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Key Challenges of Cloud Computing Resource Allocation in Small and Medium Enterprises

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Abstract: Although cloud computing offers many benefits, such as flexibility, scalability, and profitability, some small and medium enterprises (SMEs) are still unable to fully utilize cloud resources, such as memory, computing power, storage, and network bandwidth. This reduces their productivity and increases their expenses. Therefore, the central objective of this paper was to examine the key challenges related to the allocation of cloud computing resources in small and medium enterprises. The method used for this study is based upon qualitative research using 12 interviews with 12 owners, managers, and experts in cloud computing in four countries: the United States of America, the United Kingdom, India, and Pakistan. Our results, based on our empirical data, show 11 key barriers to resource allocation in cloud computing that are classified based on the technology, organization, and environment (TOE) framework. Theoretically, this research contributes to the body of knowledge concerning cloud computing technology and offers valuable understanding of the cloud computing resource allocation approaches employed by small and medium enterprises (SMEs). In practice, this research is useful to aid SMEs in implementing successful and sustainable strategies for allocating cloud computing resources.

Keywords: cloud computing; resource allocation; sustainability; small and medium enterprises

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1. Introduction

The world of computing has entered a new phase with the development of cloud computing and services, which offer several advantages such as flexibility, scalability, and profitability. The process of Resource Allocation in Cloud Computing (RACC) [1] involves the distribution of resources among different users and applications in the cloud. These resources include memory, computing power, storage, and network bandwidth. However, allocating cloud resources to meet the demands of many organizations, such as small and medium enterprises (SMEs), is a major concern and these organizations encounter a multitude of obstacles in managing these resources [2]. Therefore, it is necessary to overcome these challenges to enhance cloud computing sustainability by reducing the operational costs and accompanying carbon footprint of such massive equipment, which compromise the sustainability of cloud services.

SMEs that fail to use efficient resource allocation practices and procedures may encounter diminished productivity and heightened expenses [3]. Therefore, the success and sustainability of SMEs rely heavily on the efficient deployment of resources. However, several obstacles such as financial limitations, the restricted availability of skilled staff, and the integration of novel technology have negative effects on the RACC process [4]. Therefore, policymakers, SME owners, managers, and technology experts need to investigate potential solutions [5], practices, and procedures that aid their organizations in enhancing resource usage and attaining their desired outcomes. In this regard, this paper aims to fill the gap: it aims to conduct an empirical investigation into RACC to shed light on the obstacles encountered by SMEs in their pursuit of effective RACC.

However, several challenges that SMEs experience throughout the resource allocation process are highlighted in the literature. Ref. [6] introduced the financial aspect of RACC and proposed an economic resource allocation method to increase its efficacy by forecasting resource allocation requests using a heuristic method. However, this type of research focused only on a specific issue and did not cover other challenges.

Ref. [7] proposed the resource allocation and relocation method based on power conversion efficiency. The goal was to reduce the energy consumption of RACC while maintaining acceptable performance levels. Therefore, organizations may improve their sustainability efforts, lower their carbon footprint, and achieve greater energy utilization in cloud settings by implementing such approaches. However, this study did not focus on other challenges, especially the operating expenses.

Ref. [8] suggested a method to locate the best resources for each piece of work that is being performed in real-time by expanding the flexible algorithm. Despite this method being effective in maximizing resource use, it ignored the energy component. Similarly, ref. [9] developed an approach based on a general method for upgrading virtual machine resources. However, this method's short execution time and energy usage were its strongest points, and the cost was still substantial.

Ref. [10] has suggested a scheduling-based heuristic resource allocation strategy. Although the suggested method reduced costs and met the quality of service (QoS) requirements, it left out considerations for resource utilization and execution time. However, these studies focused on finding solutions to specific issues in RACC and ignored other aspects. On the other hand, other research works have attempted to study the challenges of RACC; for example, cost, security, technical skill, top management support, and complexity are a few of the significant aspects that ref. [11] identified as affecting resource allocation in cloud computing. Similarly, ref. [12] emphasized the importance of senior management support, comparative advantage, company scale, competitive pressure, and pressure from trade partners when it comes to cloud computing. Moreover, ref. [13] highlighted how important training programs are for helping workers learn more about using cloud computing resources. Additionally, ref. [14] identified determinants of RACC in SMEs, including compatibility, relative advantage, firm size, uncertainty, trial-ability, and top management support. In addition, ref. [3] highlighted factors such as usability, convenience, security, privacy, and cost reduction as crucial considerations for the use of cloud resources by SMEs. Ref. [15] found that the organization's limited knowledge of cloud computing technology acted as a challenge. In the context of secure cloud computing, ref. [16] discussed societal issues such as trust, privacy, and user behavior, as well as technological factors such as scalability, reliability, encryption, data rights, and transparency. Additionally. Moreover, ref. [17] discussed the financial advantages of cloud resource optimization, such as decreased up-front capital expenses and increased resource use efficiency. However, these studies ignored some important obstacles for RACC in SMEs. In addition, there is a lack of clear classification of different types of challenges.

Understanding these challenges enables SMEs to develop tailored strategies to enhance their competitiveness, cost-efficiency, and overall operational effectiveness in today's dynamic digital landscape. In addition, this study reveals efficient resource allocation practices. Furthermore, it ascertains the variables that exert influence on these practices. As a result, this will help academics, practitioners, experts, and managers enhance their knowledge of RACC. The significance of this study lies in its potential to support SMEs in achieving success, therefore contributing to the development of a robust and sustainable global economy. Moreover, this study applies the technological, organizational, and environmental TOE framework [18] to categorize the challenges. TOE describes components that influence the RACC. The TOE framework has been widely used to explore the encounters and obstacles of technology adoption. Tornatzky and Fleischer [19] state that the TOE shows challenges and opportunities for technological innovation. In their book, the technical perspective embodies the technological obstacles faced by an organization using technology, such as security, and scalability. The organizational view enters organizational

weaknesses such as a lack of sufficient skills. Environmental perspectives examine the challenges of the environment in which the organization carries out essential services, such as laws and regulations.

To address these research objectives, a qualitative research method is used in this study to answer the following research question:

> "What are the challenges that affect cloud computing resource allocation in Small and Medium Enterprises (SMEs)?"

Semi-structured interviews were used to collect data from 12 owners, managers, and experts in the SMEs in four countries: the United States of America, the United Kingdom, India, and Pakistan. In addition, the data collected were analyzed using a thematic analysis approach.

2. Materials and Methods

This section outlines the research methodology used to address the research objectives and questions. It is divided into five sub-sections that cover the research approach, sample selection, data collection methods, data analysis process, and ethical considerations. The next subsection discusses the overall approach used to guide the study.

2.1. Research Approach

This study utilized a qualitative research methodology which involved the conducting of semi-structured interviews. The utilization of semi-structured interviews in this study allows for a high degree of research flexibility and adaptability [20]. In addition, the use of this particular methodology enables the researcher to delve further into the perspectives and attitudes of the participants, thereby facilitating a more comprehensive understanding of their viewpoints [20]. Moreover, the employment of the qualitative technique enables the identification of patterns and themes within the acquired data, facilitating the derivation of pertinent inferences regarding the obstacles associated with resource allocation in SMEs.

2.2. Participants

The research on RACC obstacles has deliberated on the acquisition of data through the use of purposive sampling [21]. Focusing on individuals with extensive experience in managing cloud computing resources significantly increases the likelihood of obtaining valuable information; thus, we can guarantee the gathering of high-quality data [21]. In addition, purposive sampling, at its core, assists in selecting respondents aligned with the study's objectives, leading to a clear and thorough understanding of the subject [22].

Furthermore, in this study, participants were specifically selected using purposive sampling based on their appropriate experiences, quality, and roles to enhance the study findings and participate in a meaningful understanding of RACC. Therefore, in this study, 12 participants with experience in managing cloud computing resources in SMEs were included, representing a varied range of populations, industries, and positions. The participants were from the USA, the UK, India, and Pakistan, and held roles such as system manager, web server administrator, DevOps engineer, head of cloud computing, and team manager.

Table 1 gives an overview of the demographic information and characteristics of the interview participants.

Table 1. Key summary details for each of the 12 interviewees.

Code	Country	Role	Experience (Years)	Duration (Minutes)	Word Count
P1	Pakistan	Systems Manager	12	50	7300
P2	Pakistan	Development Manager	10	60	8000
P3	Pakistan	Team Manager	13	40	5900
P4	USA	DevOps Engineer	11	50	6200

Table 1. *Cont.*

Code	Country	Role	Experience (Years)	Duration (Minutes)	Word Count
P5	Pakistan	Head of Cloud Computing	13	50	7000
P6	USA	Sr Solution Architect	8	60	10,000
P7	USA	Manager DevOps Engineer	7	70	9000
P8	UK	Web Server Administrator	14	70	5800
P9	UK	System Administrator	12	50	7500
P10	India	DevOps Leads	8	90	10,500
P11	USA	Manager DevOps Engineer	9	80	11,000
P12	India	Team Manager	6	60	7055

2.3. Data Collection

The semi-structured interview guide was carefully crafted to study barriers of RACC flexibly and comprehensively. Ref. [23] has pointed out a systematic, five-step method for creating such a guide, including detecting the prerequisites for employing semi-structured interviews, retrieving and utilizing prior knowledge, articulating a preliminary guide, running pilot testing, and presenting the finished guide.

This methodology facilitated an exhaustive investigation of the subject while upholding the emphasis on the distinct experiences of everybody involved. There were twenty primary open-ended questions and eight supplementary open-ended sub-questions spread throughout six sub-domains in the guide. When a participant's answer to the main question did not fully address particular subjects of interest, sub-questions were used. The interview process prioritized the significance of the participants' narratives over rigorous adherence to the question order, even though all respondents were asked identical questions. This adaptable strategy improved the data-gathering process and made it easier to successfully record individual experiences [24]. Furthermore, the interview guide was distributed to the participants along with the invitation to the interview, enabling them to become acquainted with the subjects and organize their ideas beforehand. This method made the interview process more efficient and engaging [25].

This study's semi-structured interview data-gathering process, which was conducted between 1 January 2024, and 15 March 2024, provided a strong basis for reliable analysis and results. The interviews were skillfully performed via online meetings in English, which made communication with participants easy. With the help of this strategy, the researcher was able to get in touch with individuals all around the globe and collect a wide range of information and experiences that greatly enhanced the dataset for the study. The study gains a thorough grasp of the subject matter by depending on the perspectives of a participant pool that is geographically dispersed, which eventually strengthens its credibility and persuasive power. Avrio, an innovative AI-powered transcription tool, was used to record and transcribe all interviews to ensure the highest level of accuracy in data acquisition. This cutting-edge technology produced verbatim transcriptions of the interviews, accurately expressing the participants' words and presenting the material in a readable manner. Any unnecessary oral fillers, inaudible parts, or intersecting speech were found and suitably documented using a standard transcription technique [26]. A cautious approach was used when addressing private and delicate material, using either replacement words or the complete omission of the information. This strategy ensured that the essence of the interviewee's thoughts was retained while respecting their privacy and adhering to ethical guidelines for research.

For the significant task of thematic analysis, NVivo was used [27]. An unmatched program for managing, analyzing, and displaying written data is offered by NVivo, a popular and reliable qualitative data analysis tool. Because of its sophisticated capabilities, it was able to quickly and effectively find patterns, themes, and insights in the transcripts of the interviews, which resulted in a thorough and nuanced grasp of the subject [27].

This meticulous method of gathering and analyzing data not only makes the study more credible but also makes it more persuasive.

The full list of questions and sub-questions for the semi-structured interview can be found in Appendix A of this study.

2.4. Data Analysis

A thematic analysis was carried out as part of the methodology's data analysis phase to find patterns and themes that emerged from the transcripts of the interviews. A codebook that was created through a typical iterative procedure served as guidance for this analysis process [26]. The following three steps were engaged in this process:

1. Familiarization with the data: In this step, the data were studied for greater familiarity, and the interview transcripts were reread. Also, pertinent research on RACC was analyzed. This step assisted in the gaining of a comprehensive comprehension of the data and in identifying initial impressions and ideas [28].
2. Generating initial codes: In this step, data were systematically coded by identifying and labeling meaningful information units related to RACC challenges. This required highlighting sentences, phrases, or paragraphs that encapsulated essential concepts or ideas. The codes were created based on the study's research question and objectives [14].
3. Searching for themes: After generating initial codes, they were classified into various themes. Patterns, connections, and relationships between identifiers were sought to identify the data's overarching themes. This procedure entailed sifting and reorganizing codes into meaningful clusters [29].
4. Reviewing and refining themes: To ensure that the identified themes accurately represented the data and conveyed the essence of the participants' experiences and perspectives, they were reviewed and refined. Each theme and its corresponding codes were critically examined by making any necessary adjustments [29].
5. Creating a thematic relation: To visualize the relationships between themes, a thematic relation was created. This relation illustrated how the different themes were interconnected and related to one another, highlighting the main findings of the analysis [29].
6. Reporting: The results of the thematic analysis were conveyed clearly and concisely. The themes and their supporting evidence were organized into a coherent narrative, with statements or passages from interviews used to illustrate key points. The findings were then discussed concerning the existing literature and used to answer the research questions and achieve the study's objectives [14]

3. Results

RACC in small and medium-sized businesses is primarily challenged by 15 themes, as determined by data analysis. Based on the framework for TOE, these themes were then categorized; see Table 2. For ethical reasons and to protect the anonymity of the participants, the participants are numbered from 1 to 12 (P1–P12). The following subsections provide comprehensive details on each theme. Table 2 refers to obstacles for RACC in SMEs (n = 12).

Table 2. Identified barriers to RACC in SMEs (n = 15).

TOE Context	Technological Barriers	Organizational Barriers	Environmental Barriers
Themes	1. Lack of knowledge 2. Lack of expertise 3. Network performance 4. Optimization 5. Security and privacy	1. Cost efficiency 2. Inadequate training and development programs for employees 3. Monitoring resource usage and performance	1. Economic factors 2. Market competition 3. Scalability and performance

3.1. Technological Barriers

The first context in the TOE framework is technological barriers. This theme consisted of three sub-themes: (1) lack of knowledge; (2) network performance; and (3) optimization.

3.1.1. Lack of Knowledge

One of the important challenges extracted from the participants' explanations of the technological barriers to efficient RACC in SMEs was the lack of knowledge of cloud computing technology.

The participants (30%) emphasized that a lack of understanding and familiarity with cloud computing technology hampered their SMEs' willingness to accept cloud solutions. Furthermore, one of the gaps mentioned by the participants was not fully understanding the benefits, hazards, and applications of cloud computing concerning resource allocation objectives. For instance, a participant (P2) stated that knowledge of programming languages along with APIs is very important for RACC:

> "*I guess, having knowledge of programming languages and APIs for cloud applications is crucial when it comes to automating resource allocation. Being proficient in programming languages allows us to develop scripts and applications that can automate the process of allocating resources in the cloud. In my opinion, understanding various APIs helps us interact with cloud services and efficiently manage resource allocation. It's an important skillset for streamlining the allocation process and maximizing the benefits of cloud computing.*"

Additionally, the participants referred to other aspects of the lack-of-knowledge issue. For instance, a participant (P6) emphasized the basic domain knowledge and state-of-the-art of RACC:

> "*Well, domain knowledge is essential when it comes to working with cloud computing. Having a solid understanding of the concepts, principles, and practices in the field allows us to make informed decisions and effectively utilize cloud resources. In my experience, being familiar with various cloud computing software and services is crucial.*"

Moreover, a participant (P10) considered that knowledge of DevOps and the networking domain is important for RACC operations:

> "*In my opinion, knowing DevOps and the networking domain is a plus point. Along with that, being familiar with regularly used software development-related tools is also beneficial. I also think that these skills and knowledge areas can greatly enhance an individual's ability to effectively allocate resources in cloud computing.*"

3.1.2. Lack of Expertise

Another key challenge stated by most of the participants (50%) was a lack of expertise. The participants highlighted the technical expertise required, such as a knowledge of cloud computing architecture, virtualization, storage, security databases, etc. For instance, a participant (P3) said:

> "*I think, to effectively allocate resources using cloud computing, technical expertise is required in cloud computing architecture, cloud service providers, virtualization, networking, storage and databases, monitoring and management, security and compliance, and programming and automation. In my point of view, proficiency in these areas is necessary to ensure efficient and effective resource allocation in a cloud environment.*"

Further, a participant (P4) highlighted five key different areas of technical expertise that are required for effective RACC:

> "*Certainly! There are five essential technical expertise areas in cloud computing. First, we have on-demand self-service, which means users can access and provision computing resources as needed without the need for human intervention. Second, there's broad network access, allowing users to access cloud services and applications over the internet*

from various devices. Third, we have resource pooling, where multiple users share and allocate resources dynamically to meet their individual needs. Fourth, rapid elasticity enables the quick and seamless scaling of resources up or down based on demand. And finally, measured service allows for monitoring and billing based on actual resource usage. These capabilities are fundamental in the world of cloud computing."

Similarly, a participant (P5) emphasized that expertise in DevOps and cloud architecture is important for successful RACC:

"*As per my knowledge, to effectively allocate resources using cloud computing, strong technical expertise in several areas is essential. These include cloud architecture, cloud security, DevOps, automation, and orchestration. It's important to have a team of experts who possess the skills and knowledge required to handle these aspects and ensure efficient resource allocation using cloud computing technologies.*"

Moreover, a participant (P7) referred to other areas of expertise that are needed, such as architecture, automation, server management, etc.

"*Yes, it's important to have a strong grasp of various areas. These include cloud architecture, which involves designing and managing cloud-based systems and services. I guess, containerization is also crucial for efficient deployment and management of applications. Cloud automation is another essential skill, enabling streamlined and automated resource allocation and management,*"

Further, a participant (P9) believed that expertise in lowering the cost and increasing the efficiency of resource allocation is the key:

"*Certainly! When it comes to resource allocation in the cloud, it's crucial to employ effective techniques for optimizing data management and costing. By strategically managing resources and implementing cost-effective strategies, organizations can ensure efficient allocation of resources in the cloud, leading to improved performance and cost savings.*"

3.1.3. Network Performance

According to the participants, network performance is an important obstacle to implementing efficient RACC in SMEs. In this regard, 40% of participants referred to network challenges such as cloud network infrastructure configuration. In addition, the participants emphasized the significance of minimizing latency and ensuring optimal network performance for improved application outcomes; for example, a participant (P9) stated that:

"*Well, to be honest, I think in my experience network configuration is a big challenge in resource allocation.*"

In addition, a participant (P10) emphasized network latency and the way to deal with it:

"*I guess to deal with the network traffic we should make the application utilize less resources and the latency. So, if there is a network between traffic managers there should be very little latency and we performance get the best results, accurate results, and then go faster.*"

Similarly, a participant (P11) highlighted the need for a network connection between on-premises and cloud resources, which required a significant amount of time and effort to resolve:

"*Since I am working in cloud computing I think establishing a network connection between on-premises and cloud resources was a bit challenging and we had to spend a long weekend to sort out this problem.*"

3.1.4. Optimization

The participants (50%) explained the complexity of the RACC optimization as one of the obstacles against the successful implementation of resource allocation in cloud

computing by SMEs. In this regard, a participant (P10) suggested the need to explore insights related to memory utilization to achieve the better deployment of applications, particularly with the recent use of microservice technology:

> "*So, normally we have the option to explore insights which utilization and, memory utilization. So, when we deploy the application, as recently the microservice technology.*"

Furthermore, a participant (P5) emphasized the importance of cost and usage optimization to meet customer requirements:

> "*optimization is very important because Customers want to accomplish their objectives with less cost. Some of the frequent challenges we face are cost and usage optimization.*"

Another participant (P3) also confirmed this point and referred to load balancing, resources, and network optimization as an important challenge:

> "*Yes, exactly and these are a few critical aspects of cloud resource allocation, and there are several ways to address these challenges Load balancing, Resource optimization, and Network optimization.*"

3.1.5. Security and Privacy

The participants (40%) considered security and the preservation of privacy as a challenging issue. In this context, a participant (P3) mentioned several security issues that are central to consider when implementing the RACC, such as selecting suitable cloud service providers and architectures and ensuring compatibility and integration with existing IT systems:

> "*I think of few, one of the majors is in resource allocation include ensuring data security and privacy, selecting the appropriate cloud service provider and cloud architecture, and ensuring compatibility and integration with existing IT systems.*"

Another participant (P4) also confirmed this point and stated:

> "*I have seen the results from different sectors and results show that the factors of compatibility, security, and trust, as well as a lower level of complexity, lead to a more positive attitude towards cloud adoption.*"

Moreover, a participant (P9) considered that regulatory compliance requirements, security concerns, and the availability of technical expertise are additional factors that contribute to the challenge of security and privacy in RACC:

> "*Yes, there are other factors as well and it may include regulatory compliance requirements, security concerns, and the availability of technical expertise.*"

3.2. Organizational Challenges

The second context in the TOE framework is the organizational barriers associated with RACC in SMEs. This theme consisted of three sub-themes: (1) cost efficiency; (2) inadequate training and development programs for employees; and (3) monitoring resource usage and performance.

3.2.1. Cost Efficiency

The participants (30%) identified cost efficacy as one of the key obstacles to RACC in SMEs. In this regard, a participant (P4) emphasized the need for SMEs to carefully evaluate pricing structures, monitor resource utilization, and implement cost-effective strategies:

> "*Yes absolutely, I think the cost factor is one of the most important factors that you should consider when choosing a Cloud Service Provider. Pricing plays an important role in deciding which cloud service provider you should choose for your business requirements.*"

Confirming this point, a participant (P5) said:

> "*Well, in my company we ensure that cloud resources are utilized effectively by closely monitoring usage and optimizing costs.*"

In addition, the participants mentioned the slow process of achieving cost efficiency as a problem. In this regard, a participant (P8) explained:

"*As far as I know, it's a slow process but in the long run it will help to reduce the cost on the infrastructure side.*"

3.2.2. Inadequate Training and Development Programs for Employees

Lacking suitable training and development programs for employees was identified as a challenge by 80% of participants. Therefore, these issues must be solved by instituting comprehensive training and development programs to address the lack of skills and knowledge in RACC. In this context, a participant (P10) stated that:

"*Yes actually, there are many, we have optional training every time. Such as we have a community practice share, so, um, we're mostly looking into Java, so we're migrating to the how can utilize this framework and programming language, community practice every to that. We get some to get this outside this certified and once clear it can be reimbursed.*"

Additionally, the participants emphasized the weight of training on server maintenance, load balancing, and selecting the right instance types to improve scalability and performance. In this regard, a participant (P2) said:

"*Yes, of course, we provide training to employees about server maintenance, load balancing, or choosing the right instance types for better scalability and performance.*"

Furthermore, the participant noted that adequate training had improved the adoption and use of resources in the cloud, resulting in greater efficiency and effectiveness in achieving organizational objectives; a participant (P3) stated that:

"*In my company, we have provided the training to the employees, this improved adoption and utilization of cloud resources, as well as increased efficiency and effectiveness in achieving organizational objectives.*"

3.2.3. Monitoring Resource Usage and Performance

Another obstacle reported by the participants (50%) was monitoring resource utilization and performance. Therefore, SMEs need to adopt strong monitoring mechanisms and performance management methods to meet the difficulty of monitoring resource consumption and performance in RACC; a participant (P3) stated that:

"*To be honest, I think monitoring performance is a side-by-side goal to achieve performance from cloud regularly.*"

In addition, a participant (P3) mentioned the significance of adopting monitoring and management tools to track resource usage and perform capacity planning for optimizing resource allocation:

"*In my organization, Monitoring and management tools are used to track resource usage, and capacity planning is performed to optimize resource allocation.*"

The previous idea is shared with another participant (P5):

"*We try to monitor usage; we ensure that cloud resources are utilized effectively by closely monitoring usage and optimizing costs.*"

3.3. Environmental Challenges

The third context in the TOE framework is the environmental barriers. This theme consisted of three sub-themes: (1) economic factors; (2) market competition; and (3) sustainability and performance.

3.3.1. Economic Factors

An important problem stated by the participants was the economic factors associated with the RACC in SMEs. In this regard, a participant (P3) stated:

"*Cloud computing resource allocation has to be economically efficient. There are several economic benefits of using cloud computing for resource allocation, including reduced upfront capital costs, lower ongoing operational costs, and improved resource utilization efficiency.*"

Additionally, the participants reported the reduced cost achieved through cloud computing resources by decreasing the need for hardware and software investments; a participant (P5) said:

"*I guess the reason why cloud computing is famous these because of its economic benefits. The economic benefits of using cloud computing for resource allocation are significant. It allows us to achieve cost savings by reducing the need for hardware and software investments.*"

Furthermore, the participants reported the financial advantage of cloud computing compared to on-premises infrastructure, drawing an analogy of renting a car instead of purchasing one to enjoy a ride within budget; in this regard, a participant (P6) noted that:

"*Cloud computing is economical in terms of cost compared to on-premises infrastructure, for example, if you want to ride a car and you don't have the budget to buy a car you can simply rent a car and enjoy your ride.*"

3.3.2. Market Competition

According to the participants (40%), competition in the market is a challenge to RACC in SMEs. To stay competitive, participants emphasized how market dynamics and competitive pressures affect the decision-making process for allocating cloud resources. In addition, they also underscored how crucial it is to stay up to date with market trends. In this regard, a participant said (P5):

"*Yes, it's a very important factor and we ensure compliance with all relevant regulations and consider market competition when selecting cloud service providers.*"

In addition, the participants believed in the significance of business needs, regulations such as the Health Insurance Portability and Accountability Act (HIPAA) and the General Data Protection Regulation (GDPR), economic conditions, and technological innovations in the context of market competition; a participant (P7) said:

"*I guess, Business needs Regulations such as HIPAA, PCI DSS, and GDPR, Market competition such as AI or machine learning, Economic conditions, and Technology innovations.*"

Further, the participants highlighted the influence of market competition on organizations, driving them to adopt cloud-based solutions as a means to gain a competitive advantage; in this regard, a participant (P9) said:

"*Obviously yes, market competition can drive organizations to adopt cloud-based solutions to gain a competitive advantage.*"

3.3.3. Scalability and Performance

According to the interview results, 80% of respondents identified scalability and performance as a challenge. These findings highlight the need to ensure that cloud resources can expand successfully to meet variable demands, as well as to optimize performance to ensure efficient and responsive cloud services. A few of the responses are as below.

In addition, the participants emphasized that scalability is a feature of the cloud and a primary driver of its popularity among businesses; a participant (P4) said:

"*If you ask me, I guess, scalability is one of the hallmarks of the cloud and the primary driver of its exploding popularity with businesses.*" (R4)

Additionally, the participants noted the importance of leveraging the latest technology and best practices to tackle scalability and performance challenges in allocating cloud resources; a participant (P5) noted that:

> "*We leverage the latest technology and best practices to address scalability and performance challenges in allocating cloud resources.*"

Moreover, the participants highlighted the importance of adopting best practices such as auto-scaling, load balancing, and right-sizing to address the challenges of scalability and performance; a participant (P9) noted that:

> "*I have different ways to this, for example, to address the challenges of scalability and performance in cloud resource allocation, organizations should adopt best practices such as auto-scaling, load balancing, and right-sizing.*"

4. Discussion and Future Directions

The main aim of this research was to explore the challenges related to cloud computing resource allocation in SMEs. A total of 11 challenges were identified by the 12 participants, as shown in Table 2 These challenges were divided into three contexts based on the TOE framework: technological, organizational, and environmental. In the technological context challenges, there were (1) lack of expertise, (2) lack of knowledge, (3) network performance, (4) optimization, and (5) security and privacy. Organizational challenges were as follows: (6) cost efficiency, (7) inadequate training and development programs for employee monitoring, and (8) resource usage and performance. Additionally, in the environmental context, there were (9) economic factors, (10) market competition, and (11) scalability and performance; see Figure 1.

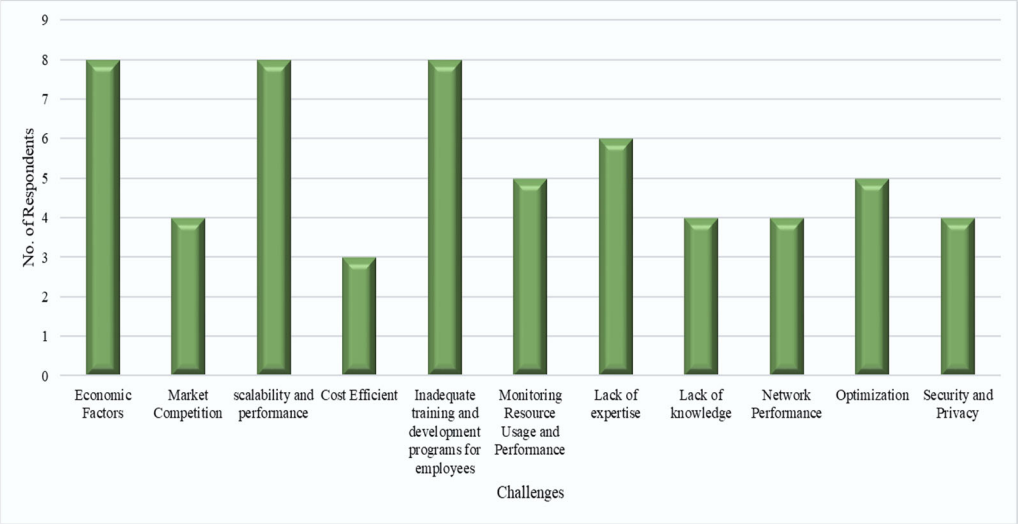

Figure 1. The challenges reported by the study's participants.

The current study's findings revealed that participants drew more attention to technology challenges than the other two contexts, with five technological challenges, three organizational challenges, and three environmental challenges, as shown in Figure 2. This may be explained based on the participants' experiences in certain contexts; see Table 1, where eight out of twelve participants are technical experts. In addition, this could be due to the technological innovation of cloud computing and the diversity in resources and their configurations.

The current findings of this study are consistent with previous research, which has mostly focused on technological challenges to successful RACC in SMEs [30]. However, it is important to note that this emphasis on technological challenges highlights a gap in understanding the importance of organizational and environmental challenges that impact the efficiency of RACC in SMEs. For instance, inadequate training in organizations, in particular, is an organizational challenge to effective RACC in SMEs [31]. This leads to a lack of experience and awareness regarding RACC which may damage many different aspects

of the resource allocation process, including resource management [32,33]. Therefore, SMEs can harness the full potential of cloud computing and improve their resource allocation practices to foster innovation and competitiveness in the digital world by recognizing and overcoming these challenges. As a result, future studies should focus on exploring and overcoming the organizational and environmental impediments to successful RACC in SMEs.

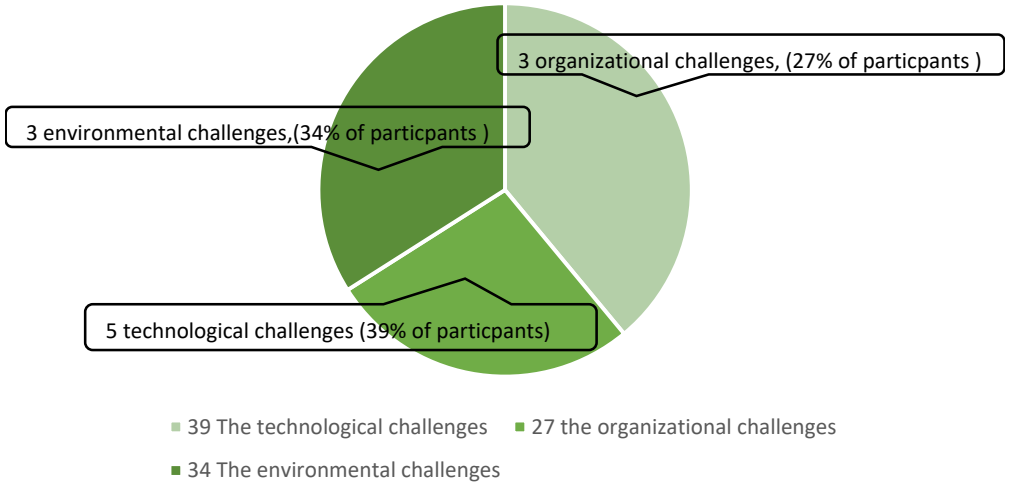

Figure 2. The number of challenges identified in each context of the TOE framework.

Similar to the findings reported by ref. [34], the participants of the current study recognized security and privacy as being among the most challenging concerns in RACC in SMEs. This stems from the lack of appropriate security skills. In addition, to preserve privacy it is required to obey strict data protection laws such as HIPAA and GDPR that require adequate skills to control which categories of information should be stored on-cloud, which can be accessed by the public, and which data we must keep secret. Therefore, the most confronting issues reported by participants were security and privacy and lack of expertise; see Figure 1. However, despite the negative impacts of lack of expertise, and its solid association with other concerns, very few research works addressed these problems [35]. Therefore, further studies are recommended on these two issues.

Furthermore, the participants in the current study considered that their SMEs may lose control of their assets and resources if they depend on cloud service providers to decide the security of resources. This is because SMEs depend on the provider's skills, rules, and techniques for securing systems. This is in line with the findings of a study by refs. [36–38], which also reported that a lack of control can lead to problems with service uptime, customization, and not being able to fix speed or security problems directly. Moreover, this study showed that when organizations rely on a single cloud service provider for resource allocation, they run into the challenge of vendor lock-in. When it becomes difficult or expensive to transfer to a different cloud provider or bring the services back in-house, this is known as vendor lock-in [39]. The participants of the current study stressed that a lack of interoperability standards and proprietary technologies can restrict an organization's adaptability and ability to negotiate better terms or adapt to changing business requirements. In addition, when allocating cloud resources, organizations in regulated industries confront compliance and legal risks. Therefore, consideration must be given to industry-specific compliance requirements and contractual obligations. Failure to comply with applicable regulations or contractual obligations may result in legal repercussions, monetary penalties, reputational harm, and a loss of consumer confidence [40].

The optimization of RACC was reported as an important challenge for SMEs. This matches the findings of other studies. For example, ref. [17] discussed the advantages of resource optimization in cloud computing, such as decreased up-front capital expenses and increased resource use efficiency. Confirming this point, ref. [33] underlined the necessity

for SMEs to carefully monitor resource utilization and optimize expenses. According to the apparent findings in this study, the participants also reported on how important cloud computing training programs are for helping workers learn how to use cloud resources efficiently. This is in line with the findings of a study by [13,41] that also reported that training has a good impact on cloud resource usage.

The integration of advanced technologies such as machine learning, artificial intelligence, and automation has the potential to significantly enhance the resource allocation procedures within small and medium enterprises (SMEs). Utilizing established principles and employing optimization algorithms, the aforementioned technologies possess the capability to effectively analyze historical data, accurately forecast resource demands, and seamlessly automate the allocation process. Future research may delve into investigating the potential viability and effectiveness of incorporating these technologies into the existing resource allocation practices within small and medium enterprises (SMEs). This exploration could potentially aid in fostering more intelligent and efficient decision-making processes. In addition, future research endeavors may be directed toward the development of resource allocation models and tools that are driven by analytics. These models and tools should be specifically designed to cater to the needs of small and medium enterprises (SMEs), allowing them to effectively monitor and optimize their cloud resources in real time.

Furthermore, it is worth noting that the collaboration and knowledge-sharing practices within small and medium enterprises (SMEs) have the potential to greatly contribute to the improvement of resource allocation in the context of RACC. The establishment of communities of practice, industry networks, and knowledge-sharing platforms has been identified as a potential strategy to facilitate knowledge exchange among small and medium enterprises (SMEs). By leveraging these collaborative mechanisms, SMEs have the opportunity to learn from one another's experiences, share best practices, and collectively address challenges related to resource allocation. Future research endeavors may delve into the examination of the feasibility of these collaborative methodologies and construct conceptual frameworks that can effectively foster the exchange of knowledge and facilitate collaboration among small and medium enterprises (SMEs) within the realm of RACC.

The scope of this study is to study the key challenges of RACC in SMEs. However, even though large enterprises encounter some of these issues, such as security, privacy, and cost-efficiency, they are managed differently. For example, big businesses use intricate, customized cloud system solutions to achieve long-term objectives, utilizing vast resources to satisfy a range of requirements. On the other hand, due to their smaller size and lack of resources, SMEs frequently choose simple, affordable solutions that concentrate on operational requirements and more basic business models. In addition, big businesses frequently choose to form internal teams of specialists dedicated to cloud adoption. The reasoning behind this is that these businesses typically have intricate, highly specialized needs that are insufficiently satisfied by off-the-shelf services. In contrast, SMEs usually go in a different direction and outsource cloud administration. This is because their top priority is cost-effectiveness, and they might not need the same tailored solutions that major enterprises do. Furthermore, when implementing cloud services, large organizations frequently devote a significant amount of IT spending to performance and customization. SMEs, on the other hand, typically focus their IT budget on affordable and effective cloud services such as security services, which introduce more vulnerabilities. However, further studies are needed to dive deeply into these challenges from the large enterprise perspective.

5. Challenges and Limitations

The current study has identified several limitations that warrant acknowledgment. The study's sample size was relatively small, potentially limiting the generalizability of the findings. It is crucial to acknowledge that qualitative studies, due to their inherent characteristics, do not strive for generalizability. Consequently, it is inappropriate to assume that the findings can be universally applied to all organizations across various contexts [42].

In addition, it is important to note that the study exclusively utilized a single research method for data collection, without integrating additional complementary methodologies to corroborate and substantiate the obtained results. By implementing a mixed-method methodology, which integrates both qualitative and quantitative data, it would have been possible to enhance the internal validity to a greater extent. The implementation of diverse data collection methodologies would have augmented the researchers' capacity to ascertain the dependability and credibility of the gathered data.

Furthermore, the present study aimed to investigate the participants' subjective viewpoints and personal encounters about the obstacles encountered during the implementation of cloud computing resource allocation techniques within small and medium enterprises (SMEs). Nevertheless, it is crucial to acknowledge the inherent difficulties associated with evaluating the objectivity and neutrality of participants' responses in studies of this nature. It is imperative to consider that the descriptions provided may potentially be influenced by various biases. Hence, it is recommended that additional surveys be conducted to investigate the perspectives of owners, managers, and employees regarding the allocation of cloud computing resources in SMEs. These surveys should specifically focus on the design and implementation stages of cloud technology applications. The inclusion of surveys in this study would serve to enhance the comprehensiveness of the data collection process, thereby contributing to the validation of the research findings.

6. Conclusions

Although cloud resources can yield several benefits, the management of these resources in SMEs remains a challenging issue. A deep exploration, identification, and categorization of perceptions of managers and experts toward the barriers of the allocation of resources in SMEs is presented in this study. This study has revealed that several barriers have caused inefficient resource allocation in SMEs. The findings revealed 11 challenges categorized into three perspectives, technological, organizational, and environmental, based on the TOE framework. The following are the technological obstacles: (1) lack of expertise, (2) lack of knowledge, (3) network performance, (4) optimization, and (5) security and privacy. Organizational challenges are as follows: (6) cost Efficiency, (7) inadequate training and development programs for employee monitoring, and (8) resource usage and performance. Additionally, in the environmental context, there are (9) economic factors, (10) market competition, and (11) scalability and performance.

In comparison to the organizational and environmental challenges, this study indicated that participants paid greater attention to technological obstacles. This highlights a gap that could have a negative impact on the efficiency of resource allocation in cloud computing for SMEs. Therefore, further research is required from an organizational and environmental perspective.

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Appendix A

Appendix A.1. Semi-Structured Interview

Section 1: Background Information

- Can you please tell me about your business and the industry you operate in?

- How long have you been in operation?
- How many employees does your business have?
- What types of cloud computing-related services are currently being provided by your business?

Section 2: Technology:

- How would you describe your experience with cloud computing?
- What are some of the challenges you have faced when implementing cloud computing for resource allocation?
- What factors influence your decision to adopt cloud computing for resource allocation?
- What kind of technical expertise do you need to effectively allocate resources using cloud computing?

Section 3: Organization:

- How has the adoption of cloud computing for resource allocation affected the organization's overall operations?
- How do you ensure that the cloud resources are utilized effectively to achieve organizational objectives?
- Have you provided any training to employees regarding the use of cloud computing? If so, how effective was it?

Section 4: Environment:

- What external factors (e.g., regulations, market competition) affect your cloud resource allocation decisions?
- What are the economic benefits of using cloud computing for resource allocation?
- How do you address the challenges of scalability and performance in cloud resource allocation?
- What economic factors do you consider when selecting a cloud computing service provider?

Conclusion:

- Is there anything else you would like to add about your experiences with resource allocation in cloud computing?
- Thank you for your time and contributions to the study.

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