = first steps, 3 = maybe it's better, 4 = good enough, 5 = professionalism.

These criteria can be evaluated with the help of financial managers or commercials, taking into account the main objectives mentioned in Figure 7. This system is used for self-assessment in the PTES industry.

The development system can be used for case studies to raise the targets. For your practical use, there are several guidelines if they are used by a group or an individual with decision-making power.

The system can systematically assess trends and mitigate strategic and market challenges.

The current framework reflects areas where businesses and policymakers must focus more on achieving similar transition goals.

This system can measure the progress of different countries by comparing the performance of the PTES sector. Further on, the higher progress could be measured after 4-5 years time period.

7. Discussion

Digital innovation and sustainability of PTES require obstetric information about the latest research findings. However, research studies have potential flaws based on general trends and challenges.

The results of this publication highlight the need for a detailed debate on the need of mainstreaming together digital with sustainable transition, especially in the context of policies in Europe and the Sustainable Development Goals announced by the United Nations. It highlights strategic research and initiatives to accelerate the digital transition combined with a sustainable one in EU countries, such as PTES and manufacturing sectors in general. The Green Deal approach announced by the European Commission aims to achieve 2050 the neutrality of climate, but digitisation has yet to focus on sustainable development, and many EU countries have no way to adapt to sustainable needs. This study highlights PTES' lack of focus on digital innovation and sustainability and calls for new research in this area. It also explores the potential benefits of moving to PTES, such as reducing the environmental footprint through digital and sustainable applications. The study emphasizes the practices in organizations and resource use revisions in achieving successful digital and sustainable transition goals. This shows that PTES can use its resources to increase its competitive advantage, implement advanced solutions, and overcome new challenges.

The study will help address the specific challenges of PTES in integrating environmentally friendly practices through digital applications. Identifying such practices will be helpful to ensure a streamlined process.

Consider growing operational capabilities to publicly and consistently evaluate the sector's performance. The author devised a scoring system to fill in the study's gaps and consider quantitative and qualitative indicators

reflecting differences in these changes. This peer review reveals a close relationship between transition and PTES, which may be necessary to select future directions.

The leaf identifies the main factors that facilitate and delay the transition of PTES. The author analysed 26 KPIs, 4 of which had a negative direction in making PTES digital and sustainable. The level of resource production achieved through the green and digital transition, the market share of products produced using green technologies, the number of these technologies applied in PTES, and two negative technologies associated with initial investment and technological diversification. The author highlights the largest research gap in Portugal and Belgium, where 18 KPIs regarding trends and the value of statistical indicators overcome the EU average. In addition, the author developed an evidence-based assessment system that helps assess the progress of PTES during transition.

Assessing the long-term effectiveness of PTES following digital and sustainable transition will help achieve sustainable development goals.

Researchers could contribute essentially to the field of studies by covering gaps and figuring out valuable investigations for politicians, practitioners, and scientists supporting the transition. The study fills gaps by analysing the PTES indicators of the 27 EU member states. This paper provides a framework for assessing continued progress in a particular country or group of companies, which varies in size.

Practical Implications: This article discusses how PTES affects the direction and speed of transition. Policymakers can facilitate the transition by seeking support systems at different levels of government. The applications require a broad and open search for effective communication and ICT solutions to achieve critical mass. Implementing decisions that meet the needs of PTES and support changes.

The study suggests a framework that could be used to measure the transition of PTES, including initial investment and reducing technical complexity, and identifies what policymakers could use to drive future growth.

More research is needed to understand each population's specific tolerances and dichotomy. Further analysis of the relationship between digitization and PTES, especially when actions are not fragmented, could be a suitable basis for future research. It will be interesting to indicate the future direction in which to investigate the relationships between SDGs and PTES and focus on these digital and sustainable aspects.

8. Concluding Remarks

The study and analysis of the status of the EU-27 production of transport equipment is an important field of management studies. Therefore, the Green Deal initiative supports the analysis of the sector's competitive advantages and encourages the consideration of various companies to achieve the SDGs.

The study examines keywords that have relationships in the digital and sustainable PTES transition. The review of the literature results indicated that most of the relationships were indicated in the third and fifth clusters. The second part discusses the relationship between digitalisation and sustainability. However, the guidelines do not address the symptoms of PTES. Part 3 shows the investigative literature that PTES is at the pinnacle and does not include digital and sustainable aspects.

According to statistical analysis, PTES was most active near several indices in Portugal and Belgium, while PTES was most active in Greece, Croatia, and Hungary, lagging at four negative indicators.

In this article, we provide a standard scoring system that allows you to measure the success of the transition in PTES. The six components identified in the paper are integrated into the proposed framework, estimating the number of PTES digitized and reproduced using the Rogers concept of an innovative application of new practices process. The proposed system may include quantitative and qualitative measurements to meet the practical requirements of the evaluation.

This agenda focuses on specific areas where PTES and policymakers need to focus more on achieving the goals of green and digital transition. It can be used to evaluate and improve a country's or region's development, comparing its performance with other countries and industries.

Research is limited because the proposed framework has six components, but it can also include multiple components, such as government policies and regulations. The study explores the digital and sustainable practices and tendencies promoting or reducing the PTES transition, which could also be important. It is useful to figure out the impact of the suggested analysis system on promoted and applied practices. However, the recommendations in this paper that could be used to assess the impact of different practices and choices comprehensively are limited and can be developed further, considering several factors.

Further, it may be helpful to look at studies that look not only at 2023 but also at other future periods.

Conflict of Interest

Author declares that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation. Author reviewed the results and approved the final version of the manuscript.

Appendix A: Detailing the calculation of the concordance coefficient

The sum of the ranks of the indicators in relation to all experts:

$$c = \sum_{j=1}^r c_{ij} (i = 1, \dots, m) = 24 + 17 + 31 + 25 + 10 + 27 = 132 \quad (\text{A1})$$

here m is the number of benchmarked alternatives; r is the number of experts.

The concordance coefficient W , which is used to validate difference in experts opinions, is calculated by the following formula:

$$W = \frac{S}{S_{\max}} \text{ when } S = \sum_{i=1}^m (c_i - \bar{c})^2 \quad (\text{A2})$$

where S is the sum of the squares of the deviations from the mean, S_{\max} is the sum of the squares in the ideally matched case, \bar{c} the total mean is calculated by the formula:

$$\bar{c} = \frac{1}{2} r(m + 1) = \frac{1}{2} \cdot 7 \cdot (6 + 1) = 24,5 \text{ then } S = 336,25 \quad (\text{A3})$$

And the sum of the squares is ideally equal to:

$$S_{\max} = \frac{r^2 m(m^2 - 1)}{12} = \frac{49 \cdot 6 \cdot (36 - 1)}{12} = 857,5 \quad (\text{A4})$$

Then

$$W = \frac{S}{S_{\max}} = \frac{336,25}{857,5} = 0,39 \quad (\text{A5})$$

After calculating W , its significance (χ^2) is checked, which is calculated as follows:

$$\chi^2 = Wr(m - 1) = 0,39 \cdot 7 \cdot (6 - 1) = 13,72 \quad (\text{A6})$$

χ^2 is divided by χ^2 into a degree of freedom with $\nu=m-1$ according to the chosen level of significance α . In order for the expert's assessments to be reconciled, the calculated value of χ^2 must be greater than χ_{cr} , which is taken from the distribution plate with $\nu=6-1=5$ degree of freedom and at the level of significance $\alpha=0.05$, is equal to 11,07.

Appendix B: Structure For The Comparison Of Alternatives

Factors			Alternatives					Sum of values
Name	Direction	Weight	A1	A2	A3	...	An	
			Values for each factor					
C ₁	Max	q ₁	d ₁₁	d ₁₂	d ₁₃	...	d _{1n}	$S_1 = \sum_{j=1}^n d_{1j}$
C ₂	Max	q ₂	d ₂₁	d ₂₂	d ₂₃	...	d _{2n}	$S_2 = \sum_{j=1}^n d_{2j}$
C ₃	Max	q ₃	d ₃₁	d ₃₂	d ₃₃	...	d _{3n}	$S_3 = \sum_{j=1}^n d_{3j}$
C ₄	Min	q ₄	d ₄₁	d ₄₂	d ₄₃	...	d _{4n}	$S_4 = \sum_{j=1}^n d_{4j}$
C ₅	Min	q ₅	d ₅₁	d ₅₂	d ₅₃	...	d _{5n}	$S_5 = \sum_{j=1}^n d_{5j}$
C ₆	Max	q ₆	d ₆₁	d ₆₂	d ₆₃	...	d _{6n}	$S_6 = \sum_{j=1}^n d_{6j}$

Appendix 3: Standard Framework Used For The Decision-Making Analysis System

Alternatives	Factors						The sum of normalized maximizing factors	The sum of normalized minimizing factors	The relative importance of comparable variants
	Name	C ₁	C ₂	C ₃	C ₄	C ₅			
	Normalized values								
A ₁	D ₁₁	D ₂₁	D ₃₁	D ₄₁	D ₅₁	D ₆₁	S ₊₁	S ₋₁	Q ₁
A ₂	D ₁₂	D ₂₂	D ₃₂	D ₄₂	D ₅₂	D ₆₂	S ₊₂	S ₋₂	Q ₂
A ₃	D ₁₃	D ₂₃	D ₃₃	D ₄₃	D ₅₃	D ₆₃	S ₊₃	S ₋₃	Q ₃
...
A _n	D _{1n}	D _{2n}	D _{3n}	D _{4n}	D _{5n}	D _{6n}	S _{+n}	S _{-n}	Q _n
Sum	D _{1j}	D _{2j}	D _{3j}	D _{4j}	D _{5j}	D _{6j}	$\sum_{i=1}^6 \sum_{j=1}^n D_{ij} = S_+ + S_- = 1$		

Normalisation is used to eliminate problems arising from different measure units of factors. Before normalization, the author's weight appears in the solution table. The matrix is then normalized according to the formula C1. The sum of the normalized values is 1.

$$D_{ij} = \frac{d_{ij}q_i}{\sum_{j=1}^n d_{ij}}, i = \overline{1,6}; j = \overline{1,n}, \quad \text{when } \sum_{i=1}^6 \sum_{j=1}^n D_{ij} = 1 \tag{C1}$$

In any case, the choice and quantity will always be the same, in order to optimize the S₊ factors and reduce complexity according to the C2 equation.

$$S_{+j} = \sum_{i=1}^6 D_{+ij}, j = \overline{1,n} \quad S_{-j} = \sum_{i=1}^6 D_{-ij}, j = \overline{1,n}$$

$$S_+ = \sum_{j=1}^n S_{+j} = \sum_{i=1}^6 \sum_{j=1}^n D_{+ij} \tag{C2}$$

The relative importance of alternatives is evaluated by the formula C3.

$$Q_j = S_{+j} + \frac{s_{-min} \cdot \sum_{j=1}^n s_{-j}}{s_{-j} \cdot \sum_{j=1}^n \frac{s_{-min}}{s_{-j}}}, j = \overline{1, n} \quad (C3)$$

Finally, there is a sense of primary purpose. $Q_1 > Q_2 > Q_3$ This means that the bigger Q_j it is, the greater the benefit.

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