

# Impact of the COVID-19 Pandemic on the Adaptation and Development of Cloud Computing Solutions in Enterprises in Poland

***Paula Bajdor***

*Czestochowa University of Technology  
Częstochowa, Poland*

*paula.bajdor@pcz.pl*

***Damian Dziembek***

*Czestochowa University of Technology  
Częstochowa, Poland*

*damian.dziembek@pcz.pl*

## Abstract

During the COVID-19 pandemic, many enterprises had to adapt their IT systems to the new conditions dynamically. One of the essential directions enabling the continuity of business activity was the migration of IT systems to cloud computing. The article aims to determine the impact of the COVID-19 pandemic on IT solutions offered in the Cloud Computing model in the sector of small and medium enterprises in Poland. The authors conducted research among 409 enterprises from the SME sector from various regions and operating in various industries. The research shows that the COVID-19 pandemic mainly resulted in the surveyed enterprises limiting operations and reducing costs in various areas of activity (including reducing investments in IT). In the group of medium-sized enterprises, the COVID-19 pandemic had a significant impact on increasing the scale of application of IT solutions in cloud computing, while in small enterprises, the impact on the broader implementation of Cloud Computing services was limited. As a result of the COVID-19 pandemic, enterprises from the SME sector migrated to the cloud mainly uncomplicated services (e.g., file sharing, communication systems, Office, e-mail, backup, or website systems), and advanced IT ERP or BI systems were migrated in a small group of enterprises. In general, the COVID-19 pandemic has increased the saturation of cloud computing solutions, and for about 40% of enterprises from the SME sector, cloud computing has become a safe environment to ensure the continuity of critical and supporting processes.

**Keywords:** Cloud Computing, COVID-19, small and medium enterprises

## 1. Introduction

Since 2020, the COVID-19 pandemic has imposed previously unknown requirements on all enterprises, forcing dynamic adaptation to new conditions and taking measures to maintain process stability and business continuity. One of the significant directions of change was the migration of IT systems to cloud computing. Cloud computing is a new emerging way of information and communication technologies [Arora: 2019]. Cloud computing is a model for enabling access to computing resources that evolved in information technology and has become a dominant business model for delivering IT infrastructure, components, and applications [Benlian et al.: 2018]. Cloud Computing can be synthetically defined as a technological model in which resources (applications, computing power, data storage, archiving, and programming tools) are provided as a set of services available via the Internet [Haag, Cummings: 2010, p. 205]. The Cloud Computing model, which offers recipients access to various types of IT solutions in the form of a service, arouses more and more interest among enterprises due to the potential benefits that it can provide them. The positive effects of using Cloud Computing in organizations contribute to the significant growth of the Cloud Computing services market. The latest PMR data from the PMR report "The Cloud Computing Market in Poland 2021. Market analysis and development forecasts for 2021-2026", published in December 2021, indicate that the value of the Cloud Computing market was growing in Poland in 2021 at a rate of

more than 30% (year on year). Initial forecasts assume that in 2022 the value of the Cloud Computing market will reach PLN 3 billion [Olszynka: 2021].

In order to determine the impact of the COVID-19 pandemic on changes in IT solutions offered in the Cloud Computing model and to determine the scale of migration of IT solutions to cloud computing in enterprises from the SME sector, the authors, using the literature analysis, posed the following research questions: RQ1: How during the COVID-19 pandemic 19 IT solutions used in the Cloud Computing model in enterprises from the SME sector were assessed? RQ2: What is the level of interest of enterprises from the SME sector in further development of IT solutions in cloud computing? RQ3: Has the COVID-19 pandemic affected the migration (transfer) of systems and applications to cloud computing in SMEs? RQ4: To what extent has the COVID-19 pandemic affected the changes in the previously used IT solutions in cloud computing in enterprises included in the SME group? In order to find answers to the above research questions, the authors researched over 400 Polish enterprises from the SME sector.

## 2. Description of the surveyed enterprises and the types of IT solutions used in them in the Cloud Computing model

In order to analyze the effects of the COVID-19 pandemic on enterprises using Cloud Computing solutions, the authors conducted research in 2021 among small and medium-sized entities conducting business in Poland. The survey involved companies operating throughout Poland and from various industries. Because there are over 60,000 such enterprises in Poland, in order to determine the minimum sample size, a formula that allows a predetermined accuracy to be obtained when estimating the structure index from a population:

$$n = \frac{u_{\alpha}^2 p(1-p)N}{u_{\alpha}^2 p(1-p) + (N-1)d^2} \approx 384 \quad (1)$$

Where:

$\alpha$  = level of significance (0,1-0,01),

$u_{2\alpha}$  = the value acquired from the table of normal distribution for the adopted level of significance,

$p$  – the structure index,

$d$  – accepted level of the highest error

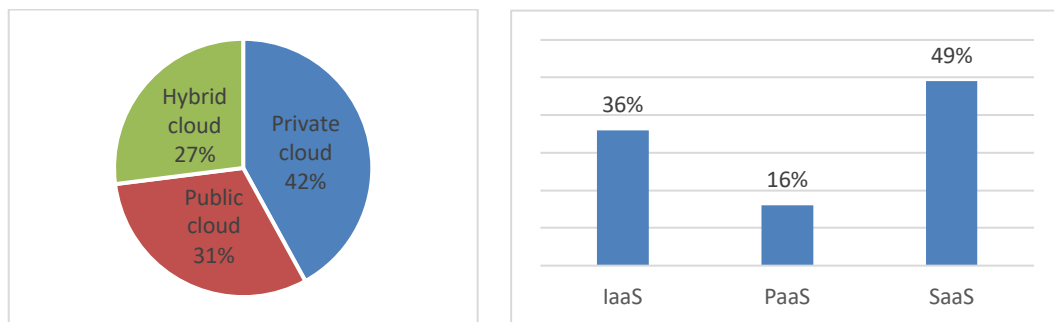
The calculations show that the minimum sample size, with the adopted confidence level of  $1-2 = 0.90$  and the maximum estimation error  $e = 5\%$ , should be 384 questionnaires. This size results from the relationship that determines the minimum sample size using the unique drawing method to select the sample. Since 409 questionnaires were qualified for the research, it can be assumed that this condition was met, and the obtained sample meets one of the assumptions of the representative method.

The research was also intended to answer the question of whether Cloud Computing solutions developed under the influence of the COVID-19 pandemic. The research was carried out using the CAWI (Computer Assisted Web Interview) method, in which the respondent filled in a questionnaire on the website. The distribution of the surveyed enterprises in terms of their size was relatively proportional: 56% of small and 44% of medium-sized enterprises operating in various sectors of the economy took part in the survey (micro-enterprises were not taken into account). Among the enterprises invited to the research, it was possible to obtain correct answers from 409 enterprises in the small and medium-sized enterprises group. The questionnaire included questions with single and multiple-choice answers and with the use of a 5-point Likert scale. The scale used in the study consisted of 5 categories of answers (e.g., from the number 5, meaning "definitely yes," to the number 1, meaning "definitely not") arranged in the correct order. MS Excel was used for data processing and analysis.

The analysis of the collected data shows that the largest share in the study was held by companies from the sectors of transport and warehouse management (43%) and trade (23%). Enterprises from the administration and support activities sector (7%), other service activities (6%), information and communication (6%), and culture, entertainment, and recreation (4%) had a much smaller share. The research represented the remaining industries by a small number of enterprises (2% or less). An essential question in the survey was the question about the position taken by the respondent because the requirement was that the surveyed personnel knew Cloud Computing and the scope of its application in the

enterprise. The largest group of respondents were representatives of the management board (62%), followed by specialists and employees of the IT department (32%). IT and other department managers accounted for the smallest number of respondents (2%). Therefore, the research involved employees who understand the role and importance of IT solutions, decide or co-decide on the scale and areas of application of the Cloud Computing model, and can analyze and evaluate the effects of using Cloud Computing in the enterprise.

On average, the surveyed companies have used Cloud services for over four years, which indicates that this period allows them to gather relevant knowledge and experience about the Cloud Computing model and its importance in the business activities of entities from the SME sector. Among the surveyed enterprises from the SME sector, the most popular (despite high implementation costs and limited flexibility) is the private cloud, selected by 42% of the respondents. The great popularity of a private Cloud may result from the possibility of its direct control by the company's IT staff and the lack of the need to transfer data to an external provider. Many enterprises also use public (31%) and hybrid (27%) Clouds. The popularity of particular types of Clouds in the surveyed enterprises is shown in Fig. 1. While the choice of a public Cloud probably resulted from many of its advantages (no investment in infrastructure, supplier's responsibility for IT resources, a wide range of services, scalability of services, low cost), the popularity of the hybrid cloud may result from the synergy of combining various types of Clouds (which affects the level of costs, efficiency, reliability, flexibility and risk reduction of IT solutions). None of the companies indicated using other types of Clouds, i.e., partner or dedicated Clouds.



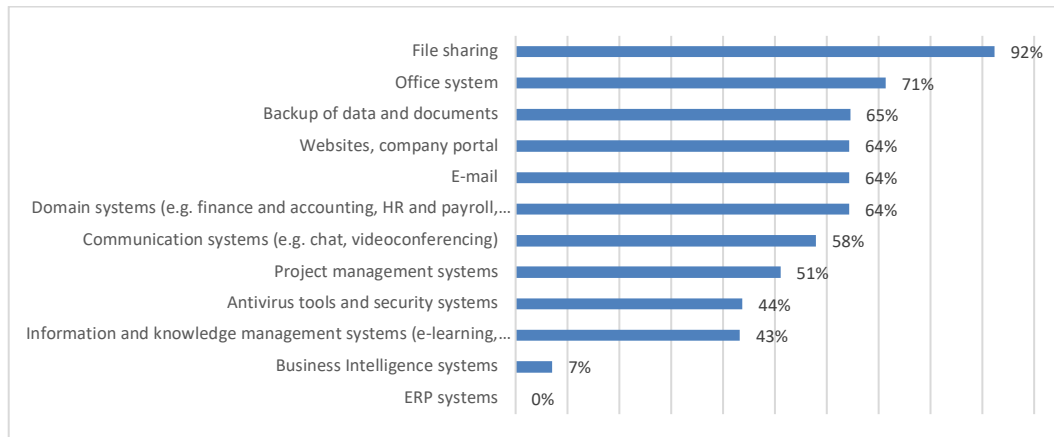
**Fig. 1.** The popularity of particular types of Clouds and service models according to the surveyed enterprises from the SME sector.

According to the respondents, the most used model of Cloud Computing services is SaaS, which was indicated by 49% of enterprises. These results mean that enterprises from the SME sector eagerly use applications in the service model that operate in an IT environment managed by a supplier responsible for the continuity of application operation, regular system updates, required configuration, and data backup. Reduction of operating costs, no need to deal with infrastructure issues, and quick access to the necessary, functional, and scalable applications supporting the activities of SMEs via a web browser determined the high rank of SaaS services.

Cloud Computing models used in the studied group of companies are presented in Fig. 1. PaaS services are the least popular (16% of responses), which shows that this model (which provides a programming environment for creating/launching own and external applications) is mainly dedicated to IT specialists. The IaaS model, indicated by 36% of respondents, is also trendy, which means that many enterprises use the infrastructure resources of suppliers (in the form of virtual machines) to implement and run various types of software.

The research shows that the most frequently used Cloud Computing service by small and medium-sized enterprises is file sharing (92%). The use of office applications (e.g., Office365) and applications supporting the circulation of documents (71%), as well as archiving and storage of data (backups), documents, and databases (65%), is prevalent. Other services often mentioned by SMEs (64%) were websites, company portals, content management systems, e-mail, and applications supporting the management of a selected area of activity (e.g., trade, marketing-CRM, finance and accounting, HR and payroll, logistics, and production). The next place in terms of popularity of use (58%) was taken by applications supporting communication (fax, instant messaging, videoconferences) and

applications supporting project management (51%). In turn, anti-virus tools, security systems, and applications supporting information and knowledge management (e.g., e-learning, corporate portals) were used in less than half of the surveyed enterprises from the SME group (44% and 43%, respectively). The least frequently used Cloud Computing applications are applications supporting business analytics - Business Intelligence systems (7%). In contrast, applications for supporting the management of the entire enterprise (ERP systems) were not indicated by any entity from the SME sector. The presentation of the most important Cloud Computing services for the surveyed enterprises from the SME sector is shown in Figure 2.



**Fig. 2.** Essential Cloud Computing services according to the surveyed enterprises from the SME sector.

In conclusion, Cloud Computing in SMEs classified as SMEs primarily supports individual tasks and processes. The obtained results allow us to conclude that although the scope of Cloud Computing applications in SMEs is gradually increasing, supporting more and more business processes, the most popular Cloud services (file sharing, office applications, data archiving, and storage) have a limited impact on improving competitiveness and digital transformation in small and medium-sized enterprises. ERP and BI systems could play an essential role in these changes. Although most manufacturers in the Polish market offer Cloud Computing ERP systems, they are not popular among entities from the SME sector. In contrast, BI systems are used in the Cloud Computing model to a small extent.

### 3. Presentation of research

Table 1 summarizes the respondents' answers regarding the assessment of IT solutions in the Cloud Computing model during the COVID-19 pandemic and the level of interest in their further development in enterprises. The results are presented for all surveyed enterprises from the SME sector and broken down into small and medium-sized enterprises.

The analysis of the research results in terms of the impact of the COVID-19 pandemic on the functioning of IT solutions in the cloud computing used in enterprises allows us to conclude that:

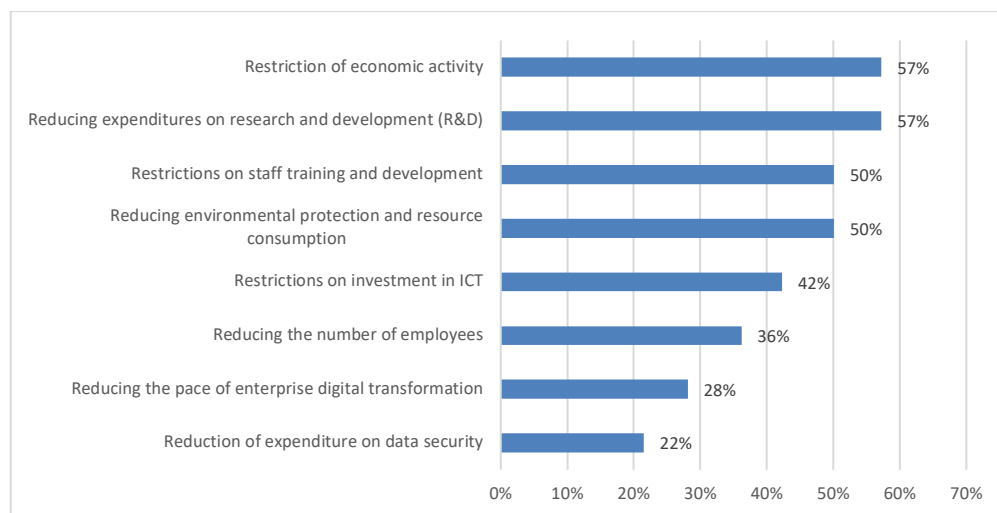
- more than half of the surveyed enterprises (57%) from the SME sector (61.9% of small and 51.1% of medium-sized enterprises, respectively) stated that the COVID-19 pandemic did not increase the cost of using IT solutions in the cloud. In the opinion of this part of small and medium-sized enterprises, expenditure on IT solutions in the Cloud Computing model (e.g., subscription, media costs) remained at the same level or even decreased (which resulted from the introduction of various promotions during the COVID-19 pandemic). An increase in costs caused by the COVID-19 pandemic was declared by 28% of the surveyed enterprises from the SME sector (13% of small and 48.3% of medium-sized enterprises, respectively). Increased costs in these enterprises could relate not only to an increase in operating costs (e.g., the need to increase the number of systems for remote work or increase the Internet capacity) but also the need to modernize or invest in computer equipment (e.g., in laptop computers for employees). The COVID-19 pandemic did not significantly impact the increase in the cost of using IT solutions in cloud computing

among enterprises from the SME sector. 14% of respondents did not know about the increase or decrease in the cost of IT solutions during the COVID-19 pandemic.

**Table 1.** Evaluation and prospects for the development of IT solutions in the Cloud Computing model in enterprises during the COVID-19 pandemic

Answers	Evaluation and prospects for the development of IT solutions in the Cloud Computing model in enterprises during the COVID-19 pandemic								
	The impact of the COVID-19 pandemic on the increase in the cost of using IT solutions in the cloud			Cloud computing reduces the impact of the COVID-19 pandemic			Impact of the COVID-19 pandemic on the decision to increase the scale of application of IT solutions in the cloud computing		
	All	Small	Medium	All	Small	Medium	All	Small	Medium
Yes	28,4%	13,0%	48,3%	50,4%	49,8%	51,1%	43,0%	13,9%	80,9%
No	57,2%	61,9%	51,1%	28,6%	30,7%	25,8%	42,6%	74,0%	1,7%
I do not know	14,4%	25,1%	0,6%	21,0%	19,5%	23,0%	14,4%	12,1%	17,4%

- the most important effects of the COVID-19 pandemic, according to the surveyed enterprises from the SME sector (answers of respondents describing a given effect on a five-point Likert scale as essential), were: limiting activity, reducing costs (for research and development, staff training), reducing investments in IT and the need to make rapid changes to employment conditions (including dismissal) and staff remuneration. Other effects of the COVID-19 pandemic, not indicated by the respondents, may also include downtime and a decrease in revenue. The most important effects of the COVID-19 pandemic declared by the surveyed enterprises from the SME sector are presented in Figure 3.



**Fig. 3.** The most important effects of the COVID-19 pandemic according to the surveyed enterprises from the SME sector.

Half of the enterprises from the SME sector confirmed that the use of IT solutions in the cloud has reduced the negative consequences of the COVID-19 pandemic, facilitating the adaptation of this group of enterprises to the new market realities. A different opinion was held by about 29% of the surveyed enterprises (30.7% of small and 25.8% of medium-sized enterprises, respectively), which did not notice that IT solutions in the cloud had less impact on the effects of the COVID-19 pandemic. Based on the research, using IT solutions in the cloud reduces the adverse effects of the COVID-19 pandemic. In this case, as many as 21% of respondents could not determine whether cloud computing impacts the less noticeable effects of the COVID-19 pandemic.

- enterprises from the SME sector did not declare that the COVID-19 pandemic significantly impacted the decision to develop existing IT solutions in cloud computing further or undertake new implementations based on the Cloud Computing model. For some of the surveyed enterprises (43%), COVID-19 significantly impacted the decision to use IT solutions in the Cloud Computing model more widely. However, almost the same proportion of enterprises (42.6%) still need to declare expanding their existing cloud computing solutions since the emergence of the COVID pandemic -19. Among the

surveyed population, the vast majority of medium-sized enterprises (80.9%) indicated that the COVID-19 pandemic impacted the expansion of existing IT solutions in the cloud. Only 13.9% of small enterprises had such certainty. About 2% of medium-sized and 74%, 1% of small enterprises, denied that the COVID-19 pandemic had an impact on the increase in the number of IT solutions based on the Cloud Computing model. Among medium-sized enterprises, the COVID-19 pandemic had a significant impact on increasing the scale of the application of IT solutions in the cloud. From the results obtained, it can also be concluded that in the group of small enterprises, the impact of COVID-19 pandemic had a limited impact on increasing existing or implementing new IT solutions in the Cloud Computing model. Based on the above results, some enterprises (especially small ones) may have already completed the implementation of all IT solutions in the cloud before the COVID-19 pandemic. During the COVID-19 pandemic, there were no new needs or challenges in using additional IT solutions. More than 14% of the surveyed enterprises could not clearly state whether the COVID-19 pandemic impacted the expansion of the scale of application of IT solutions in cloud computing.

Table 2 summarizes the respondents' answers regarding assessing the impact of the COVID-19 pandemic on the migration (transfer) of IT systems to the cloud. The results were presented for all surveyed enterprises from the SME sector and broken down into small and medium-sized enterprises.

**Table 2.** The scale of migration of IT solutions to cloud computing in the surveyed enterprises from the SME sector

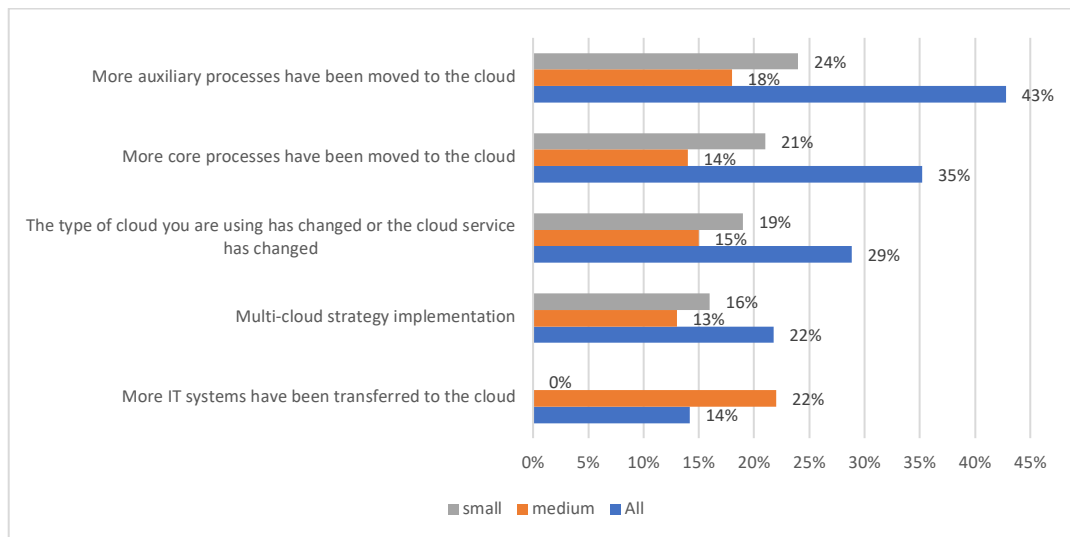
IT solution type	All	Medium	Small
Sharing file	70,9%	69,1%	72,3%
Chat or video conferencing systems	64,1%	65,2%	63,2%
Office systems	56,5%	53,4%	58,9%
E-mail	49,9%	34,3%	61,9%
Backup systems	42,8%	42,1%	43,3%
Website	42,3%	42,7%	42,0%
E-learning systems	41,8%	39,9%	43,3%
CRM systems	35,7%	33,1%	37,7%
PM systems	28,6%	30,3%	27,3%
Domain systems (ACC, HR, LOG)	28,4%	24,7%	31,2%
E-business systems (online shop)	21,5%	0,6%	37,7%
BI systems	21,3%	16,9%	24,7%
ERP systems	14,2%	16,9%	12,1%
SCM systems	14,2%	15,7%	13,0%

The analysis of the research results in terms of the impact of the COVID-19 pandemic on the migration (transfer) of IT systems to the cloud allows us to conclude that:

- most often, enterprises from the SME sector transferred to the cloud such IT solutions as file sharing and storage systems, communication systems (e.g., chat, videoconferencing systems), office systems (e.g., Office365), e-mail (in this case, as many as 62% of small enterprises confirmed e-mail migration to the cloud). Slightly less often (less than 50% of responses), IT solutions such as data backup systems, company websites, information and knowledge management support systems (e.g., e-learning systems), and CRM systems were transferred to the cloud. Systems that have been migrated to the cloud to a limited extent (below 30% of responses) include project management support systems, domain systems (concerning accounting, HR and payroll, trade and logistics, and production), e-business systems (online stores, which was indicated by as many as 38% of small enterprises and only 1% of medium-sized enterprises) and the least frequently transferred systems such as Business Intelligence, Enterprise Resource Planning and Supply Chain Management. Based on the above data, the COVID-19 pandemic has significantly influenced the migration to cloud computing concerning uncomplicated IT solutions used in SMEs. In this group of enterprises, the COVID-19 pandemic had a limited impact on

the migration to the cloud of advanced IT systems (such as ERP, BI, SCM), which can have the most significant impact on the digital transformation of enterprises. The poor scale of migration of advanced IT solutions may also result from the fact that these solutions were previously implemented in the on-premise model and remote and secure access for staff was provided or that there is no acceptance for transferring key IT solutions operating in enterprises to the cloud.

Chart 4 summarizes the responses of the surveyed enterprises from the SME sector regarding the impact of the COVID-19 pandemic on changes in IT solutions in cloud computing.



**Fig. 4.** The most significant changes introduced in IT solutions in cloud computing under the influence of the COVID-19 pandemic in enterprises from the SME sector

The analysis of the essential changes indicated by the surveyed enterprises from the SME sector (responses of respondents describing a given change on a five-point Likert scale as essential) allows us to conclude that:

- the most frequently indicated response to the COVID-19 pandemic was the transfer of more auxiliary processes to the cloud, which was indicated by 43% of enterprises from the SME sector (24% of small and 18% of medium-sized entities, respectively). Another meaningful change, according to the respondents, was the transfer of main processes to cloud computing, which was indicated by 35% of enterprises (21% of small and 14% of medium-sized entities, respectively). Therefore, cloud computing has become a safe environment for some respondents to ensure the continuity of key and supporting processes carried out in enterprises from the SME sector. As a result of the COVID-19 pandemic, the saturation with IT solutions used in the cloud has gradually increased. Interestingly, however, earlier respondents did not indicate migration to cloud computing of critical IT systems (such as ERP, which are usually the environment for implementing main and auxiliary processes) as particularly important. In addition, the surveyed enterprises did not state that they use ERP systems in the cloud (see Fig. 4). Therefore, the question arises - how was the transfer of the primary and auxiliary processes in the surveyed enterprises to the cloud? This issue will be analyzed in more detail in the next edition of the author's in-depth research. Another significant reaction of the surveyed group of enterprises to the COVID-19 pandemic was changing the type of cloud used (from private to public or vice versa) or changing cloud services (from IaaS to SaaS), which was indicated by 29% of respondents, the use of multiple services in from different providers (implementation of the multi-cloud strategy) declared by 22% of the surveyed enterprises and the transfer of more IT systems to the cloud, which was confirmed by 14% of enterprises from the SME sector. The COVID-19 pandemic influenced changes in the existing IT solutions in cloud computing in enterprises, including in the SME sector, although this impact was not very large.

#### 4. Conclusions

According to the Central Statistical Office, in 2021 in Poland, 43% of medium-sized and about 24% of small enterprises used IT solutions in the cloud. The decision to use cloud computing services in enterprises from the SME sector was probably influenced by the benefits (e.g., flexibility, lower initial costs, availability, and security) and the COVID-19 pandemic. The authors conducted research among Polish enterprises from the SME sector, which made it possible to find answers to the research questions posed regarding the impact of the COVID-19 pandemic on the use of IT solutions in the cloud computing model. The COVID-19 pandemic mainly resulted in the surveyed enterprises: limiting operations and reducing costs in various areas of activity (including reducing investments in IT). IT solutions in cloud computing allowed us to reduce the adverse effects of the COVID-19 pandemic. Moreover, the costs of services in the Cloud Computing model did not increase significantly during the COVID-19 pandemic.

In the group of medium-sized enterprises, the COVID-19 pandemic had a significant impact on increasing the scale of application of IT solutions in cloud computing. In contrast, the impact on the broader implementation of Cloud Computing services was limited in small enterprises. As regards the migration of IT solutions to the cloud, the most frequently indicated services were not too complicated (e.g., file sharing, communication systems, Office, e-mail, backup, or website systems), IT systems crucial for the digital transformation of enterprises, such as ERP or BI were migrated in a small number of enterprises. The COVID-19 pandemic has increased the saturation with cloud computing solutions, and for about 40% of enterprises from the SME sector, cloud computing has become a safe environment to ensure the continuity of critical and supporting processes. The limitation of the conducted research is the selection of only Polish enterprises from the SME sector, and undoubtedly exciting research conclusions may emerge when a sample of enterprises from other countries, e.g., from the EU, is taken into account, along with mutual comparisons. The direction of future research is to specify the questions about activities for changes in IT solutions in the cloud computing model and their role in minimizing the effects of the COVID-19 pandemic, as well as to examine the stages and effects of the migration process of key and supporting processes in the SME sector.

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