

Assessment of the Differentiation of Benefits of Using CC in Enterprises Using ELECTRE TRI Methods

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Abstract

The emergence and development of Cloud Computing (CC) provide enterprises with new opportunities in acquiring and using information and communication technologies. Implementing cloud computing can benefit enterprises in several aspects, i.e., strategic, economic, organizational, technological, social, and environmental. To assess the diversity of benefits resulting from using CC in an enterprise, the authors conducted empirical research among enterprises using services available in the CC in their operations. The results were assessed using the ELECTRE TRI, one of the methods from the ELECTRE family included in the Multi-Criteria Decision Analysis group. The final part of the article presents the results of the conducted analysis. The results indicated that the benefits from the organizational aspect were rated the highest. However, in general terms (all benefits), most enterprises belong to classes 1-2 and 2, which indicates that the examined enterprise evaluates the benefits resulting from using CC as low or average.

Keywords: Cloud Computing, ELECTRE TRI, advantages, class, MCDA.

1. Introduction

Nowadays, cloud computing is one of the most critical trends in the IT market, and it receives a lot of attention in scientific publications, industry reports, and press articles. The Cloud Computing model, offering customers access to various types of IT solutions (e.g., hardware, programming platforms, software) in the form of a service, is attracting more and more interest from different types of enterprises. This is due to the many potential benefits that can be provided by implementing and using IT solutions in the cloud. Nowadays, cloud computing, offering significant potential in terms of flexibility, scalability, and security of the provided IT solutions, is increasingly becoming a key element of the digital transformation of enterprises.

Thus, the article aims to differentiate the benefits resulting from the use of CC in the enterprise using the ELECTRE TRI method classified as MCDA. The choice of this method is dictated by the fact that ELECTRE TRI allows grouping by criteria (benefits) and preferences for these criteria. The determinant of the use of the ELECTRE TRI method is the assumption that the use of this method will enable a more precise determination of the characteristics of enterprises benefiting from the use of CC in the enterprise.

2. Literature review

The scale and pace of changes in the environment determine the need to use various IT

solutions that increase the efficiency and effectiveness of modern enterprises. Currently, IT solutions provided as cloud computing services can play an essential role in supporting enterprise operations. Generally, using cloud computing solutions transforms the methods of managing IT resources in enterprises. As a result, instead of investing in expensive hardware and software infrastructure and incurring expenses related to maintaining, updating, and securing these resources, enterprises are increasingly using cloud services offered by providers (external or internal).

The intention behind the creation of Cloud Computing is to provide mass IT services similar to other media, e.g., telephony, television, gas, electricity, or water. Cloud computing is perceived as a new technology that could potentially revolutionize IT implementation and delivery [2]. However, Cloud Computing is not an entirely new or revolutionary data processing model; it is more a combination and development of such IT solutions as virtualization, web services, service-oriented architecture, parallel computing, ubiquitous computing, autonomic computing, grid computing, and distributed computing. Cloud Computing can be synthetically defined as a technology model in which any resources (application software, processing power, data storage, backup facilities, and development tools) are delivered as a set of services via the Internet [5]. Another definition emphasizes that cloud computing is a parallel and distributed system involving groups of networked remote servers that allow the sharing of centralized data storage, data processing tasks, and online access to information technology (IT) services or resources [12]. According to NIST - Cloud computing enables convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. According to NIST, these are the main features of cloud computing - the possibility of independent operation of IT resources by the recipient, without the need to involve the service provider; high availability of the offered services, which recipients use via various computer devices with access to the network; high flexibility of services and dynamic allocation of IT resources offered by the supplier in the form of services (computing power, memory resources, applications, databases) depending on the changing needs of the recipient; sharing IT resources, which enables parallel use of services by many recipients and automated service measurability, facilitating control and accounting of IT resources used by the recipient [8].

Today, cloud computing is allied with and connected with other emerging technologies like big data and analytics, the Internet of Things (IoT), edge computing and systems, fog computing, and blockchains [11]. The wide range of types and diversity of services available in the Cloud Computing model means that cloud computing can be successfully used for various kinds of enterprises, varying in size and reported needs. Choosing a specific type or service of Cloud Computing requires a thorough analysis of the needs and capabilities of a given enterprise, as well as the benefits and risks associated with adopting a cloud computing solution.

The literature defines the benefits and effects of using cloud computing in various ways (tab. According to L.Y. Astri [3], cost reduction, flexibility, redundancy and reliability, scalability, collaboration, efficiency, virtuality, and availability are essential benefits of using cloud computing. According to P. Modisane and O. Jokonya [9], CC offers greater flexibility, accessibility, data security, and disaster recovery benefits. In turn, Islam et al., in addition to increased flexibility and analytical capabilities, mentioned such CC benefits as reducing overhead costs by avoiding capital investments in purchasing, installing, administering, and maintaining hardware/software infrastructure, simple scale-up increasing or decreasing storage space, computing power, and bandwidth, more accessible and better security for the entire system and simple technology integration [6]. As a result, Cloud computing enables businesses to multiply, scale, and adapt, accelerating innovation, increasing company agility, streamlining operations, and cutting costs. Afolabi [1] also claims that cloud computing allows companies to focus on their core operations by saving resources to become more efficient and enhance their competitiveness by improving their operational productivity and effectiveness. According to T. Chen et al. [4], after adopting cloud computing, businesses can improve the utilization of computing resources, reduce

capital expenditures, reduce maintenance and operational costs, and improve efficiency through dynamic deployment and recovery capabilities of computing resources.

Table 1 presents the advantages and effects of cloud computing in enterprises based on literature studies.

Table 1. Potential effects of using cloud computing in enterprises

Strategic	Economic
<ul style="list-style-type: none"> – The company's focus on critical competencies and business development; – Greater flexibility of business operations and support for the company's global and mobile operations; – It is possible to accelerate the development of the enterprise and launch innovations more quickly (e.g., new/modified business models, services, processes, products). 	<ul style="list-style-type: none"> – Greater economic efficiency (reduced level of investment outlays and conversion of CAPEX investment costs into OPEX maintenance costs spread over time); – Reduction of costs related to the maintenance and development of IT infrastructure; – Higher predictability and stability of IT costs; – Reduction of investment risk in the IT area.
Technological	Organizational
<ul style="list-style-type: none"> – Possibility to access and use technologically advanced IT resources (hardware, software, services); – High flexibility and scalability; – Higher level of security; – Independence from the hardware and software used by users; – Higher efficiency; – High availability; – High quality of technical support provided by the supplier. 	<ul style="list-style-type: none"> – Ease of use of IT resources (access to resources anytime, anywhere) – Better cooperation with clients and partners; – Improving collaboration between employees; – Transferring responsibility for the operation and development of IT resources to the supplier; – Reducing the need for IT specialists; – Easier management of IT infrastructure; – Better ensuring business continuity; – Possibility to standardize and simplify organizational procedures.
Social	Ecological
<ul style="list-style-type: none"> – Development of knowledge and activation of employees in the scope of more profound and broader use of IT technologies (improving the level of education); – Possibility to deepen relationships and improve people's cooperation; – Possibility to get to know the immediate social environment better; – Generating changes in the labor market (mobile work and limiting business trips, increasing/decreasing employment, new professions). 	<ul style="list-style-type: none"> – Lower electricity consumption; – Saving natural resources (reduction of IT resources); – Reducing emissions of harmful substances (carbon dioxide); – Reduction of radiation, noise, and noise related to the use of IT equipment; – Decrease in waste levels.

Different types of Cloud Computing solutions can bring significant benefits of varying nature and value to enterprises. A.E. Oke et al. [10] and P. Modiasane and O. Jokonya [9], among others, analyze the benefits resulting from the use of CC using various methods. One proposal for analyzing the benefits of using cloud computing in enterprises may be using the ELECTRE TRI method, which is presented in this article.

3. The Methodology

3.1. ELECTRE TRI

The ELECTRE method was developed by B. Roy, who proposed extending the set of basic preference situations to include equivalence, weak preference, strong preference, and incomparability [13]. The ELECTRE method (ELimination Et Choix Traduisant la REalia) is one of the methods included in MCDA (Multi-Criteria Decision Analysis); it is a multi-criteria algorithm used in the decision support process, enabling the selection of the best alternative from among many possible options.

This group includes several methods known as ELECTRE I, ELECTRE Iv, ELECTRE Is, ELECTRE III, ELECTRE I+SD, ELECTRE III+SD, and ELECTRE TRI, which were used to conduct the analyses for this article.

The ELECTRE method generally defines a set of decision criteria and their weights. It creates a decision matrix in which each row corresponds to an alternative, and each column

corresponds to one of the criteria. Then, for each pair of alternatives, measures of membership in the order relationship are determined, taking into account the values of the criteria and their weights. These affiliation measures create a relationship matrix whose elements indicate whether one alternative dominates the other. Finally, the algorithm calculates the sum of the criteria weights for each pair of alternatives, ranks the alternatives, and presents the optimal alternative along with its criteria values [14]. In the next step, pairs of alternatives are compared using the dominance and independence thresholds for each criterion. An alternative is dominant if it is better than or equal to the other alternative on all criteria and the appropriate dominance and independence thresholds are met for each criterion. An alternative is independent if no relationship of dominance or dependence exists with another alternative. Then, for each pair of alternatives, the sum of the weights of the criteria in which one of the alternatives is better than the other is calculated (Figure 1). Based on these results, a ranking of alternatives is determined, and the one with the highest ranking is selected [7].

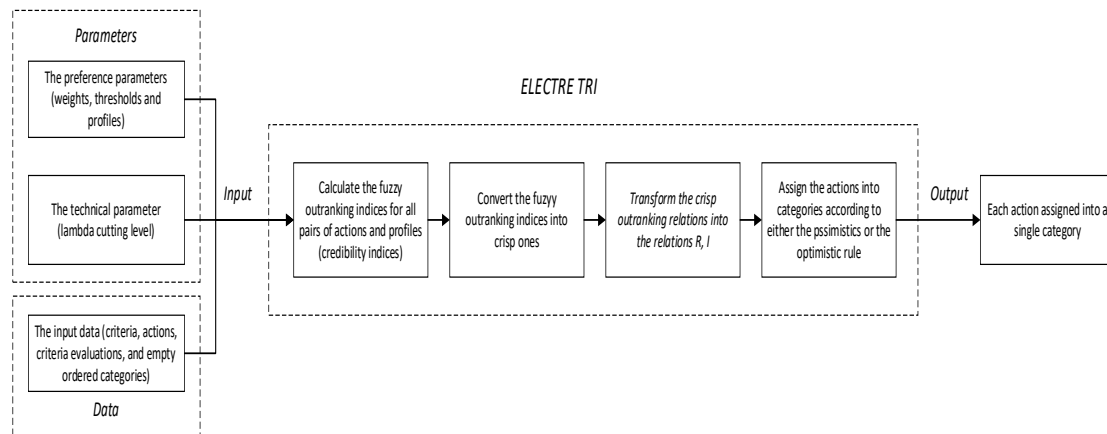


Fig. 1. The ELECTRE TRI procedure

However, ELECTRE TRI allows you to classify decision variants into predefined, ordered categories described by profiles. The variant is assigned to a given category using a pessimistic or optimistic procedure [14].

3.2. The subject of the research

The subjects of the research were small and medium-sized enterprises operating in Poland and using solutions offered by CC in their activities. In total, 409 enterprises (56% small and 44% medium-sized) participated in the study. Because there are approximately 55 thousand small and medium-sized enterprises in Poland, a formula was used to determine the minimum sample size and the minimum value of the research sample that meets the representativeness condition. The conducted calculations show that the minimum sample size, with the adopted confidence level of $1-2 = 0.90$ and the maximum estimation error $e = 5\%$, should be 384 questionnaires. However, considering that the research covered 409 economic entities, it can be assumed that the representativeness condition was met. The study used the simple random sampling methods as the simplest method of selecting a research sample. It involves the direct and unlimited selection of research units into the statistical sample directly from the general population and without restrictions. The companies covered by the study operate in various industries (Table 2).

The largest share of the surveyed enterprises were those operating in the Transport and warehouse industry (43%), followed by trading enterprises (23%) and enterprises from the administration sector (7%). All the surveyed enterprises are young, starting their operations after 2000. The oldest has been operating for over 23 years, and the youngest has been operating for over 13 years.

The primary quantitative statistics regarding the use of CC by the surveyed enterprises are as follows (Table 3).

Table 2. Enterprises' characteristics

Company's profile	Number of enterprises	Percent
Transport&Warehouse	175	43%
Trade	95	23%
Administration	30	7%
Services	26	6%
Information&Communication	24	6%
Culture&Entertainment	18	4%
Construction	10	2%
Professional, scientific, and technical activities	9	2%
Education	9	2%
Industry	9	2%
Accommodation&Gastronomy	6	1%
TOTAL:	409	100%

Over 80% of surveyed enterprises have used CC for over five years, while only 1% have used the cloud for over 16 years. The most popular type of cloud is a private cloud (57%), characterized by the fact that it is a cloud created and available only to a single enterprise, organization, or individual entity. As for the model, the most frequently used is the IaaS model (65%), in which the provider offers access to hardware infrastructure elements by generating images of virtual machines that have the computing power defined and required by the recipient, along with the operating system and the required disk space. Over 90% of enterprises use CC to share files, followed by applications supporting communication (71%), archiving and storing data, documents, and databases (65%), e-mail, websites, and applications supporting management total processes implemented in the enterprise (64%).

Table 3. The main characteristics of CC in the enterprises

Period of use		
	Number of enterprises	%
Up to 5 years	327	80%
6-10 years	69	17%
11-15 years	9	2%
16 – 20 years	4	1%
CC solutions		
File sharing	378	92%
Applications supporting communication	292	71%
Archiving and storing data, documents, and databases (backup)	264	65%
E-mail	263	64%
Websites, company portal on hosting basis, content management systems	263	64%
Applications supporting the management of all processes carried out in the enterprise	263	64%
Office applications (e.g., Office365) and document flow support	237	58%
Applications supporting project management	209	51%
Antivirus tools and security systems	179	44%
Applications supporting the management of a selected area of activity	177	43%
Applications supporting business analytics	29	7%

3.3. Characteristics of the benefits resulting from the use of cloud computing

As mentioned earlier, the article aims to find the answer to which companies benefited the most from using CC due to their size and business profile. These benefits (criteria) have been grouped according to the following aspects: safety, organizational, usability, economic, ecological, and social (Table 4).

Thirty-nine advantages (criteria) were identified and grouped into six groups.

Table 4. The main advantages of CC

Aspects	Advantages
Safety	Higher level of security
	Better accountability and control of IT resources
	High flexibility and scalability of IT solutions (dynamic adaptation of IT resources to the changing needs of the enterprise)
	High quality of technical support provided by the supplier
	High availability (stability of IT solutions used)
Organizational	Ease of use of IT resources (access to resources anytime, anywhere)
	Better cooperation with customers and partners
	Improving cooperation between employees
	Transferring responsibility for the operation and development of IT resources to the supplier
	Reducing the need for employees from the IT department
	Improving employee efficiency (including IT services)
	Easier management of IT infrastructure (reduction of IT environment complexity)
	Better ensure business continuity.
	Possibility to standardize and simplify organizational procedures
	Possibility to launch innovations faster (e.g., new/modified services, processes, products)
	Accelerating the development of the enterprise (faster introduction of changes, mass digitization, dynamic introduction of new forms of activity)
	Accelerating the implementation of economic and decision-making processes
	Focus on your core business activities.
Usability	Higher performance (increase in computing capabilities)
	Ability to quickly launch IT environments
	Improving the quality of data processing through the ability to use technologically advanced IT resources (hardware, software, services)
	Independence from the hardware and software used by users
Economical	Greater economic efficiency (reduced capital expenditure)
	Reducing the costs of maintaining and developing IT solutions (e.g., payment only for resources used, favorable ratio of computing power to costs)
	Higher predictability and stability of IT costs
	Reduction of investment risk in the IT area
Ecological	Protecting the environment by reducing electricity consumption
	Environmental protection by reducing emissions of harmful substances (e.g., reducing carbon dioxide emissions released during energy production in conventional power plants and by limiting business trips as a result of employees' mobile work)
	Savings of natural resources (e.g., as a result of reducing purchases for IT infrastructure)
	Reduction of radiation, noise, and noise related to the use of IT equipment
	Reducing waste levels
Social	Development of knowledge and activation of employees in the field of more profound and broader use of IT technologies (improving the level of education)
	Possibility to deepen relationships and improve people's cooperation
	Possibility to get to know the social environment better
	Generating changes in the labor market (mobile work and limiting business trips, increasing/decreasing employment, new professions)
	Possibility to perform work and activate many professional groups (including disabled people, older adults, women, and other people in difficult situations)
	Increased employee satisfaction with the flexibility of work

4. The research results

This section presents the results of the analyses that were conducted. In our case, the input data of the ELECTRE TRI method are vectors of criteria values for the examined enterprises (objects), criteria weights, class profiles, and thresholds: indistinguishability, preferences, and veto. In the first step, each group of benefits (criteria) was assigned weights equal to 1, and three main classes were created (1, 2, and 3) and additionally, two virtual classes (1/2 and 2/3) for objects that received ambiguous assignments to neighboring basic classes:

- Class 1 – meaning very low level
- Class 1/2 – meaning low level
- Class 2 – meaning medium/average level
- Class 2/3 - meaning high level

- Class 3 meaning very high level

In the next step, their boundaries, i.e., separating profiles, were determined after determining the number of primary classes. Then, the following threshold values were established for each profile and criterion: indistinguishability (Q), preference (P), and veto (V) (Table 5). The cut-off threshold λ should be in the range (of 0.5-1) per generally recommended practice; 0.75 was adopted for research purposes [14]. The type for all criteria indicating the benefits resulting from the use of CC was set to "profit", meaning ("the more, the better" - the decision-maker prefers objects from higher classes over objects from lower classes).

Table 5. Results of the tests

	Weight	P1*	Q (indistinguishability)	P (preference)	V (veto)
Economical	1	9,33	0,28	1,4	2,8
Safety	1	11,67	0,35	1,75	3,5
Usability	1	9,33	0,28	1,4	2,8
Organizational	1	33,67	1,01	5,05	10,1
Social	1	14,00	0,42	2,1	4,2
Ecological	1	11,67	0,35	1,75	3,5
	Weight	P2*	Q (indistinguishability)	P (preference)	V (veto)
Economical	1	14,67	0,44	2,2	4,4
Safety	1	18,33	0,55	2,75	5,5
Usability	1	14,67	0,44	2,2	4,4
Organizational	1	54,33	1,63	8,15	16,3
Social	1	22,00	0,66	3,3	6,6
Ecological	1	18,33	0,55	2,75	5,5

*P1 – optimistic procedure, *P2 – pessimistic procedure

ELECTRE Tri calculations were performed. Forty-one extremely ambiguous assignments of objects to classes were also identified. The optimistic procedure assigned them to class 3, and the pessimistic procedure to class 1. These are variants incomparable with the designated profiles. When the resulting assignments differ, the decision maker makes the final assignment. Because the share of these ambiguities in the entire study did not exceed 10%, which can be considered an excellent result in the case of data obtained in the form of a survey expressing various subjective opinions and feelings of users), these objects were excluded from further analysis.

Charts 1, 2, and 3 summarize the allocation of objects to individual classes in the optimistic procedure (Figure 2), the pessimistic procedure (Figure 3), and the general procedure (Figure 4).

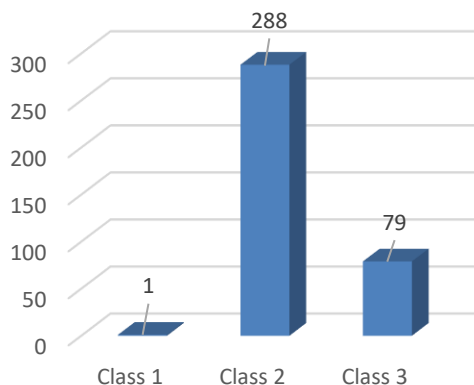


Fig. 2. Class affiliation in optimistic procedure



Fig. 3. Class affiliation in pessimistic procedure

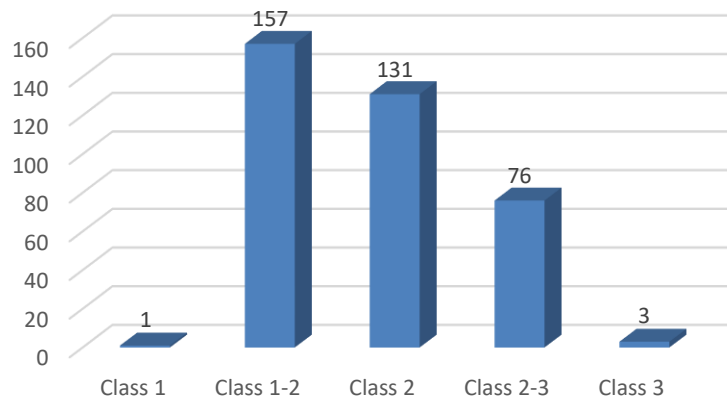


Fig. 4. Class affiliation - general

In the optimistic procedure, enterprises were classified as one, two, and three. Most (78%) were classified as class 2, meaning these enterprises assess the benefits of using CC on average. 21% of enterprises that rate the benefits of using CC very highly are classified as class three. In this procedure, only one company rated the benefits of CC very low. This one is a small company operating in the transport & warehouse industry.

In the pessimistic procedure, more than half of the enterprises (56%) rated the benefits of using CC as average. Almost half of the enterprises (43%) rated the benefits of using CC as very low, and only three of them (0.8%) rated it as very high. These three enterprises include two medium-sized enterprises operating in the administration industry and one small enterprise operating in the transport & warehouse industry.

Comparing the results obtained as a result of applying two different procedures, the structure of individual classes is somewhat similar because, in both cases, the most significant number were those enterprises that assessed the benefits resulting from the use of CC on average. However, there is quite a substantial difference concerning membership in classes 1 and 3 - in the optimistic procedure, membership in class 1 was declared by one enterprise, and in the pessimistic procedure - by 158. The opposite situation occurs in the case of class 3 - in the optimistic procedure, membership in this class was declared by 79 enterprises, and in the pessimistic procedure - three. Analyzing the affiliation to classes in general, i.e., aggregating the different results of the optimistic and pessimistic allocation to two virtual classes, it is visible that the majority of enterprises (42%) rated the benefits of using CC low (including one very low), 36% - medium, and only 20% high (including three very high).

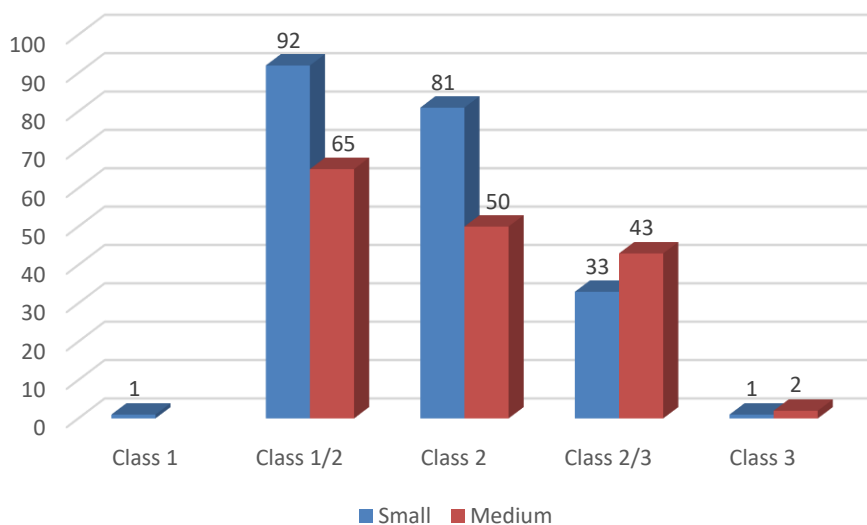


Fig. 5. Class affiliation depending on the size of the enterprise

Figure 5 presents the affiliation to individual classes depending on the size of

enterprises. It clearly shows some convergence among the analyzed enterprises regarding their size. In the small enterprises group, most % of them, 44% rated the benefits of using CC as low, 39% as medium, and only 16% as high. Similar proportions occurred in the case of medium-sized enterprises. Most of them, 40%, rated the benefits of CC as low, 31% rated it as medium, and 26% rated the benefits of CC as high. Two small enterprises were placed in extreme classes (class 1 and class 3), and only two medium-sized enterprises rated the benefits of using CC very highly.

However, concerning the business profile, the affiliation to individual classes is as follows (Figure 6). Only three groups of enterprises operating in the following industries were selected for analysis: Transport & Warehouse, Trade, and Administration, because they constitute over 70% of the surveyed population of enterprises.

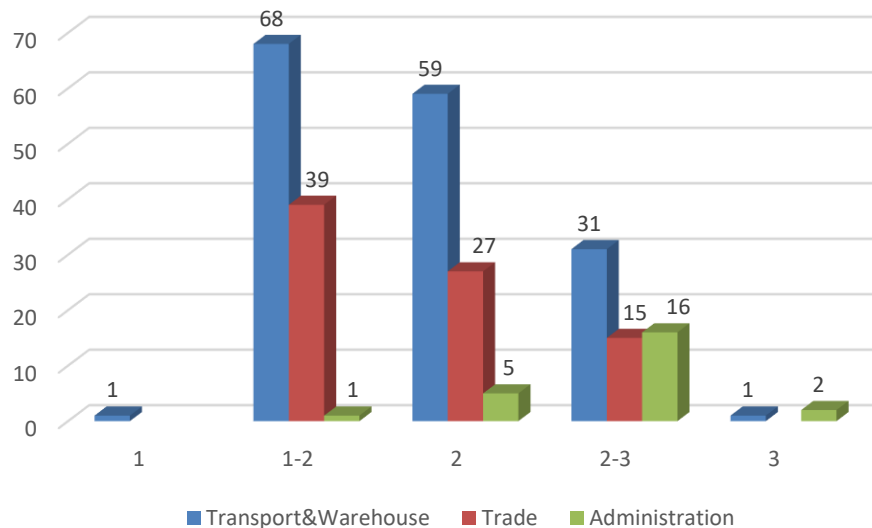


Fig. 6. Class affiliation depending on the business profile

Also, in this case, there is an inevitable convergence of results among enterprises operating in the Transport & Warehouse and Trade industry - both groups rated the benefits of using CC as low, and in second place were enterprises that rated the benefits of using CC as a medium. The situation is slightly different in the case of enterprises operating in the Administration industry - only one of them rated the benefits of using CC as low, five - average rated the benefits of using CC, and the remaining number (72%) rated the benefits of using CC as high. Three companies operating in the Trade & Warehouse and Administration industry were placed in the extreme classes (class 1 and class 3).

5. Conclusions

The growing popularity of cloud computing among various industries and the size of enterprises results from the positive effects of its use in business practice. In general, cloud computing solutions, thanks to the possibility of better cost control, high-quality services, and flexible access to almost unlimited computing power, can influence the competitiveness of enterprises and help them respond dynamically to changes in the environment.

The article aimed to assess the diversity of benefits resulting from using CC in the enterprise using the ELECTRE TRI method. Thirty-nine benefits were analyzed and grouped into six groups (Safety, Organizational, Usability, Economic, Ecological, and Social). The use of the ELECTRE TRI method made it possible to determine which group of benefits is rated the highest by the surveyed enterprises and how, in general terms, all benefits resulting from the use of CC are assessed depending on the size and business profile of the enterprise. The obtained results indicated that the highest rated benefits were in the organizational aspect, i.e. ease of use of IT resources (access to resources at any place and time); better cooperation with customers and partners; improving collaboration between employees; transfer of responsibility for the operation and development of IT resources to the supplier; reducing the need for employees from the IT department; improving employee efficiency (including IT services); easier IT infrastructure management (reduction of IT environment complexity); better ensuring

business continuity; the possibility of standardizing and simplifying organizational procedures; ability to launch innovations faster (e.g. new/modified services, processes, products); acceleration of enterprise development (faster introduction of changes, mass digitization, dynamic introduction of new forms of activity); accelerating the implementation of economic and decision-making processes and focusing on your core business activities. However, when assessing all the benefits depending on the size and business profile of the enterprise, it was shown that most often, enterprises assessed these benefits at a low or medium level, which may indicate that enterprises expect more from the solutions offered under CC, or are not able to use the potential of CC fully.

Of course, the research has some limitations; the assessments and analyses concerned only Polish enterprises, so extending them to a group of foreign enterprises would be worth extending. Moreover, it is worth considering conducting research among employees of enterprises that use CC solutions as part of their daily professional duties. This would provide a broader perspective on the benefits of CC. Moreover, considering that in the course of the analysis, it was assumed that all groups of benefits were assigned equal weights, subsequent research may focus on assessing these benefits but with different weights.

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