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SEEKING IT DECISION MAKERS' VIEWS ON ACQUISITION OF CLOUDMANUFACTURING IN INDIA

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ABSTRACT: Cloud manufacturing has emerged as a breakthrough of IT services, including the internet of things (IoT) and artificial intelligence (AI) for business processes in the manufacturing sector. It has also brought the need to complete the integrated business processes such as an integrated supply chain, inventory management, and production for utilizing this technology. In this context, IT decision-makers attempt to develop a cloud-based manufacturing model for downloading, configuring, and maintaining machinery from cloud providers that enables the top managers just to focus on their product in business. The research aims to build for monitoring the differences between cloud manufacturing adopters and non-adopters to understand the behavioral intention by monitoring the Diffusion of Innovation (DOI) theory and the Technological, Organizational, and Environmental (TOE) theory of cloud manufacturing adoption. An independent t-test sample was used to analyze data. 19 manufacturing cloud adopters and 19 non-cloud adopters were selected to analyze data via SPSS 26.0 in Turkey. The results exhibited that manufacturing cloud adopters and non-cloud adopters considered the same for relative advantage, cost-saving, competitive pressure, and regulatory support. However, they found differences in security concerns, compatibility, complexity, technological readiness, and top management support. The study brought an outlook for understanding the benefits, drawbacks, and hinders of cloud manufacturing of manufacturers. This will enable comprehensive information for cloud providers to offer appropriate integrated software according to manufacturers' needs of the production.

Keywords: Cloud Manufacturing Adoption, IT decision-makers, independent t-test analysis, DOI theory, TOE theory

1. INTRODUCTION

With Web 3.0 technology, cloud computing has changed the way business model and operation management was operated in the manufacturing sector by the digital transformation [1]. With this technology shift, cloud-based manufacturing was developed to enclose cloud computing, virtualization, and the Internet of things (IoT) for these operations to increase productivity and decrease costs [2]. Along with these benefits, the investment in cloud manufacturing has also been increased recently and in the future, underlined that spending on cloud-based manufacturing was $19.1 billion in 2017and is expected to raise $28.8 billion by 2028. With the cloud manufacturing market growth numerically, it was undoubtedly seen that cloud computing usage was demanded. 88 percent of manufacturing enterprises considered moving to the cloud [3]. Cloud computing was nearly implemented by 66 percent of manufacturing enterprises in practice [4]. 82 percent of manufacturing enterprises applied product lifecycle management (PLM) strategies and applications to shift their real-time business decisions through cloud manufacturing. Thus, the study is required as it contributes to obtaining information from Turkish manufacturers to adopt cloud manufacturing and giving a comprehensive knowledge about the possibility of barriers to cloud manufacturing providers. There have been several definitions of the cloud. The description of the cloud was defined as data, which was stored outside of servers [5]. Hoberg et al. [6] described the cloud as software, which is hosted by the internet. Youseff et al. [7] defined the cloud as the virtualization of computers to utilize manufacturers' operations. Cloud was described as a pay-per-use model of software over the internet defined the cloud as an environment, in which the automated system was built by the external cloud suppliers under service level agreements.

The definitions of cloud manufacturing are varied by distinct scholars. Wu et. al. [10] described cloud manufacturing as a demand-driven manufacturing model to develop flexible solutions for industrial systems. Milisavljevic-Syeda et al. [11] extended the cloud manufacturing definition as utilization of real-time data for contributing real-time supply chain under the internet of things(IoT) enabled quality improvement and robot improvement. Hence, Mukhopadhyay & Mukhopadhyay [12] suggested the term cloud-based manufacturing that has become a basis of Industrial 4.0 development with artificial intelligence (AI) and machine learning to build a continuous improvement frame for sustaining the businesses' existence. There are many benefits of cloud manufacturing, as well as limitations. The benefits of cloud manufacturing were classified into two groups: business and technical. From the business perspective, automated ordering systems mentioned by Forbes [13] were applied to minimize inventory costs. Business intelligence was integrated to apply company-wide intelligence [14]. From the technical perspective, cloud manufacturing served to build elasticity in resource allocation and develop desktop grid applications based on the size and storage of manufacturers [15]. The limitations of cloud manufacturing were lack of control and perceived weaker security [16]. For lack of control, the cloud computing architectural plan for cloud manufacturing adoption was obliged to specify the level of adoption to avoid dependency over cloud manufacturing providers. For perceived weaker security, data owners should have absolute authorization to access data at any time [15]. They should also cooperate with IT auditors to audit the IT assets by specifying control procedures against volatile attacks [17].

There are several studies, in which IT adoption theories were held. Proposed a DOI theory to observe the successful implementation of cloud computing adoption from a technical perspective. Alajmi et al. [19] presented an integrated DOI and fit viability model (FVM) to observe thebenefits of cloud computing adoption from a manager's perspective. Gutierrez et al. [20] developed a technological, organizational, and environmental (TOE) model to observe the factors influencing cloud computing adoption from an external perspective. There are plenty of studies related to cloud manufacturing adoption in the manufacturing sector. Saleem Al-Shura et al. [21] investigated the important factors in the Pharmaceutical sector in Jordan. Narkhede et al. [22] formed a SWOT analysis for the strategic survival of Indian manufacturing sectors. Oliveira et al. [23] compared manufacturers with the service sector about the necessity of cloud-based service offerings adoption in Portugal. Kyriakou et al. [24] explored the factors affecting cloud computing adoption of glass, ceramic, and cement sectors in France, the UK, Italy, Germany Spain, and Poland. Yassin& Alnidawy [25] specified the adoption requirements of the manufacturing sector in Iraq. Inspected public and private manufacturers in Ethiopia. Goktas& Baysal [27] examined the cloud-based human resource systems in Turkish manufacturers.

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Narkhede et al. [22] probed the educational sector of India. As a result, there are researches on cloud computing adoption applied IT adoption theories there is no specific study to compare non-cloud manufacturers and cloud manufacturers by applying IT adoption theories such as DOI theory, institution theory, and TOE models for developing countries.

The study has the contribution for cloud manufacturing providers and cloud manufacturing market by analyzing non-cloud manufacturers and cloud manufacturer adopters' intentions over a cloud manufacturing adoption. Since there are no specific studies to compare non-cloud manufacturers and cloud manufacturers applied IT adoption theories, DOI and TOE model was proposed in this study to understand the behavioral differences among non-cloud manufacturers and cloud manufacturers from both technical and external aspects

2. MATERIALS AND METHODS

This study compares and contrasts innovation diffusion factors and TOE factors towards cloud adopters and non-cloud adopters in the manufacturing sector in Turkey. Corresponding research questions are:

1. What are IT decision makers' views about innovation diffusion and TOE factors of cloud adopter manufacturers over non-cloud adopter manufacturers?
2. Are there any significant differences in the views of innovation diffusion and TOE factors ofcloud adopter manufacturers over non-cloud adopter manufacturers?

The research design was descriptive and deductive with the independent variable of adopter types (adopter or non-adopter). The independent variables were derived from DOI and TOE theory. The firstpart of the study consists of eight demographic information of IT decision-makers in terms of gender, education level, working experience, age, market region, cloud application use with numbers, company sizes, and sectors as shown in Table 1. The second part of the study contains DOI and TOE theories questionnaires, including 5 Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree) as shown in Table 2.

H1b: There is a difference in cost-saving (CS) between cloud adopter manufacturers and non-cloud adopter manufacturers.

H0c: There is no difference in security concerns (SC) between cloud adopter manufacturers and non-cloud adopter manufacturers.

And the alternative hypothesis is:

H1c: There is a difference in security concerns (SC) between cloud adopter manufacturers and non-cloud adopter manufacturers.

H0d: There is no difference in compatibility (CO) between cloud adopter manufacturers and non-cloud adopter manufacturers.

And the alternative hypothesis is:

H1d: There is a difference in compatibility (CO) between cloud adopter manufacturers andnon-cloud adopter manufacturers.

H0e: There is no difference in complexity (CX) between cloud adopter manufacturers and non-cloud adopter manufacturers.

And the alternative hypothesis is:

H1e: There is a difference in complexity (CX) between cloud adopter manufacturers and non-cloud adopter manufacturers.

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Table 1. Demographic information of participants

IT Decision Makers (N=38)	Variables	Frequencies	Percentages
1. Gender	Male	23	60.5%
	Female	15	39.5%
2. Education Level	High School	1	2.6%
	Vocational School	2	5.3%
	Graduate	24	63.2%
	Postgraduate	10	26.3%
	Doctorate	1	2.6%
3. Working Experience	1-3 years	6	15.8%
	4- 7 years	11	28.9%
	8- 10 years	11	28.9%
	11-20 years	7	18.4%
	21 years and above	3	8.0%
4. Age	Age 20-25	0	0%
	Age 26-30	11	28.9%
	Age 31-35	10	26.4%
	Age 36-40	5	13.2%
	Age 41-45	1	2.6%
	Age 46 and above	11	28.9%
5. Market Region	International	23	60.5%
	National	15	39.5%
6. Cloud App with Numbers	1-3 services	13	34.2%
	4-6 services	3	7.9%
	7 and above services	3	10.5 %
	None	19	53.5%
7. Company Size	Micro Manufacturers (1-9)	8	21.1%
	SMEs (10-249)	19	50.0%
	Large Manufacturers	11	28.9%
8. Sectors	Textile	5	13.1%
	Automative	1	2.6%
	Energy	2	5.2%
	Construction	3	7.8%
	Ceramics	2	5.2%

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	Pharmaceutical	3	7.8%
	Food	22	57.8%

Here are the null (H0) and the alternate hypothesis (H1) of TOE theory from 'f' to 'i'.

H0f: There is no difference in technological readiness (TR) between cloud adopter manufacturers and non-cloud adopter manufacturers.

And the alternative hypothesis is:

H1f: There is a difference in technological readiness (TR) between cloud adopter manufacturersand non-cloud adopter manufacturers.

H0g: There is no difference in top management support (TMS) between cloud adopter manufacturers and non-cloud adopter manufacturers.

And the alternative hypothesis is:

H1g: There is a difference in top management support (TMS) between cloud adopter manufacturers and non-cloud adopter manufacturers.

H0h: There is no difference in competitive pressure (CP) between cloud adopter manufacturersand non-cloud adopter manufacturers.

And the alternative hypothesis is:

H1h: There is a difference in competitive pressure (CP) between cloud adopter manufacturersand non-cloud adopter manufacturers.

H0i: There is no difference in regulatory support (RS) between cloud adopter manufacturersand non-cloud adopter manufacturers.

And the alternative hypothesis is:

H1i: There is a difference in regulatory support (RS) between cloud adopter manufacturers and non-cloud adopter manufacturers.

The results and discussion of the demographic data, DOI and TOE factors were specified in the following sections.

3. RESULTS

The data is also normally distributed. As it is illustrated in Table 2, the skewness (SK) values and the kurtosis (RKU) values of the range should be between -1 and +1 [28], which all factors were satisfied except the relative advantage factor of cloud manufacturing adopters and the compatibility factor of non-cloud manufacturing adopters. The skewness (SK) values and the kurtosis (RKU) values of the range were between -1.5 and +1.5 [29], which is the relative advantage factor of cloud manufacturing adopters, the security concerns, compatibility, and technology readiness factors of non-cloud manufacturing adopters were satisfied.

An independent-samples t-test was conducted to compare factors of DOI and TOE theory in cloud manufacturing adopters and non-cloud manufacturing adopters. The result was also declared below andpresented in Table 2.

Table 2. Mean (M), standard deviations (SD), skewness (SK), and Kurtosis (RKU), and the Results formanufacturing cloud adopters and non-cloud adopters

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(N=38)	MANUFACTURING CLOUD ADOPTERS				MANUFACTURING NON-CLOUD ADOPTERS				RESULTS
THEORIES	M	SD	SK	RKU	M	SD	SK	RKU	
DOI Theory									
RA (Items 1-5)	3.74	0.54	1.06	1.30	3.63	0.66	0.32	-0.08	**H0a Supported**
CS (Items 6-8)	3.56	0.55	0.96	0.80	3.36	0.56	-0.18	0.76	**H0b Supported**
SC (Items 9-11)	2.80	0.50	-0.16	-0.42	3.82	0.86	-0.09	-1.29	**H1c Supported**
CO (Items 12-15)	3.68	0.82	0.32	-0.80	2.86	0.75	-1.20	1.63	**H1d Supported**
CX (Items 16-19)	2.65	0.71	0.44	1.15	3.14	0.62	-0.10	-0.50	**H1e Supported**
TOE Theory									
Technological Context									
TR (Items 20-21)	3.65	0.97	-0.14	-1.02	2.86	0.66	-0.09	-1.37	**H1f Supported**
Organizational Context									
TMS (Items 22-24)	3.78	0.73	0.21	-0.98	2.94	0.65	0.44	-0.25	**H1g Supported**
Environmental Context									
CP (Items 26-28)	2.94	0.80	-0.27	-1.24	2.70	0.73	-0.42	-0.01	**H0h Supported**
RS (Item 28-29)	2.94	0.79	0.65	1.33	2.76	0.51	-0.95	0.85	**H0i Supported**

- RA is found that there is no significant difference between adopters (M = 3.74, SD = 0.54) andnon-adopters (M = 3.63, SD = 0.66) with t (36) = -0.586, p = 0.562. **(H0a Supported)**

- CS is found that there is no significant difference between adopters (M = 3.56, SD = 0.55) andnon-adopters (M = 3.36, SD = 0.56) with t (36) = -1.061, p = 0.296. **(H0b Supported)**

- SC is found as the significant difference between adopters (M = 2.80, SD = 0.91) and non-adopters (M = 3.82, SD = 0.86) with t (28.883) = 4.444, p = 0.000. **(H1c Supported)**

- CO is found as the significant difference between adopters (M = 3.68, SD = 0.82) and non-adopters (M = 2.86, SD = 0.75) with t (36) = -3.179, p = 0.003. **(H1d Supported)**

- CX is found as the significant difference between adopters (M = 2.65, SD = 0.71) and non-adopters (M = 3.14, SD = 0.62) with t (36) = 2.229 p = 0.032. **(H1e Supported)**

- TR is found as the significant difference between adopters (M = 3.65, SD = 0.97) and non-adopters (M = 2.86, SD = 0.66) with t (36) = -2.923, p = 0.012. **(H1f Supported)**

- TMS is found as the significant difference between adopters (M = 3.78, SD = 0.73) and non-adopters (M = 2.94, SD = 0.65) with t (36) = -3.753, p = 0.000. **(H1g Supported)**

- CP is found that there is no significant difference between adopters (M = 3.78, SD = 0.89) andnon-adopters (M = 2.94, SD = 0.85) with t (36) = -0.983, p = 0.332. **(H0h Supported)**

- RS is found that there is no significant difference between adopters (M = 3.78, SD = 0.89) andnon-adopters (M = 2.94, SD = 0.85) with t (36) = -0.848, p = 0.403 **(H0i Supported)**

4. DISCUSSION

Cloud manufacturing adoption was at a low level in every sector since only 34.2% of the manufacturers used 1-3 cloud manufacturing services. Adopters related to RA, CS, CP, and RS had also the commonly perceived judgment, whereas non-adopters related to SC, CO, CX, TR, and TMS had different opinions over cloud manufacturing adoption. Amongst the sectors, the highest participants were the food sectors,which affected the results over more agreeing on environmental effects but consider differently over technological and organizational factors. Common and different judgments were declared in thesubsections.

Current Common Views on Cloud Manufacturing Adoption among Manufacturing Adopterand Manufacturing Non-adopters

IT adopters of Manufacturing Adopter and IT adopters of Manufacturing Non-Adopter agreed with each other about RA (H0a), CS (H0b), CP (H0h), and RS(H0i).

For RA, manufacturing cloud manufacturing adopters and non-cloud manufacturing adopters agreed equally that cloud manufacturing adoption finishes specific tasks rapidly, uses business operations easily, improves the quality of operations, offers new opportunities, and increases productivity. Applying the human factor and the automated processes at the right time is important for the process of product design and supply chain to reach customers fast via cloud manufacturing [30]

For CS, manufacturing cloud adopters are considered the same as non-cloud manufacturer adopters about cloud manufacturing adoption that has benefits over adoption costs, decreasing energy costs, environmental costs, and decreasing maintenance costs. Applying a cost-benefit analysis of production planning, return of investment of supply chain tools, and cloud manufacturing provider selection is significant for manufacturers to specify the invariable costs within a reasonable budget [31].

For CP, manufacturing cloud adopters and manufacturing non-cloud adopters agreed equally because of influencing competition in their industry and their competitors have already started using cloud computing. Application program interface (API), cloud, and artificial intelligence (AI) are the main challenges of cloud manufacturing adoption for the internet & IT systems of manufacturers [32].

For RS, manufacturing cloud adopters admitted equally that there is legal protection in the use of cloudcomputing and the laws and regulations that exist nowadays are sufficient to protect the use of cloud manufacturing. Because of the absence of the safe harbor agreement in Turkey against Europe and the US for data migration, third-party cloud providers have vulnerable defects for preventing patents, industrial design, and trademarks .

Current Different Views on Cloud Manufacturing Adoption among Manufacturing Adopterand Manufacturing Non-adopters

IT adopters of Manufacturing Adopter and IT adopters of Manufacturing Non-Adopter considerdifferently about SC (H1c), CO (H1d), CX (H1e), TR (H1f), and TMS (H1g) with the mean differences

-1.02, 0.82. -0.49, 0.79, and 0.84, respectively

For SC, the company's data security concerns, customer data security concerns, and concerns about privacy manufacturing of non-cloud adopters in cloud manufacturing were by far higher than the cloud manufacturing adopters. Creating a policy and procedures is important for every step of IT assets such as RFID, QR barcode, and computer-aided manufacturing (CAM) systems, as they can reduce the vulnerability of inside attacks and threats of outside attacks in the supply chain [17]. Computer-assisted audit techniques should be applied by IT auditors to trace bugs, unpermitted entry of networks, and report to the top managers [34].

For CO, cloud adopter manufacturers were much different from non-cloud adopter manufacturers in that they fit the work style of the company, are compatible with business operations, with the company's corporate culture and value system, and with existing hardware and software in the company. Creatingeducation platforms and guidelines is significant to specify the job descriptions for deploying every workers' duties and evolving their qualifications in every workstation of the assembly lines [35]. Audit evidence collection techniques such as interviews and preliminary surveys should be conducted to understand the business risks and the critical processes of business operations [34].

For CX, cloud manufacturing adopters had slightly a high level of mental effort, the advanced skills than non-cloud manufacturing adopters. The data of manufacturing processing planning (MRP), warehouse management, assembly-line monitoring, and customer relationship management should be linked in the centralized database system for gathering the simplicity of manufacturing systems [17]. Business process improvement and business process reengineering should be applied in the short and long term of avoiding complexity by forming project groups from separate business functions, such as marketing, sales, production, and human resources [31]

For TR, cloud manufacturing adopters much more had necessary IT infrastructures and a high level of internet access to implement cloud computing than non-cloud manufacturing adopters. 5G internet is an important basis for increasing broadband data connection and internet bandwidth speed, which it is expected to build in the next years [33]. Fiber buildings should be built for using IT assets effectively for the next decades to build IoT applications with algorithmic artificial intelligence solutions [32].

For TMS cloud manufacturing adopters much more had strong leadership and an ability to take financial and organizational risks than non-cloud manufacturing adopters. Line managers and staff in the workstations should be collaborated to reduce blocking and starving situations against bottleneck issues in the company's operations [35]. Enterprise systems such as Enterprise resource planning (ERP), supply chain management system (SCM), and customer relationship management (CRM) should be well-integrated to report top-level managers as clear spreadsheets to forecast the operating, sales, production, and human resource plan .

IT decision-makers should specify hinders, and drawbacks of cloud manufacturing adoption according to their IT assets, policies, procedures, guidelines for the automated and manual processes of their companies' business processes. IT decision-makers should also build a centralized database system for the integration of Application program interface (API), cloud, and artificial intelligence (AI) into their master MRP systems processes to reach customers fast in the market by considering the cost-benefit analysis of the production and supply chain.

5. CONCLUSION

The research contributes to cloud providers for understanding the enthusiasm of non-adopters into two theories: DOI and TOE theory. It also gives the courage of manufacturing non-cloud adopters by acknowledging them of manufacturing cloud adopters' views before cloud manufacturing adoption. Theresults show that there is a far difference in security concerns, much difference in compatibility, top management support, and technological readiness, and a slight difference in complexity among manufacturing cloud adopters and manufacturing non-cloud adopters, whereas there is not a significantdifference in relative advantage, cost-saving, competitive pressure, and regulatory support among manufacturing cloud adopters and manufacturing non-cloud adopters.

Internal factors such as trialability and prior IT experience factors could be applied to examine cloud manufacturing adoption processes from previous experiences. This study will also be extended by monitoring small and medium enterprises (SMEs), large enterprises (LEs), and international companies (IC) for further cloud manufacturing adoption research.

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CONFLICT OF INTEREST

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