European Research Studies Journal
Volume XXVII, Issue S2, 2024

pp. 276-289

Leveraging Cloud Computing for Innovation in Polish Manufacturing Industries

Submitted 08/09/24, 1st revision 20/10/24, 2nd revision 06/11/24, accepted 30/11/24

Anna Pamuła[1], Magdalena Zalewska-Turzyńska[2]

Abstract:

Purpose: *Is to examine the impact of implementing cloud computing services on the emergence of innovation in manufacturing companies.*
Methodology: *Quantitative research survey among IT managers (CIO) or company owners (in the case of small enterprises) in 300 Polish manufacturing companies.*
Findings: *Almost 44% of surveyed companies reported experiencing innovation after implementing cloud services. Most commonly, companies pointed to innovations in the areas of new or improved methods of company organization, while innovations in communication with supply chain partners and public administration were less frequent.*
Practical implications: *The findings contribute to the discussion on the importance of implementing new technologies and translating them into organizational outcomes. The results suggest that innovations occur across various areas, indicating the need for further research in this area.*
Originality/Value: *The study on presents significant insights into the role of cloud computing in accelerating the innovation in manufacturing companies.*

Keywords: *Cloud computing, manufacturing companies, innovations.*

JEL codes: *M11, O14, O33, M15.*

Paper type: *Research paper.*

[1]*Dr., hab. Katedra Informatyki, Wydział Zarządzania, Uniwersytet Łódzki, Poland, e-mail: anna.pamula@uni.lodz.pl;*
[2]*Dr., hab. Katedra Zarządzania, Wydział Zarządzania, Uniwersytet Łódzki. Poland, e-mail: magdalena.zalewska@uni.lodz.pl;*

1. Introduction

Innovation is one of the elements that allows achieving a competitive advantage. However, the pursuit of novelty, which borders on madness, has reached a level where it is difficult for companies to decide on the order of importance of innovations to implement. These are the conditions organizations have to successfully cope with. Innovation is a key factor for business survival, growth, employment generation, improved productivity, and business competitiveness (Pino, *et al.*, 2016). For the purposes of this study, the Oslo approach to innovation categorization was implemented.

The fast and 'forced' digitalization of organizations, the introduction of cloud computing and IT tools for communication (ICT), and job performance dictated by the pandemic situation have also incited and intensified all types of innovations.

Therefore, the quick and compulsory absorption of cloud solutions undoubtedly affected the innovations introduced to the organization. Hence, the question arises: what kind of innovation did it affect the most (product, process, marketing, organization, business innovations), and which ones did companies decide to implement as the first one? The above questions have jet remained unanswered.

We have concentrated on manufacturing companies because they strongly felt the lockdown, as it hit the core of their business (Rababah *et al.*, 2020). They are the ones who detected this pursuit of continuous change enforced by insatiable customers, and to survive, they implemented servilization cloud-supported solutions – cloud manufacturing or smart manufacturing.

This led us to distinguish the research gap since the environment and inter-organizational conditions have changed. Thus, findings need to be empirically verified – the unknown current, post-pandemic situation of organizations, particularly the types of innovation that arose as a result of cloud computing implementation in the manufacturing companies. The detailed research questions are formulated in the paragraph below.

2. Literature Review

Fascination with innovation has resulted in a proliferation of innovation research, studies, and theories (Todorovic *et al.*, 2022) in various disciplinary fields, such as sociology, engineering, economics, marketing, and psychology. These studies have become pervasive. According to the Oslo Manual '*an innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations'*.

Thus, product innovation is defined as *new products and/or services that are introduced to meet the needs of external users or market needs* (Damanpour, 1991), whereas process innovation is the adoption of new or significantly improved production methods (Oslo Manual). Radical innovation generates drastic social change, while progressive (incremental) innovation contributes to systematic change (Pinto *et al.,* 2016). Technological innovations '*comprise new products and processes and significant technological changes of products and processes. An innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). Innovations therefore involve a series of scientific, technological, organisational, financial and commercial activities*' (Oslo Manual, 2005).

Scholars (Geldes *et al.*, 2017; Pino *et al.*, 2016; Gunday *et al.*, 2011; Mothe, Nguyen, 2010) have adopted the Oslo Manual (the version that is also a base for this article, despite update in 2018) recommendations in their analysis and conceptualization; therefore, it is the frequently quoted innovation typology in the literature, presenting four different types of innovation: product, process, marketing, and organizational.

The implemented perspective is that product and process innovation are classified as technological, while marketing and organizational innovation are considered non-technological innovations. Moreover, non-technological innovation is indirectly related to the organization's basic work activity, thus affecting the management systems (Todorovic *et al.,* 2022).

Nevertheless, numerous other definitions and innovation typologies have already been elaborated in the literature (e.g., Todorovic *et al.,* 2022; Tidd, 2006). IT-based product innovation can be applied to both new product development (Pavlou, El Sawy, 2006) and incorporating IT into existing physical products to make them more innovative in features and/or functionality by reengineering them (embedding IT hardware and software in them) (Klat *et al.*, 2016).

Process innovation is the implementation of a new or significantly improved method of production or distribution (Paris: OECD/Eurostat, 2005). Process innovation encompasses activities from product design to distribution and commercialization, related to the technological process involving the use of novel, cloud computing based methods to organize logistics, import materials, distribute products, and introduce supplementary operations (Bui, 2022).

By innovating production and business processes, companies can reduce production costs, enhance product quality, improve efficiency and productivity, and ultimately boost their competitive edge (Tidd *et al.*, 2005). In this paper, we focus on the central process innovation in manufacturing companies, facilitated by IT, especially cloud computing, that serves as an enabler for process innovation by overcoming temporal and spatial constraints.

Communication technologies integrated into process design foster collaboration, while shared information resources, such as databases and imaging, reduce mediation and the number of hand-offs.

The organizational innovation encompasses the adoption of a new organizational method in an enterprise's business practices and procedures of the company, organizational restructuring or external relations (Manual 2005). It leads to improved employee job satisfaction, reduced administrative and internal costs for customers and suppliers, enhanced access to knowledge and external resources, thereby facilitating enterprises' labour productivity and operational efficiency (Bui, 2022; Pino *et al.,* 2016).

Contrary to the Oslo Manual's suggestion, organizational innovation influences technical product and process innovations in two ways: by serving as prerequisites and facilitators for them and by offering a competitive advantage through its significant impact on business performance, encompassing productivity, lead times, quality, and flexibility (Armbruster *et al.,* 2008; Knight and Cavusgil, 2004).

Marketing innovation involves the implementation of new marketing methods that bring significant changes in product design, packaging, sales channels, promotion strategies, and pricing (Mothe and Nguyen, 2012; Manual 2005). It directly impacts the consumption of a company's output and shapes the relationship between businesses and customers.

Business model innovation '*describes either a process of transformation from one business model to another within incumbent companies or after mergers and acquisitions, or the creation of entirely new business models in start-ups'.* (Geissdoerfer *et al.,* 2016) Business model innovations are believed to yield higher returns compared to product or process innovations (Chesbrough, 2007), although many business model innovations ultimately fail (Patel, 2015). With the advent of digitization, traditional industry barriers can be overcome, prompting the need to reevaluate existing business models (Gerlitz, 2016).

Cloud Computing (CC) understood as *a distributed information technology (IT) architecture in which client data is processed at the periphery of the network, as close to the originating source as possible* (Stergiou *et al.,* 2018). In cloud computing, everything is treated as a service, aligning with the concept of servilization (Xu, 2012).

Cloud computing shares some of the typical features of disruptive technological innovations (Choi *et al.,* 2018) it is both the subject to innovation itself, supporting and improving organizational operation as well as it supports and fosters innovations in the organizations (Huang and Yang, 2011) and provides a new way to do business and support innovation (Zhang and Xu, 2013).

It enhances the sharing of information, applying modern analytic tools and managing controlled access and security (Radke, Tseng 2015), provides a flexible stack of massive computing, storage and software services in a scalable manner and at low cost (Xia *et al.*, 2015; Li *et al.*, 2014). Real-time monitoring of cloud resources is crucial for a variety of remote collaboration tasks including performance analysis, workload management, capacity planning and fault detection (Andreolini *et al.*, 2015).

The rise of new information and communication technologies ICTs, Internet of Things (IoT), Big Data, Cloud Computing, and Blockchain, has facilitated the implementation of servitization (Wang *et al.*, 2021). Numerous examples in the literature support this trend (Yang *et al.*, 2018; Gaiardelli *et al.*, 2016). In recent decades, the manufacturing industry has undergone significant changes, with companies facing increased competition amid technological advancements (Wang *et al.*, 2021).

Customer preferences, characterized by a constant desire for novelty, have driven the demand for personalization and customization. Customers now focus on the outcomes and usage of products rather than the mere purchase of a product itself (Agrawal and Bellos, 2017). This has led to the concept of servitization, where companies transition from solely supplying physical products to providing a combination of products and services along with their associated functionalities (Örsdemir *et al.*, 2019).

The impact of servitization extends beyond just product and process aspects. The adoption and utilization of ICT play a role in smart manufacturing, serving as a key source of competitiveness and growth for firms that effectively leverage them (Arredondo-Trapero *et al.*, 2020). In the context of innovation and development within organizations, it is essential to recognize the collective contribution of people, processes, and tools – '*tools are only as effective as the people and organizations using them'* (Thomke, 2006) – thus successful implementation of innovation requires the integration of these three elements.

By leveraging cloud computing, manufacturing companies can successfully address the diverse requirements and expectations of two distinct groups of stakeholders: clients, supply chain partners, and public authorities (Thomke, 2006). ICT enables the efficient exchange of large volumes of information, promoting information sharing among supply chain partners.

Communication processes within the organizational context can promote or inhibit innovation. Top management has the power to create an organizational context or a pro-innovative, change-supportive organizational culture that fosters the core message of the company's mission and vision (Baker, 2012).

The main research question of the study was "*How managers of manufacturing companies perceive Cloud Computing's impact on innovations"*. Two following research questions were identified for further investigation:

RQ1: Is the impact of cloud computing on innovation noticeable?
RQ2: What types of innovation are most often noticed in organizations?

The next stage of the work was to find answers to research questions based on primary data collected in manufacturing enterprises in Poland.

3. Research Methodology

The analysed data were collected in the year 2023 through quantitative research as part of an ongoing study on the proliferation of Cloud Computing solutions in Polish manufacturing companies. The main objective of wider research is to understand the impact of CC on manufacturing companies.

This part of the research was specifically dedicated to its influence on innovation. To gather the data, questionnaires were developed based on a comprehensive literature review, considering the Oslo Manual innovation types and the adoption of ICT communication in the context of cloud adoption.

The survey was conducted using the CATI technique among IT managers (CIO) or company owners in the case of small enterprises, who were responsible for implementing IT solutions in their respective manufacturing companies on the territory of the Republic of Poland. This respondent selection ensured their familiarity with both the enterprise architecture and the business processes of the organization. The questionnaires were administered by professional agency selected through a request for quotation form.

The sampling frame was a commercial polish database of business entities on record in the REGON register (database of polish enterprises with information a declared business activity). Companies of manufacturing operations were randomly selected, but according to size described by number of employees (micro company 0-9; small 10-49; medium 50-249, large more than 250 – according to *Polish Act of Accounting*).

The collected data was then examined, and a total of 300 records were deemed suitable for further analysis. Records were represented by companies – micro 12.33%, small 42.33%, medium 29.33% and large16%. Almost 75% of them were established more than 15 years ago, 13% lasted from 10-15 years, 9.99% from 5-10 and only 3.67% was younger than 5 years. In the questionnaire, respondents were asked to rank the degree of impact of innovative changes resulting from the implementation of Cloud Computing across various areas of their organization. It was a question with no forced entry.

The Likert scale was used, ranging from 1 (very low significance) to 5 (very high significance). The following types of innovation, as defined in the Oslo Manual, were examined as part of the study (operationalized as variables from innov1 to innov9):

1. new or improved products have been introduced,
2. new customer services have been introduced,
3. new or improved production methods have been introduced,
4. new methods and channels of customer services used by the company have been introduced (focus on products and the way they are delivered)
5. new or improved methods of company organization have been introduced.

The list was extended to include the following areas, considering the significant impact of communication on the introduction of innovation, and the role of IT and cloud computing:

6. new business models have been introduced, (Geissdoerfer *et al.,* 2016; Gerlitz, 2016),
7. new methods of communication within the organization have been introduced, (Baker, 2012),
8. new methods of communication with customers have been introduced (focus on communications before and after sales) (Khan *et al.,* 2021; Arredondo-Trapero *et al.,* 2020),
9. new methods of communication with supply chain partners and public administration (Yao *et al.,* 2022; Khan *et al.,* 2021; Thomke, 2006; Peng *et al.,* 2021).

To measure the total degree of CC impact on innovation perceived by respondents the new construct was proposed. It was calculated as the sum of respondents' ratings for the nine types of innovation studied for each surveyed company. In case the respondent did not answer the questions the record was not considered. The results can vary from 9 to 45, with higher values indicating a greater impact on the innovations resulting from the company's adoption of cloud technology.

4. Research Results

In order to assess the impact of Cloud Computing on innovation, a Cronbach's alpha test was conducted for nine variables that were created based on the questionnaire responses. The Cronbach's alpha test measures the internal consistency or reliability of a scale or measurement instrument. In this case, it was used to determine the consistency between the scale items related to the impact of Cloud Computing on different areas of innovation within manufacturing companies.

The Cronbach's alpha value obtained was 0.863, indicating a high level of consistency between the scale items. This suggests that the questionnaire used in the study is reliable and valid for measuring the impact of Cloud Computing on innovation in manufacturing companies. Detailed data related to the Cronbach's alpha test and the variables can be found in Table 1.

Table 1. *Cronbach's alpha test results for questionnaire variables*

Variable	**Scale Mean of Item Deleted**	**Scale Variance if Item Deleted**	**Corrected Item Total Correlation**	**Multiple correlation square**	**Cronbach's Alfa if Item Deleted**
innov1	30,35	32,730	0,665	0,545	0,842
innov2	30,38	35,055	0,436	0,300	0,863
innov3	30,32	33,809	0,571	0,412	0,851
innov4	30,33	35,238	0,517	0,492	0,855
innov5	30,14	33,032	0,663	0,476	0,842
innov6	30,27	32,714	0,609	0,561	0,847
innov7	30,29	32,069	0,693	0,554	0,839
innov8	30,39	32,088	0,680	0,626	0,840
innov9	31,04	31,794	0,538	0,367	0,857

Source: *Own compilation.*

Data analysis used principal component analysis and exploratory factor analysis was performed in order to establish convergent and divergent validity. Principal component analysis was performed to check possible structure of the variables. In the anti-image correlation matrix all variables results were greater than, 0.5, so all variables were used for next analysis.

The correlations between variables were less than 0.8, the determinant value was 0.021. the KMO test value was equal to 0.816 and the Bartlett's the significance less than 0.001 showed that variables are significantly correlated and that factor analysis is appropriate The two components were found as being responsible of almost 62% of cumulative variance.

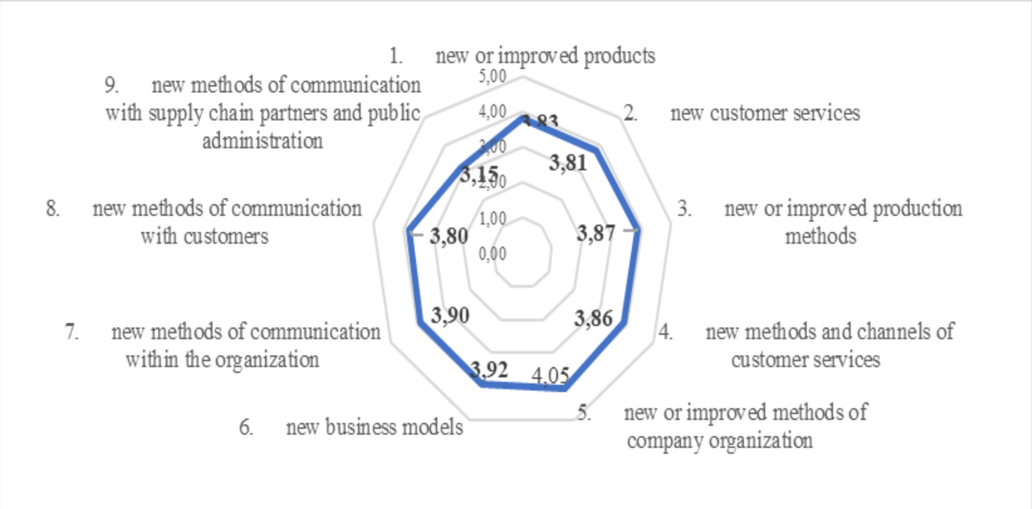
After applying Varimax method of rotation the highest correlation for the component 1 was observed for the innov7 variable (new methods of communication with customers have been introduced) In case of the component 1 corelations to all variables are high with the value grater that 0.5).

After applying rotation, it was observed that component 1 is loaded more strongly by variables 1, 4, 5, 8 and 9, while component 2 is loaded more strongly by variables 2, 3, 6, 7. The performed Exploratory Factor Analysis (EFA) showed that two components were found as being responsible of almost 52% of cumulative the variance.

Common method bias – Harman's single method test showed that single factor is responsible for 48.73% of total variance that was less than 50% and it was assumed that there was no common method bias. The calculated innovation index variable (TINNOV) represents the sum of respondents' ratings for the nine types of innovation studied for each surveyed company. This variable can range from 9 to 45, with higher values indicating a greater impact of the innovations resulting from the company's adoption of cloud technology. The distribution of the TINNOV variable was assessed using the Kolmogorov-Smirnov test, which showed that the distribution deviated from a normal distribution. The significance level of the test was found to be less than the chosen alpha value of 0.05.

The first significant finding from this part of the survey is that nearly 44% of the surveyed companies that use cloud computing technology reported noticing its impact on the innovations they introduced. Among these companies, four rated the impact at the maximum level, resulting in an indicator value of 45. The average value of the innovation index was found to be 34.19, and the median was 34. This suggests that managers perceive high impact of cloud computing technology on innovation.

Figure 1. *Average ranks for each type of innovation*



Source: *Based on own compilation.*

TINNOV analysis also revealed the lowest average score 3,1 for new methods of communication with supply chain partners and public administration, suggesting a relatively lower impact in these areas. Overall, these results confirmed RQ1 regarding the impact of cloud computing technology on innovation. The results allows to confirm that IT managers perceive CC technology as important factor of innovation in all investigated types of innovation in manufacturing companies.

5. Discussion and Conclusion

Implementing cloud computing into organization fostered by covid changed attitude towards this IT innovation. Cloud services are evidenced to be used by individuals and then by organisations for around two decades now, organizations have also begun to use them as a tool for meeting their IT needs (Lin and Chen 2012). Researches first concerned on constrains and advantages of IT innovation, then turned into computational power and ability to help companies in costs saving and security concerns and standardisation (Pamuła *et al.,* 2020).

This study presents significant insights into the role of cloud computing in accelerating the innovation in manufacturing companies. By employing a comprehensive CATI questionnaire with 300 companies representants, the research effectively captured the perception of cloud computing as a across various types of innovations. The discussion of the research findings highlights several key points.

Firstly, a positive answer was obtained for RQ1 and RQ2, indicating the emergence of innovations in various areas. We can confirm that Cloud Computing technology is seen as an accelerator of innovation in manufacturing companies. Findings align with parallel research (anticipations by Golightly *et al.,* 2022) and emphasizes the importance of further investigation in this area.

The research allows to designate those innovations driven by CC that are perceived by IT managers or company's owners as the most influential on company's growth and development. Moreover, for practitioners who are facing the need of technical change this research may suggest the order of innovation introduction to obtain the most noticeable acceleration in innovation in the possible shortest time after introducing CC.

The subjective knowledge and perception of the respondents, who were managers in charge of IT solutions or company owners, may have influenced the results. It could influence the high innovation result in the area of new methods and channels of customer services as they are mainly connected with IT services.

It is important to acknowledge certain limitations of the study. The survey is limited to Polish respondents (N=300), which may influence the generalizability of the conclusions to other countries. The face validity was not conducted as an external expert's assessment. Since respondents had to be familiar with IT, we used general categories of innovations from the Oslo Manual (the version with 4 categories of innovation, similarly to Geldes *et al.,* 2017; Pino *et al.,* 2016; Gunday *et al.,* 2011; Mothe and Nguyen, 2010).

The study of the impact of CC on innovation was based solely on the perception of this relationship by managers responsible for IT implementation or business owners in the case of small entities. This limitation results from the purpose of the study. At the same time, the perception was not confronted with the actual state, due to the lack of access to the financial data of these 300 companies.

Avenues for further studies and analyses we indicate in depth analysis within certain innovation types. The second direction of studies should concentrate on AI influence on innovation, since cloud computing and artificial intelligence (AI) are technologies enhancing various growth possibilities for companies, both in terms of work effectiveness and development of new ideas. The enterprises are incorporating those technologies since they seem to be enhancing computing capabilities and reducing expenses – that could be a field for further detailed research.

In conclusion, the paper addressed the issue of innovation in the context of cloud computing adoption in manufacturing companies. However, the findings raise additional questions that warrant further investigation. The prominence of organizational innovations over innovations related to client-company relations indicates a focus on internal processes and self-care within organizations.

This could imply that companies have already established satisfactory relationships with the external environment and do not see a pressing need for further innovation in that area. Alternatively, it may suggest that internal issues within organizations require immediate attention, taking precedence over external concerns. Both of these suggestions warrant further investigation to gain a deeper understanding of the underlying factors.

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