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USING SAAS TO ENHANCE PRODUCTIVITY FOR SOFTWARE DEVELOPERS: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Cloud computing has gain popularity as it provides on-demand software as a service (SaaS) over the internet. Nevertheless, the environment is intensely competitive and posed challenges for software developers in the development process. SaaS development is a very complex process, and the success depends highly on its productivity. The objectives of this review are twofold; to identify the key factors that influenced software developers' productivity and how cloud computing, especially SaaS, can increase productivity. This paper identifies essential factors from the literature and provides software developers' methods to support productivity. We perform a systematic literature review with total of 746 papers/documents and discover 61 papers that fit the inclusion and exclusion criteria and at the same time identify four major productivity factors i.e. cost, time, resources, and quality of the product or services.

Keywords: *Cloud Computing; SaaS; Influencing Factor; Software Developer; Productivity*

1. INTRODUCTION

The Fourth Industrial Revolution (Industry 4.0) disrupts the global setting of doing things and brings new challenges as it requires rapid digital transformation to remain competitive. According to [1] [2] [3], the transition to new digital realities has supported all kinds of new information technologies along the way. Industry 4.0 has gained popularity as it aims to build a highly flexible production model for personal and digital products and services, with real-time interaction between users, products, and devices during the production process. Ultimately, industries need to embrace digitization to achieve timely product launch, increase flexibity and at the same time, improve resource efficiency.

The revolution is closely linked to the need for continuous software development in order to meet increasingly sophisticated users' demand. The emergence of millions of remotely programmable tools in our environment poses significant challenges for software developers [4]. Directly, the rise of cloud computing has been instrumental in supporting software developers to make development and implementation work faster and systematic. As an innovative service platform, cloud computing provides a variety of resources such as Infrastructure as a Services (IaaS), Platforms as a Services (PaaS), and Software as the Services (SaaS) [5]. However, according to [6], cloud computing is a practice in which computing services such as storage options, processing units, and network capabilities are exposed to Internet users. This is similar to the electricity distribution industry, whereby users are not custodian of any major electricity grid network but instead, draws electricity according to their individual needs from a broader application of electricity [7].

Preliminary analysis shows that the concept of cloud computing, especially SaaS is vital for software developers as it facilitates the tasks in hand, increases productivity, and eventually contributes to cost savings. Therefore, this research aims to identify the major contributions of SaaS services; especially towards increasing software developers' productivity.

Motivation and research questions are based on commonly used cloud computing models, a method that helps software development to be implemented more efficiently and subsequently contribute to an increase in productivity. We review journal papers and conference proceedings related to the research topics to validate the hypothesis.

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2. BACKGROUND

In principle, cloud computing technology represents a new paradigm for hosting software applications. This paradigm simplifies the time-consuming processes of hardware provisioning, hardware procurement, and software deployment [8] to support the development, customization, and deployment of application components across multiple clouds [9]. More often than not, developers face obstacles such as compatibility issues to find the best product for their needs, which may divert them from focusing on their service development tasks. Hence, developing a service diagnostic evaluation system is an increasingly important area in cloud computing field [10].

Cloud offers many strong points: infrastructure flexibility, faster deployment of applications and data, cost control, an adaptation of cloud resources to real needs, and improved productivity [10]. Meanwhile, [11] understanding, measuring, and optimizing software developers' productivity is essential to deliver software on time and at reasonable cost and quality. Developers' productivity plays a vital role in software development organizations [12]. On the other hand, productivity increases using cloud computing-evolving technology. It offers significant benefits such as pay only for what was being used and efficient resource allocation. These benefits have resulted in a tremendous increase in the number of applications and services hosted in the cloud [9].

The focus of research is on SaaS, which is part of a paradigm shift towards cloud computing in information technology procurement software, hardware, and procurement services. SaaS applications are also known as web-based software, on-demand software, or hosted software [13]. Its use is widespread when using the latest technologies while making it easier for the software developer to achieve it [14]. However, SaaS can help software developers to enhance the existing cloud computing support to meet the requirements and needs of stakeholders or users [15]. Therefore, SaaS helps software developers to develop quality and effective systems in terms of their use [16]. Furthermore, it reduces cost, as SaaS applications are mostly free at the moment [17].

In this paper, we present findings from our systematic literature review on SaaS. The objectives of this review are to identify the key factors affecting software developers' productivity and the various ways that cloud computing, especially SaaS, are able to increase productivity. A systematic literature review is defined as a procedure of identifying, evaluating and interpreting all available research evidence to answer particular research questions, topic areas, or phenomena of interest [18]. It provides comprehensive overviews of particular research objects and identifies areas where extensive research had been done or areas that need further research. The rest of this article is organized as follows. Section 2 explains the review of methodological approach to analyze the current state of literature. Section 3 details the results according to different analyzed variables. Section 4 describes each of the design key factors of productivity, and finally, Section 5 concludes this paper.

3. METHODOLOGY

The review follows the procedures of Kitchenham and Charter Guideline [18] [19]. The overall process is organized into three phases: (i) planning, (ii) conducting the review, and (iii) reporting the result; as summarized in Figure 1. The planning phase identifies the review objectives, define the research questions, develop a review protocol, and validate the review protocol. The conducting phase identifies relevant study, select primary studies, assessing study quality, extracting required data, and synthesizing data. The last phase reports the review results.

2.1 Planning Phase

This review aims to answer the following research questions;

Q1. Which cloud computing models used the most by software developers during the last five years (2015 – 2019)?
Q2. Which journals and conferences lead this research topic?
Q3. Which cloud services (SaaS) methods can help software development?
Q4. What factors influenced the productivity of software developers the most?
Q5. What are the benefits of using SaaS that can increase the productivity of software developers?

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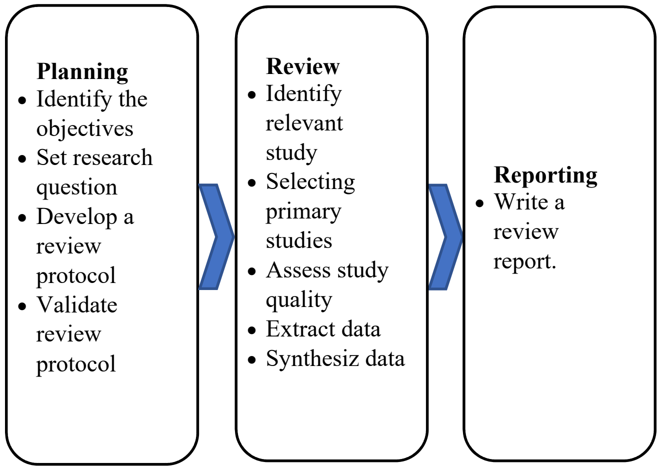

Figure 1: Three Phases Of The Review Method

The search strategy comprises searching the terms, literature resources, and the search processes. For the search process, we focused on four online databases: IEEE Xplore, Scopus, Science Direct, and ISI Web of Science.

The following search terms were used: "cloud computing," "SaaS," "Software as a Services," "productivity," and "software developer." To generate the search string, a Boolean language with AND, and OR, and quotation marks for exact text were used. Thus, the search string used is:

- ("software developer" AND “productivity”) OR
- ("software developer" AND “cloud computing”) OR
- ("cloud computing" AND “productivity”) OR
- ("cloud computing" AND “SaaS”) OR
- ("cloud computing" AND “Software as a Service”) OR
- ("software developer" AND “SaaS”) OR
- ("software developer" AND “Software as a Service”)

In addressing Q1 and Q2, we identify the number of documents published per year and the respective journal/conferences that published them. For Q3 and Q4, we analyzed the methods applied and the factors of productivity by authors. We also established, the criteria with regards to the literature sources and keyword searches. For example, the analysis may include documents written only in English language or published in each database.

The selection criteria are established to determine which studies are included or excluded for the review. The inclusion and exclusion criteria are shown in Tables 1 and 2, respectively.

Table 1: Inclusion Criteria In The Qualitative Review

Id	*Criteria*
I1	Documents which depict their applications regarding Cloud Computing, SaaS, and software developer
I2	Documents which clearly describe the objective
I3	Documents which clearly describe their factors of productivity
I4	The publications are in English.
I5	The publications are published in the timeframe from Jan 2015 to Dec 2019.

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Table 2: Exclusion Criteria In The Qualitative Review

Id	*Criteria*
E1	Documents which do not apply Cloud Computing, SaaS, and Software developer
E2	Duplicate content, i.e., an extension of a conference document to a journal article
E3	E-book review, Book chapter, Technical Report, Thesis
E4	Article in Press, Accepted Manuscript, Unpublish work

3.2 Review Phase

In this phase, the search string was executed in the search engine of each selected digital library. The keyword based search yields 746 articles. Based on the abstracts we eliminate the duplicates as some articles were indexed by more than one database. Of the 746 articles, nine articles are duplicates based on the abstract. Of these remaining 737 articles, 163 were selected as we discard 574 articles after screening using inclusion and exclusion criteria on the title, keywords, and abstract.

In the analysis procedure, the 163 selected articles were thoroughly analyzed via thorough reading. Subsequently, 102 articles were eliminated based on the exclusion criteria, which leaves 61 articles. The last step of the conducting phase is synthesizing the extracted data from the primary studies to answer the research questions. These review processes are illustrated diagrammatically in Figure2.

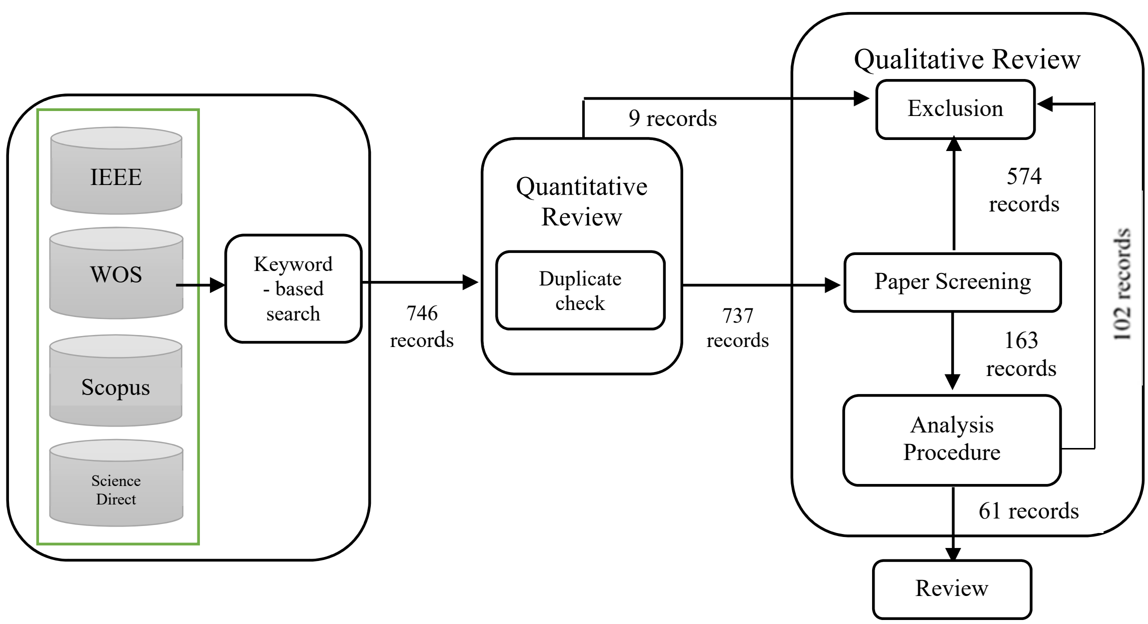

Figure 2: Flowchart Of Systematic Literature Review Process And Number Of Included And Excluded Papers In Each Step

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4. RESULTS

The following sections discuss the answers to our research questions.

Q1. Which cloud computing models used the most by software developers during the last five years (2015 – 2019)?

Figure 3 shows the articles related to the research topics published during 2015-2019. Interestingly, we found that articles on SaaS are discussed the most by researchers, comprising 74.3% of the total articles (26 articles). In contrast, IaaS only represents 11.4% of total articles (five articles), mainly on edge and fog computing.

The Fog computing infrastructure uses processing power to reduce data transmission and delay. IaaS model provides virtual infrastructure functions to flexibly provision suitable virtual machines' (VM) types and locations, configure the network connection for each VM, and shared network lets to represent a set of virtual machines (VMs). Although PaaS only covers four articles during that period, which involved a lot of serverless computing. Serverless computing provides scalability and cost reduction, without requiring any additional configuration overhead on the part of the developer.

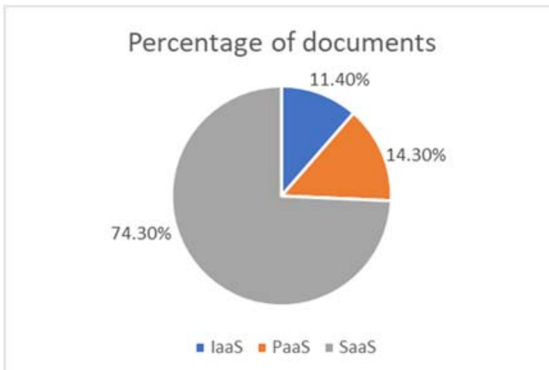

Figure 3: Type Of Model Of Cloud Computing Per Documents

Q2. Which journals and conferences lead the research topic?

The articles are classified into two types i.e. scientific journals, and conference proceedings. Table 3 presents the 2019 Journal Citation Reports (JCR) Impact Factor (IF) which reflects the average number of citations. Journals with higher impact factors are considered to be highly influential in their respective field than those with lower impact factors. As shown in Table 3, most of the recorded articles were published in journals ranked in the first up until a fourth quartile.

To conduct a more in-depth analysis, we extract the categories of these leading journals to explore the areas of knowledge in which this research topic has a more significant impact. As such, a journal may have been associated with more than one subject category. Table 4 details, , the different types of which the journals in Table 3 are indexed accordingly. The second column indicates the number of times that the category is repeated among the various journals. These results provide quantitative evidence about the multi-disciplinary character of this research topic.

Following the same criteria of the journal's analysis, Table 5 presents the research domain's most relevant conferences. The total number of conferences is 35, most of which are of international scope. These conferences represent almost 50% of records concerning conference-type (17 out of 35). Finally, the last column shows the 2018 CORE Conference Ranking [48], which provides assessments of conferences in the computing disciplines (CORE, 2018). The conferences are classified according to the following categories: A* (exceptional conference), A (excellent conference), B (good to a very good conference), C (sound and satisfactory conference), Australasian (a conference for which the audience is primarily Australians), unranked (a conference for which no ranking decision has been made) and unlisted (a conference was unclear that it met minimum academic requirements).

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Table 3: Reference Journals For The Research Topic And Their Impact Factor

Journals	***No. doc***	***JCR-IF (2019)***	***Quartile***
Information and Software Technology	1	2.627	Q1
Journal of Systems and Software	3	2.278	Q1
IEEE Transactions on Cloud Computing	2	7.928	Q1
Software: Practice and Experience	2	1.338	Q3
ACM Transactions on Autonomous and Adaptive Systems	1	1.216	Q2
IEEE Transactions on Parallel and Distributed Systems	2	3.971	Q1
Gigascience	1	7.267	Q1
Cluster Computing	1	1.601	Q2
IEEE Transactions on Services Computing	3	4.418	Q1
Astronomy and Computing	1	2.704	Q2
IEEE Pervasive Computing	1	3.022	Q1
Journal of Logical and Algebraic Methods in Programming	1	0.634	Q4
Future Generation Computer Systems	2	4.639	Q1
IEEE Transactions on Reliability	1	3.520	Q1
Canadian Journal of Information and Library Science	1	0.258	Q4
Concurrency and Computation: Practice and Experience	1	1.447	Q3
Ann. Telecommunication	1	1.933	Q2
Journal of Internet Technology	1	1.301	Q3
Total	**26**		

Table 4: Indexed Categories Of Journal In Table 3

Subject Categories	***No. journals***
Computer Science, Theory & Method	8
Computer Science Applications	6
Computer Science, Software Engineering	5
Computer Science, Information System	4
Multidisciplinary Science	1
Information Science & Library Science	1
Telecommunication	1
Total	**26**

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Table 5: Reference Conferences For The Research Topic Where Records Are Published

Conference	No. doc	Acronym	CORE 2018
International Conference: Sciences of Electronics, Technologies of information and Telecommunication	1	NICS	Unranked
Information Technology, Electronics, and Mobile Communication Conference	1	IEMCON	-
ACM Conference	2	ACM	Unranked, A*
IEEE International Conference on Communications	2	ICC	B
IEEE Conference on Electronic Commerce Technology and Enterprise Computing, eCommerce and eServices	1	CBI	B
International Conference on Recent Advances in Information Technology and Applications	1	RAIT	C
Iberian Conference on Information Systems and Technologies	1	CISTI	Regional
International Conference on Software Engineering	1	ICSE	A*
IEEE International Symposium on Parallel and Distributed Processing with Applications	1	ISPA	B
IFIP/IEEE International Symposium on Integrated Management	1	IFIP/IEEE(IM)	A
International CSI Computer Conference	1	CSI	C
IEEE International Conference on Multimedia Computing and Systems	1	ICMCS	A
Conference on Computers, Freedom, and Privacy	1	CF	C
International Conference on Computational Science	1	ICCS	A
IEEE Network Operations and Management Symposium	1	NOMS	B
Total	**17**		

Q3. Which cloud services (SaaS) methods can help software development?

We identify four computational methods: visualization, multi-tenancy, Cloud Restful API and Open API, and distributed development from the articles. As shown in Table 6, most SaaS uses a visualization method, whereby multiple users share physical resources without them knowing each other. This virtualization system enhances the efficiency of resource utilization and power consumption [49]. In such a scenario, container-based virtualization is lightweight virtualization technology, enabling high resource utilization and less overhead, suitable for hosting software and effectively managing the resources.

The multi-tenancy method can be economical because software development and maintenance costs are shared. Additionally, SaaS can run one instance of its application on a database and provide web access to multiple customers. Each tenant's data is isolated and remains invisible to other tenants. In this way, customers do not share or see each other's data. The SaaS distribution model helps the software developer to access applications hosted online, hence minimizing them from encountering issues such as installation, maintenance, or integration.

While Cloud Restful API and Open API methods are to develop and design interoperable with using different platforms. RESTful web service will provide data via an API over the network using HTTP, possibly interacting with databases and other web services. Finally, the distributed development method is to extend and support packages. The applications are location independent, and the users can access the cloud services from any location and with any mobile device through the Internet.

Table 6: Computational Method To Using SaaS

Reference	Method	Description
Celesti[23], Dehury[24], Fokaefs[25], Hong[26], Kim[27], Morris[31], Chae[32], Crago[33], Degouw[34], Candiea[38], Sharif[40], Church[41], Saha[43], Sobczak[44]	Visualization	• docker container for virtualization • to directly control Virtual Machines through HTML5 web applications are emerging • managing virtual and heterogeneous resources • GPU virtualization • Visualization container
Maenhuat[30], Preveneers[35], Cao[36], Kumara[37], Martino[39]	Multi-tenancy	• migrate existing applications to a public cloud environment • integration of systematic scalability tests in a continuous integration process • can considerably complicate SaaS development, deployment, and maintenance • allows a set of virtual service networks to coexist on the same service network at runtime simultaneously
Braba[20], Lee[29], Grace[42] Tseng[45]	Cloud Restful API and Open API	• to develop and design interoperable
Huang[21], Cai[22], Kranjc[28]	Distributed development	• to extend and supports distributed development with packages

Q4. What factors influenced the productivity of software developers the most?

According to [33], [36], and [46], SaaS has attracted substantial attention as a tool for software delivery. The service model provides developers flexibility because it is able to provide a vast pool of computing resources for the purpose of code development and testing. It is a well known fact that code repositories, a key driving force to support developer collaboration as well as software productivity.

We focus on, four key productivity factors: cost, time, resources, and quality of the product or services. Figure 4 presents the number of articles according to the respective authors' factors during the period. As any particular record may address more than one aspect, the number of copies per year does not tally with the previous results presented in Figure 3. The focus is on enhancing productivity to meet the competition of quality, cost, time, and flexibility issues [47]. Therefore, according to Table 7, these four factors are closely related to the system developer's productivity for efficiency in producing a product or services.

Figure 4. The Number Of Documents Per Year And Factor

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Table 7: Identified Design Key Factors Through Systematic Literature Review

Factors	References	Frequency
Cost	[21], [24], [25], [29], [30], [31], [33], [35], [36], [38], [39],[40], [41], [43], [44]	15
Time	[21], [22], [24], [36], [37], [42]	6
Resources	[20], [23], [25], [26], [27], [28], [32], [33], [34], [35], [36], [41], [43], [45]	14
Quality of product/service	[34], [35], [38], [40]	4

A. Cost

The annual cost of the organization will be less as hardware setup is not required. Hence, so that it saves the setup as well as maintenance costs.

B. Time

The user does not have to write code as such logic can easily be added by using the drag and drop function. Ultimately, the coding time can be saved, and consequently contribute to timely development process.

C. Resources

Resource sharing for tenants:

- Federal sharing: subscribed resources are shared between unrelated tenants or sibling tenants in one federal. The ownership of such resources is not changed. Security is ensured by federal trust and outer-role constraints.
- Inheritance sharing: system resources inherit from parent to child tenants. The ownership of such resources may be changed from the parent-tenant to the subtenant, such as the data space re-allocation case. Once the ownership is changed, the former owner loses its authority over the resource until the data space re-allocation case. Once the ownership is changed, the former owner loses control of the resource.

D. Quality

Quality of a product can be primarily described as the collection of features and characteristics of a product that contribute to its ability to meet given requirements and satisfy the customer's demands and needs.

Q5. What is the benefit of using SaaS that can increase the productivity of software developers?

From this systematic literature review, we have also identified several benefits as elaborated further below:

A. Shorten the time required

In contrast to the traditional model, the software (application) in SaaS is already installed and configured. Users have the advantage of easily provisioning the server in the cloud, and can have the application ready for use in no time. This reduces the time spent in installation and configuration and can reduce the issues that can get in the way of the software deployment [21] [22] [24] [36] [37].

B. Lower Cost

SaaS has a differential regarding costs since it usually resides in a shared or multi-tenant environment where the hardware and software license costs are low compared with the traditional model [36] [37] [38]. Maintenance costs are reduced, as well [26].

C. Scalability and Integration

SaaS solutions reside in cloud environments that are scalable and have integration with other SaaS offerings. Hence, software developers do not have to purchase additional server or software. They only need to enable a new SaaS offering and server capacity planning [34] [35].

D. New Releases (Upgraded)

SaaS providers offer continuous upgrade and made them available to their customers [22] [23]. Hence, the costs and effort associated with upgrading and acquiring new releases are lower than the traditional model. Otherwise, software developer needs to incur additional costs to purchase package upgrade or pay for specialized services to upgrade the environment [28].

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E. Easy to Use and Perform Proof of Concepts

SaaS is easy to use since it is already incorporates the best practices and samples for easy guidance and reference. Software developers can proof concepts and test the software functionality or a new release feature in advance [26]. They can also have more than one instance with different versions and do a smooth migration [23]. Even for large environments, software developers can use SaaS offerings to test the software.

5. DISCUSSION AND CONCLUSION

In conclusion, this research contribution helps software developers explore the widespread use of SaaS and allows them to increase work productivity more effectively and efficiently. The research questions raised will also be able to help software developers use the methods in the execution of work. Therefore, the benefits that will be obtained are very beneficial to software developers.

Hence, understanding software developer productivity is important to deliver software on time and at a reasonable cost. Yet, there are numerous definitions of productivity and, as previous research found, productivity means different things to different developers. In this paper, we analyze the success of software developers is entirely dependent on four factors of productivity: cost, time, resources, and quality. Identifying key success factors of software developers' productivity will help industries win customer satisfaction and easily achieve IR 4.0.

From this point, the suggestion is to use SaaS applications available in the market such as office software, software development, software management, and others to launch the tasks to be carried out with more structured and systematic.

This paper presents a systematic literature review to investigate how cloud computing as a software service (SaaS) affects software developers' productivity. We identify the time and quality of the main design factor that is deficient in literature. In the future, we will study and analyze to increase productivity from technical factors such as process, development environment, and product for software developers. Therefore, we developed a model to ensure that technical factors can accelerate a system's development and increase software developers' productivity.

Finally, for further reviews like this, it would be extremely useful if the researchers that report about the influence of specific factors on productivity were describing the factors, the measurement units, and the context in more detail. Then the knowledge can be aggregated in ways that can provide even more value.

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