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Adoption of Cloud Computing in Manufacturing: SWOT Analysis

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Abstract

Emergence of cloud computing has brought evolution in many sectors like education, healthcare, governance, etc. Cloud computing is growing interest to manufacturer, but rate of adopting the cloud computing is low in manufacturing sector. Cloud manufacturing is in the early stage of development and successful as a prototype particularly in additive manufacturing. However, it still requires a great amount of research in order for successful implementation on a large scale. In this paper, first we discuss adoption of CC for manufacturing in industry for various categories like small and medium-sized enterprises, startup companies etc. Then we use the SWOT analysis to study the opportunities and challenges of CC for manufacturing. A SWOT analysis is here demonstrated to be a helpful guide in decision-making for industry when considering the migration to cloud based systems. Finally, the paper concludes with some further research areas in the field of CC for manufacturing.

Keywords
Cloud Computing, Adoption, SWOT Analysis, SMEs, Security

1. Introduction

Cloud Computing (CC) has been cited as 'the fifth utility' (along with water, electricity, gas, and telephone) whereby computing services are readily available on demand, like other utility services available in today's society (Buyya et al., 2009). Many authors, organizations defined CC as commentators on the subject, all definitions eventually indicate the utility of CC in several aspects like: pay as you go structure, on demand services, scalability of applications, strong importance of SLAs, guaranteed Quality of Service (QoS), reliability of services. Among the various definitions, the one by the NIST (National Institute of Standards and Technology) has gained recent recognition and popularity, which states as "A model for enabling ubiquitous, convenient, on demand network access to a shared pool of configurable computing resources (e.g. - networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Mell and Grace, 2009). CC enables organizations to consume computing resources as a utility just like electricity. Essential characteristics of CC are broad network access, measured services, on-demand self-service, rapid elasticity and resource pooling.

Wu et al. (2013) defines CC for manufacturing as "Cloud manufacturing is a customer-centric manufacturing model that exploits on-demand access to a shared collection of diversified and distributed manufacturing resources to form temporary, reconfigurable production lines which enhances efficiency, reduces product lifecycle costs, and allow for optimal resource loading in response to variable-demand customer generated tasking". In last 15-20 years many organizations have started restructuring their business models in order to acquire agility, flexibility and sustainability in rapidly changing market scenario. Also emergence of concepts like "Design Anywhere, Manufacturing Anywhere" has led many industries to reform their strategic viewpoints. Thus, to combine this collaborative work, use of CC paradigm in manufacturing sector has gained lot of attention lately. 'Pay as you go' mode, virtualization of resources, convenient and fast data transfer ability etc. are some the advantageous factors which make CC, the ideal solution to handle distributive nature of modern manufacturing world. Many researchers, R and D organizations have been working on adoption of CC system in manufacturing or integration of cloud-based platform with manufacturing. Though ideal or fully operational system is yet to be developed, many theories and implementation proposed so far have proved effective and promising in that direction and can be considered as stepping stones in global cloud technology adaption in manufacturing sector.

In this paper, we have a brief study on a CC for manufacturing with following objectives:

- Identifying existing cloud-based manufacturing issues and applications
- Studying the opportunities and threats and strength and weaknesses of CC for manufacturing through SWOT (strength, weakness, opportunities and threats) analysis
- Understand existing research themes and future directions of CC for manufacturing

The remainder of the study is organized as follows. Section 2 explores adoption of CC in industry; section 3 presents a SWOT analysis on CC adoption for this sector; section 4 concludes with a summary, outlines some issues for further and future study.

2. Adoption of CC in Industry

On prototype level, Cloud based design and manufacturing was a successful venture, but we have to consider limitations of it too. The most important of those shortcomings are follows:

i) Apart from additive manufacturing sector, CC for manufacturing applications are still in very early stages and requires great amount of research and work for full scale implementation especially in case of subtractive manufacturing where number of variables and complexities of problems are huge.

ii) Most of the work is done on selected SMEs point of view and seldom on big organization or large scale level or concerning wide-scale implementation, where resource and knowledge sharing becomes crucial (Adamson et al. 2017).

Based on literature survey, we have divided CC for manufacturing into 5 subcategories as shown in Figure 1, while Table 1 gives summary of 29 papers in these categories. This categorization is done to understand different issues in these sectors of manufacturing.

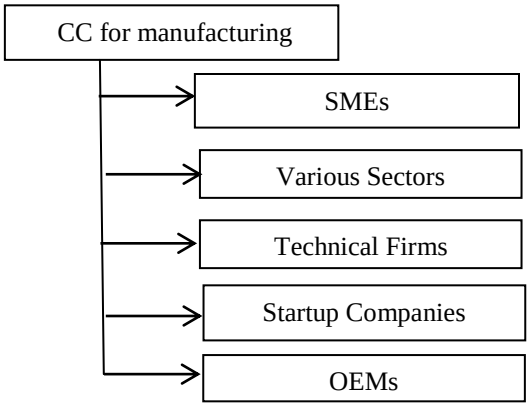

Figure 1 Classification of CC for manufacturing

Commonly used theories in cloud adoption are as follows:

- Technology-organization-environment (TOE)
- Diffusion of innovation (DOI)
- Technology acceptance model (TAM)
- Theory of planned behavior (TPB)
- Unified theory of acceptance use of technology (UTAUT)
- Organisational sustainability modelling (OSM)

Also many researchers create their own theoretical/ conceptual model. Among these models, TAM is widely accepted model for understanding IT adoption and usage processes. TAM seeks to explain the relationship between technological acceptance and adoption and subsequently, behavioral intention to use it (Davis, 1989). TOE framework was developed by Tornatzky and Fleischer (1990) to examine firm-level adoption of various IT products and services; inclusion of technological, organizational and environmental variables has made TOE advantageous over other adoption models in studying technology adoption, technology use and value creation from technology innovation. OSM is a new method to model and analyze risk and return systematically forCC . According to TPB, an individual's performance of a certain behavior is determined by his or her intent to perform that behavior. TPB does not specify the particular beliefs that are associated with any particular behavior, so determining those beliefs is left up to the researcher (Ajzen, 2014). Venkatesh et al. (2003) developed the Unified Theory of Acceptance and Use of Technology (UTAUT) by reviewing eight models; the purpose is to explain a user's intentions to use ICT and the subsequent user behavior.

Table 1 CC for manufacturing

Sr. No.	Authors	Year	Type of Industry	Country	Theory, Model
1	Alshamaila et al.	2013	SMEs	England	TOE
2	Arsovski et al.	2015	SMEs	Central Serbia	Conceptual Model
3	Bharathi and Mandal	2015	SMEs	India	AHP Tool
4	Carcary et al.	2014	SMEs	Ireland	Cloud Readiness Model and Cloud Lifecycle Management Framework
5	Doherty et al.	2015	SMEs	Ireland	TAM
6	Gangwar et al.	2015	IT, manufacturing and finance sectors	India	TAM-TOE
7	Grubisic	2014	SMEs	Western EU, Japan, USA, China, Russia, Balkan and Brazil	AHP Tool
8	Gupta et al.	2013	SMEs, SMBs	India, Singapore/ Malaysia, USA	No specific theory is used
9	Haug et al.	Article in Press	Various Industry Sectors	13 European countries	TOE
10	Hsu, et al.	2014	SMEs and Large Corporations	Taiwan	TOE
11	Hsu and Lin	2016	Various enterprises	Taiwan	TOE
12	Low et al.	2011	High- Tech industry	Taiwan	TOE and DOI
13	Marston et al.	2011	SMEs	USA	-
14	Martins et al.	2016	SMEs	United Kingdom (UK)	Nvivo 8 QSR software package
15	Misra and Mondal	2011	Start-up companies	India	Mathematical Model based on ROI
16	Oliveira et al.	2014	Manufacturing and service industries	Portugal	DOI TOE
17	Ratten	2015	Technology firms	Australia	No specific theory is used

18	Repschlaeger et al.	2013	Start-up companies	Germany	No specific theory is used
19	Ross and Blumenstein	2015	Internationally orientated SME	Australia, USA	No specific theory is used
20	Sehgal et al.	2016	EDA Industry	USA	No specific theory is used
21	Sultan	2011	SMEs	UK	No specific theory is used
22	Trigueros-Preciado et al.	2013	SMEs	Spain	No specific theory is used
23	Tsai and Hung	2014	Various sectors	Taiwan	Artificial Neural Network (ANN)
24	Wang and Unger	2013	Hardware manufacturing industry	Taiwan	No specific theory is used
25	Wang and Heb	2014	Small enterprises	Taiwan	No specific theory is used
26	Wu	2011	High- Tech industry	Taiwan	TAM and Rough Set Theory (RST).
27	Wu et al.	2015	SMEs	USA	Economic Model
28	Yigitbasioglu	2015	Manufacturing and service industries	Australia	Theoretical model
29	Yu et al.	2016	Various Industries	China	No specific theory is used

2.1 SMEs

Adoption of CC for SMEs is discussed here. According to Marston et al. (2011) CC makes prominent sense for SMEs than large enterprises as CC services are often not cost-effective for larger enterprises, especially those having very high computing operations efficiency. Alshamaila et al. (2013), Bharathi amd Mondal (2015), Trigueros-Preciado et al. (2013), Ross and Blumenstein (2015) used qualitative method through interviews in countries like England, India, Spain, Australia and USA. Semi- structured approach, discussion methods were used to collect the primary data, followed by coding and processing statistically using software like SPSS, NVivo. Arsovski, et al.(2015), Carcary et al.(2014), Doherty et al.(2015), Grubisic (2014), Hsu et al.(2014) adopted quantitative approach through questionnaire in countries like Central Serbia, Ireland, Western EU, Japan, USA, China, Russia, Balkan, Brazil and Taiwan, followed by analysis of usable responses. To address main barriers in CC adoption, Martins et al. (2016) used qualitative and quantitative approaches through survey in large corporations and SMEs of England, Nvivo 8 QSR software package was used for analysis. Gupta et al. (2013) used secondary data from literature to determine core variables in CC adoption, then primary data were collected of SMEs and SMBs situated in India, Singapore/Malaysia, and USA, followed by Exploratory Factor Analysis (EFA) using Smart PLS and CFA (Confirmatory Factor Analysis) valid respondents. Sultan (2011), Wang and Heb (2014) used case study approach of British and Taiwan SMEs to understand issues in adoption. Wu et al. (2015) carried out economic benefit analysis of Cloud-Based Design, Engineering Analysis, and Manufacturing (CBDM) of a SME which manufactures mini drone by identifying cost objects, activities, cost drivers and its rates.

2.2 Various Sectors

Gangwar et al. (2015), Hsu and Lin (2016) and Oliveira et al. (2014) applied questionnaire approach in various industries from India, Taiwan, and Portugal respectively, with adoption models as TAM-TOE, TOE, and DOI-TOE respectively; testing of models were done using structural equation modelling. Hsu et al. (2014) done survey of 200 Taiwanese firms using TOE model, followed by PLS and discriminant analysis. Yigitbasioglu (2015) used theoretical model to understand role of top management, conducted survey in Australia to receive 120 responses while partial least squares (PLS) modeling technique was used for hypothesis analysis. Haug et al. (2016) used TOE framework and secondary data from two sources Harte Hanks CI Technology Database (CITDB) and BureauVan Dijk's ORBIS in which data of various industry sectors of 13 European countries were analysed. Tsai and Hung (2014) proposed system dynamic model for CC using artificial neural network (ANN) where ANN was trained using data of various sectors of Taiwan. To understand CC adoption in VLSI, Sehgal et al. (2016) considered a case study of Electronic Design Automation (EDA).

2.3 Technical Firms

Low et al. (2011), Ratten (2016), and Wu (2011) investigated CC adoption in technical firms through questionnaire-based survey in Taiwan, Australia and Taiwan respectively. Low et al. (2011) used TOE- DOI model and collected

data from 111 firms followed by factor analysis, logistic regression, while Wu (2011) used TAM model followed by Rough Set Theory (RST), a data mining technique tool was used for data reduction in qualitative analysis using Rough Sets Data Explorer (ROSE) software. Ratten (2016) collected 142 responses from managers, followed by SPSS and confirmatory factor analysis (CFA).

2.4 Startup Companies

Misra and Mondal (2011) used Mathematical Model based on return of investment (ROI) which gives score to determine whether company can go for CC adoption. Repschlaeger et al. (2013) examined 108 start-up companies in Germany, by combining factor and cluster analysis, factor analysis to define customer preferences, while cluster analysis to identify customer segments, followed by discriminant analysis and one-way ANOVA.

2.5 OEMs

To enable CC adoption to traditional Taiwanese OEM/ODM vendor, Institute for Information Industry (III) developed Cloud Appliances for Enterprises (CAFÉ), CAFÉ Solution Technology Center (CSTC), launched by III in July 2012, gives easily installed and managed enterprise cloud offerings (Wang and Unger, 2013).

3. SWOT Analysis

There are various statistical and analytical approaches like analytic hierarchy process (AHP), analytical network process (ANP), decision making trial and evaluation laboratory (DEMATEL), interpretive structural modeling (ISM), Interpretive ranking process (IRP), multiple linear regressions (MLR) etc. The SWOT analysis is a strategic planning tool and is an acronym representing strength, weaknesses, opportunities, and threats. As CC for manufacturing does not only bring benefits, but also challenges and for that reason SWOT analysis is used.

The idea behind a CC and manufacturing combination makes prominent sense for industry. SWOT analysis is used for following reasons i) to understand CC for manufacturing better ; ii) to address weaknesses of CC for manufacturing ; iii) deter threats of CC for manufacturing; iv) capitalize on opportunities of CC for manufacturing.

This section of the paper investigates internal and external conditions for adoption of CC for manufacturing using SWOT analysis. Nowadays, industry have plan to move to the CC environment, so before moving the manufacturing sector require to have some idea about the strengths, weakness, opportunities, and threats of CC services. Therefore, the strengths and weaknesses within the industry adopting cloud architecture and the opportunities and threats from outside the industry are highlighted. Figure 2 shows the SWOT analysis of CC for manufacturing.

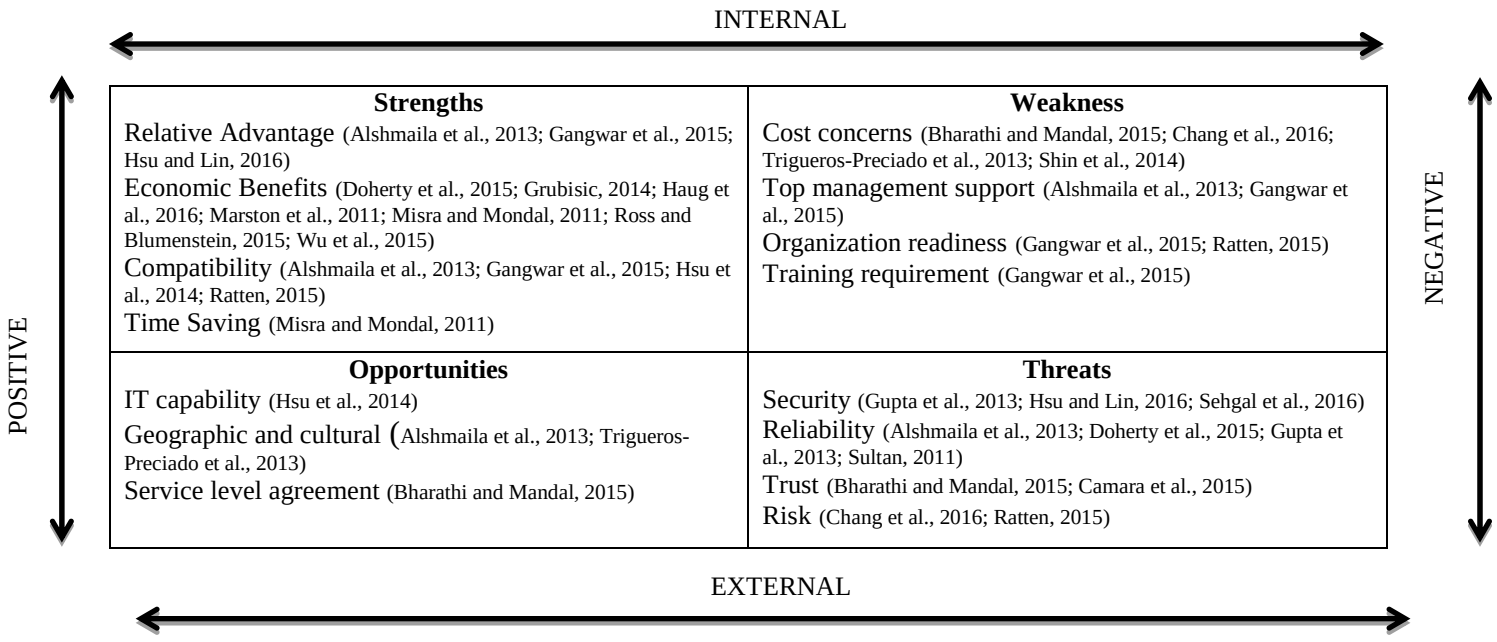

Figure 2 SWOT Analysis of CC for manufacturing

3.1 Strength

In SWOT analysis, strengths are those internal beneficial characteristics. The Strengths of CC in the manufacturing sector include: Relative Advantage, Compatibility, Economic Benefits and Time Saving.

Advantageous properties of Cloud technology such as pay-as-you-go, Everything-as-a-Service (XaaS) etc. which enables manufacturing resources and capabilities can be operated and made available to oneself or other manufacturers, independent of time and location constraints (Alshmaila et al., 2013; Gangwar et al.,2015; Hsu and Lin, 2016).

Rogers (2003) defined compatibility as "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters." According to Gangwar et al (2015) high compatibility of CC enables users not to make major changes and compatibility has positive effect on perceived ease of use. For study conducted for SMEs, Alshamaila et al. (2013) and Hsu et al. (2014) concluded that SMEs expected to adopt cloud services with ease. For study carried out for technology firms in Australia, Ratten (2016) concluded that from innovation and creative perspective there is intention of continuance use of CC.

Using the CC in the manufacturing lead to cost reduction because does not need huge infrastructural cost and start up expenditure (Haug et al., 2016; Marston et al., 2011). SMEs which faces problems of lack of the enough resources and affordable expenses will be benefited by CC (Doherty et al., 2015; Grubisic, 2014; Ross and Blumenstein, 2015; Wu et al., 2015). Start-up companies are also analyzing several characteristics of their business and pre-existing IT resources so as to move to adoption of cloud (Misra and Mondal, 2011).

The most striking contribution of Cloud technology to the business world is speed with which you can transfer information or data (Misra and Mondal, 2011). Also Cloud Manufacturing has accelerated the entire process of product development, i.e., from design to supply chain management.

3.2 Weakness

The absence of the certain strengths may be viewed as weaknesses. From the SWOT analysis point of view, weaknesses are those internal characteristics of the project that may become disadvantageous compared to other projects. The weaknesses of the CC in the industrial sector contain: Cost concerns, Top management support, Organization readiness, and Training requirement.

Cost related factors like subscription fees, maintenance cost and implementation cost featured as critical factors for Cloud ERP adoption in SMEs of India (Bharathi and Mandal, 2015). Return of investment (Chang et al., 2016), cost (Trigueros-Preciado et al., 2013) and service fee (Shin et al., 2014) are major concerns for organizations to move to cloud.

According to Alshamaila et al., 2013, for SMEs to adopt cloud services sufficient financial investment is needed and support from top management is the main challenge. Top management must understand business-related benefits of CC as well as its technological competencies and competitiveness. For manufacturing sector of India, top management support will have positive affect on perceived ease of use and perceived usefulness (Gangwar et al., 2015).

Organizational leadership is important in gaining support from members in a workforce also administrators of organizations could help better effectively use CC (Ratten et al. 2015). Organizational readiness for use CC services as well as training and education is must and will have direct effect on adoption (Gangwar et al., 2015).

3.3 Opportunities

Opportunities are those external elements that a project can use for its advantage and success. Major opportunities that can be explored and tapped into a cloud-based manufacturing system include: IT capability, Geographic constraints, and Service level agreement (SLA).

Hsu et al., 2014 examined CC adoption intensions of SMEs and large corporations of Taiwan and found that IT capability has positive influence on CC adoption. Firms' IT capability (more IT employees and greater IT budget) significantly affects their cloud adoption intention than firm size.

Based on exploratory study on SMEs in England, Alshmaila et al., 2013 identified geo-restriction as crucial factor for SMEs when considering adopting CC services. Also cultural type needs to be removed and used to positive effect (Trigueros-Preciado et al., 2013).

Service level agreement (SLA) with CC provider is significant factor companies before going for CC adoption (Bharathi and Mandal, 2015)

3.4 Threats

In SWOT analysis, threats are those external elements that, unless minimized, can cause the project to fail. The major concerns are Security, Reliability, Trust, and Risk

There is lack of control by the service provider, lack of information about the type of security the service provider employs. It causes security of data in a cloud-based service is particular concern. Data protection regulations,

security requirements and mandatory notifications of data breaches are must have exponential growth of CC for manufacturing (Gupta et al., 2013; Hsu and Lin, 2016). According to Sehgal et al., 2016 security is listed as a top concern both in the study and in the EDA industry.
Concern over continuous availability of the service is prominent in SMEs as loss of service will result in substantial loss of sale opportunities and customer dissatisfaction (Alshamaila et al., 2013; Doherty et al., 2015; Sultan, 2011). According to Gupta et al. (2013) reliability of cloud services for SMEs needs to be improved through data protection regulations, security requirements and mandatory notifications of data breaches.
Data confidentiality (Bharathi and Mandal, 2015) and trust (Camara et al., 2015) plays an important role in the information-sharing process between customer and cloud service provider.
Analyzing risk and return status of CC services and help organisations that adopt CC to evaluate and review their CC projects and services (Chang et al., 2016). According to Ratten, 2015 study on technology firms of Australia risk analysis is crucial factor for intention of CC adoption.

4. Conclusion

Cloud technology holds a key for future in all sectors, research and development has been remained topic of attraction around the globe. Cloud technology application in manufacturing paradigm is becoming popular in additive manufacturing sector and seldom in other sectors like subtractive manufacturing. This affects SMEs, OEMs throughout the globe. Based on literature review done, it is clear that CC for manufacturing has come a long way since its inception. Good amount of research and development has been going on in countries like China or USA. But there are several issues involved in industry. So this paper explains CC adoption, feature of it and manufacturing need to using the CC, and investigated on advantages and disadvantages of CC. SWOT analysis of CC in the manufacturing sector was evaluated. The results of SWOT analysis shows that manufacturing sector particularly SMEs will get benefited from CC. This needs top management support as well as overcoming issues of security and reliability.

References

Adamson, G., Wang, L., Holm, M. and Moore, P., Cloud manufacturing–a critical review of recent development and future trends. *International Journal of Computer Integrated Manufacturing*, vol. 30, no. 4-5, pp.347-380, 2017.

Ajzen, I., The theory of planned behaviour is alive and well, and not ready to retire: a commentary on Sniehotta, Presseau, and Araújo-Soares. *Health Psychology Review*, vol. 9, no. 2, pp.131-137, 2015.

Alshamaila, Y., Papagiannidis, S. and Li, F., Cloud computing adoption by SMEs in the north east of England: A multi-perspective framework. *Journal of Enterprise Information Management*, vol. 26, no. 3, pp.250-275, 2013.

Arsovski, S., Arsovski, Z., Stefanović, M., Tadić, D. and Aleksić, A., Organisational resilience in a cloud-based enterprise in a supply chain: a challenge for innovative SMEs. *International Journal of Computer Integrated Manufacturing* ,vol. 30, no. 4-5, pp.409-419, 2017.

Bharathi, S.V. and Mandal, T., Prioritising and ranking critical factors for sustainable cloud ERP adoption in SMEs. *International Journal of Automation and Logistics*, vol. 1, no. 3, pp.294-316, 2015.

Buyya, R., Yeo, C.S., Venugopal, S., Broberg, J. and Brandic, I., Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility. *Future Generation computer systems*, vol. 25, no. 6, pp.599-616, 2009.

Cámara, S.B., Fuentes, J.M. and Marín, J.M.M., Cloud computing, Web 2.0, and operational performance. *The International Journal of Logistics Management*, vol. 26, no. 3, pp.426-458., 2015.

Carcary, M., Doherty, E., Conway, G. and McLaughlin, S., Cloud Computing Adoption Readiness and Benefit Realization in Irish SMEs—An Exploratory Study. *Information Systems Management*, vol. 31, no. 4, pp.313-327, 2014.

Chang, V., Walters, R.J. and Wills, G.B., Organisational sustainability modelling—An emerging service and analytics model for evaluating Cloud Computing adoption with two case studies. *International Journal of Information Management*, vol. 36, no. 1, pp.167-179, 2016.

Davis, F.D., Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, pp.319-340, 1989.

Doherty, E., Carcary, M. and Conway, G., Migrating to the cloud: examining the drivers and barriers to adoption of cloud computing by SMEs in Ireland: an exploratory study. *Journal of Small Business and Enterprise Development*, vol. 22, no. 3, pp.512-527, 2015.

Gangwar, H., Date, H. and Ramaswamy, R., Understanding determinants of cloud computing adoption using an integrated TAM-TOE model. *Journal of Enterprise Information Management*, vol. 28, no.1, pp.107-130, 2015.

Gupta, P., Seetharaman, A. and Raj, J.R., The usage and adoption of cloud computing by small and medium businesses. *International Journal of Information Management*, vol. 33, no. 5, pp.861-874., 2013.

Haug, K.C., Kretschmer, T. and Strobel, T., Cloud adaptiveness within industry sectors–Measurement and observations. *Telecommunications Policy*, vol. 40, no. 4, pp.291-306, 2016.

Hsu, P.F., Ray, S. and Li-Hsieh, Y.Y., Examining cloud computing adoption intention, pricing mechanism, and deployment model. *International Journal of Information Management*, vol. 34, no. 4, pp.474-488, 2014.

Hsu, C.L. and Lin, J.C.C., Factors affecting the adoption of cloud services in enterprises. *Information Systems and e-Business Management,* vol. 14, no. 4, pp.791-822, 2016.

Low, C., Chen, Y. and Wu, M., Understanding the determinants of cloud computing adoption. *Industrial management & data systems*, vol. 111, no. 7, pp.1006-1023, 2011.

Marston, S., Li, Z., Bandyopadhyay, S., Zhang, J. and Ghalsasi, A., Cloud computing—The business perspective. *Decision support systems*, vol. 51, no. 1, pp.176-189, 2011.

Opara-Martins, J., Sahandi, R. and Tian, F., Critical analysis of vendor lock-in and its impact on cloud computing migration: a business perspective. *Journal of Cloud Computing*, vol. 5, no. 1, p.4, 2016.

Mell, P. and Grance, T., Effectively and securely using the cloud computing paradigm. *NIST, Information Technology Laboratory*, vol. 2, no. 8, pp.304-311, 2009.

Misra, S.C. and Mondal, A., Identification of a company's suitability for the adoption of cloud computing and modelling its corresponding Return on Investment. *Mathematical and Computer Modelling*, vol. 53, no. 3, pp.504-521, 2011.

Oliveira, T., Thomas, M. and Espadanal, M., Assessing the determinants of cloud computing adoption: An analysis of the manufacturing and services sectors. *Information & Management*, vol. 51, no. 5, pp.497-510, 2014.

Trigueros-Preciado, S., Pérez-González, D. and Solana-González, P., Cloud computing in industrial SMEs: identification of the barriers to its adoption and effects of its application. *Electronic Markets*, vol. 23, no. 2, pp.105-114, 2013.

Ratten, V., Continuance use intention of cloud computing: innovativeness and creativity perspectives. *Journal of Business Research*, vol. 69, no. 5, pp.1737-1740, 2016.

Repschlaeger, J., Erek, K. and Zarnekow, R., Cloud computing adoption: an empirical study of customer preferences among start-up companies. *Electronic markets*, vol. 23, no. 2, pp.115-148, 2013.

Ross, P.K. and Blumenstein, M., Cloud computing as a facilitator of SME entrepreneurship. *Technology Analysis & Strategic Management*, vol. 27, no. 1, pp.87-101, 2015.

Sehgal, N., Acken, J.M. and Sohoni, S., Is the EDA Industry Ready for Cloud Computing?. *IETE Technical Review*, vol. 33, no. 4, pp.345-356, 2016.

Shin, J., Jo, M., Lee, J. and Lee, D., Strategic management of cloud computing services: Focusing on consumer adoption behavior. *IEEE transactions on engineering management*, vol. 61, no. 3, pp.419-427, 2014.

Sultan, N.A.,. Reaching for the "cloud": How SMEs can manage. *International journal of information management*, vol. 31, no. 3, pp.272-278, 2011

Tornatzky, L.G. and Fleischer, M., 1990. *The Processes of Technological Innovation*. 1990. Lexington, MA: Lexington Books.

Tsai, J.M. and Hung, S.W., A novel model of technology diffusion: System dynamics perspective for cloud computing. *Journal of Engineering and Technology Management*, vol. 33, pp.47-62, 2014.

Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D., User acceptance of information technology: Toward a unified view. *MIS quarterly*, pp.425-478, 2003.

Wang, G. and Unger, J., A strategy to move taiwan's it industry from commodity hardware manufacturing to competitive cloud solutions. *IEEE Access*, vol. 1, pp.159-166, 2013.

Wang, F.K. and He, W., Service strategies of small cloud service providers: A case study of a small cloud service provider and its clients in Taiwan. *International Journal of Information Management*, vol. 34, no. 3, pp.406-415, 2014.

Wu, W.W., Mining significant factors affecting the adoption of SaaS using the rough set approach. *Journal of Systems and Software*, vol. 84, no. 3, pp.435-441, 2011.

Wu, D., Greer, M.J., Rosen, D.W. and Schaefer, D., Cloud manufacturing: Strategic vision and state-of-the-art. *Journal of Manufacturing Systems*, vol. 32, no. 4, pp.564-579, 2013.

Wu, D., Terpenny, J. and Gentzsch, W., Economic benefit analysis of cloud-based design, engineering analysis, and manufacturing. *Journal of Manufacturing Science and Engineering*, vol. 137, no. 4, p.040903, 2015.

Yigitbasioglu, O.M., The role of institutional pressures and top management support in the intention to adopt cloud computing solutions. *Journal of Enterprise Information Management*, vol. 28, no. 4, pp.579-594, 2015.

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