Analysing The Factors Influencing DevOps Adoption in The Existing DevOps Adoption Models: A Systematic Review

Zalehah Muyet*[1], Shamsul Sahibuddin[2]

[1,2]*Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, Kuala Lumpur*
[1]*mzalehah2@graduate.utm.my*,[2]*shamsul@utm.my*

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*Corresponding author
mzalehah@graduate.utm.my

Abstract

DevOps is a modern software process that evolved to fill the gap between software development (Dev) and IT operation (Ops) teams emphasising collaboration. Breaking the silos amongst the software developers and IT Operations teams is essential to achieve the same goal in the software process and deliver quality software. However, there are relatively few DevOps models in the literature. Practitioners have different perspectives on how to adopt DevOps. Thus, understanding the factors that influence the decision-making toward DevOps adoption is crucial. Even though previous studies have discussed the factors influencing DevOps adoption, this paper will identify the factors stated in the existing DevOps adoption models. We conducted a systematic literature review on the DevOps adoption model and identified six related DevOps adoption models. Next, we identified the factors influencing DevOps adoption highlighted in the models. The factors highlighted are automation, collaboration, sharing, measurement, resilience, agility, develop and deploy cloud-based application, quality, continuous improvement, and leadership.

Keywords: *DevOps, DevOps adoption model, automation, collaboration, sharing, measurement, resilience, agility, cloud-based application, quality, continuous improvement, leadership*

1. Introduction

Demands for software solutions increased as customers discovered they could expect more features, functionality, and quality from their software investment. Traditional software development approaches might not be enough to obtain a competitive edge in the software market. It might take months or years for software to be developed, deployed, and used by customers. At the same time, operation functions are often not in line with the development function, which also happens in modern software approaches like Agile. This created silos and a bottleneck situation, which extended software deployment. DevOps, as a modern software process [1], bridges the gap between software development (Dev) and IT operation (Ops) teams emphasising collaboration [2].

Organisations over the years have shown the growing significance of the need to understand and implement DevOps [3]. The cycle, lead time, and risk of errors associated with development and operation activities are reduced by DevOps. Additionally, it decreases time-to-market and increases customer satisfaction [4-

* *Corresponding author. mzalehah@graduate.utm.my*

10]. However, it is still ambiguous and challenging to implement DevOps in reality [11]. There are relatively few DevOps models in the literature [12]. As a result, practitioners have various viewpoints regarding how to adopt DevOps [13-14]. Therefore, understanding the factors that affected the adoption of DevOps is essential. Agencies will implement DevOps with more success if they comprehend this.

This paper presents a systematic review of the DevOps adoption model and the influence factors of DevOps adoption that have been stated in DevOps adoption models. The findings will be helpful for a more comprehensive assessment of the factors influencing DevOps adoption. The paper is organised into four sections: Section 2 explains the research methodology. Section 3 describes the results. Section 4 presents research conclusions, limitations, and suggestions for future research.

2. Methodology

This study uses a Systematic Literature Review (SLR) to identify the existing DevOps adoption model in the literature. SLR enables researchers to look for studies outside their subject areas and networks compared to traditional literature reviews by adding advanced search techniques, specified search strings, and standard inclusion and exclusion criteria [15]. This study also analysed the factors influencing DevOps adoption in the models. Established guidelines by Mohamed Shaffril et al. [16] has referred to as a guide for SLR. Systematic searching strategies were run to identify the existing DevOps adoption model. Three sub-processes of systematic searching strategies were performed to ensure rigorous and systematic searching: identification, screening, and eligibility. The details of sub-processes are presented in Table 1.

Table 1. Three sub-processes of systematic searching strategy

Sub-processes	Details
Identification	**Main Keywords** DevOps, Adoption, and Model **Enriched Keywords** DevOps = Development and Operation, Continuous Integration, Continuous Delivery, Continuous Deployment Adoption = Acceptance, Approval Model = Model **Suggested Keywords by Scopus** DevOps Implementation Framework; DevOps Reference Architecture; DevOps Practices DevOps Maturity Model; DevOps Conceptual Framework **Full Search String (Scopus and Web of Science)** (("DevOps" OR "development and operation" OR "Continuous Integration" OR "Continuous Delivery" OR "Continuous Deployment") AND (" adoption" OR "acceptance" OR "approval") AND ("model") OR ("D evOps Implementation Framework" OR "DevOps Reference Architecture" OR "DevOps Practices" OR "DevOps Maturity Model" OR "DevOps Conceptual Framework"))
Screening	**Inclusion Criteria** Timeline: 2015 to 30 September 2020

Sub-processes	Details
	Publication Type: Article journal, book, chapter in the book, conference paper. Language: English **Exclusion Criteria** Timeline: Before 2015 and after 30 September 2020; Publication Type: Newspaper, review paper; Language: Non-English
Eligibility	Reading the title and abstract of the articles, and if there was still no clear understanding, the article's content was examined.

2.1 Systematic Searching Strategy

Identification starts with searching for synonyms and related terms for the main keywords, namely DevOps, adoption, and model. Then, suitable keywords are determined, relying on an online thesaurus and keywords suggested by Scopus. This study uses two databases, Scopus and Web of Sciences. This is in line with the suggestion by Gusenbauer and Haddaway [17], who confirmed the searchability of these two leading databases as search sources. Using an advanced search, 1473 potential articles were obtained during the initial stage of the keyword search. The 1473 articles chosen for this study were all screened by selecting the automatic sorting criteria that were made available in the chosen databases. The same criteria were used across the selected databases; whenever sorting functions were unavailable, the articles were excluded manually. Okoli [18] recommended that researchers choose the range of periods they can review. Therefore, the timeline between 2015 and 2020 (30 September) was selected as one of the inclusion criteria. To assure the quality of the review, only articles published in a journal, book, or chapter in a book, as well as conference papers, are included. Moreover, only articles published in English are incorporated in the review. There were 1009 articles selected, and seven were retrieved using manual searching (handpicking, citation, reference tracking). A total of 1016 articles were used for the eligibility process. The eligibility process has excluded 950 articles, and 52 are duplicated articles, leaving 14 for a quality appraisal (Table 2).

Table 2. 14 Articles for Quality Appraisal

Author	Title
[19]	Toward a unified DevOps model
[20]	DevOps Shifting Software Engineering Strategy Value Based Perspective
[21]	Composable DevOps: Automated Ontology Based DevOps Maturity Analysis
[22]	On the Impact of Mixing Responsibilities Between Devs and Ops
[23]	Simplifying the DevOps Adoption Process Challenges of DevOps Adoption
[24]	Closing the IT development-operations gap: The DevOps knowledge sharing framework
[25]	The DevOps adoption playbook: a guide to adopting DevOps in a multi-speed IT enterprise
[26]	A DevOps collaboration culture acceptance model
[27]	The Path to DevOps
[28]	Microservices: Architecting for Continuous Delivery and DevOps
[12]	Towards the adoption of DevOps in software product organizations: A maturity model approach
[11]	Adopting DevOps in the real world: A theory, a model, and a case study
[29]	In DevOps Culture, Communication and Collaboration Are Key

Author	Title
[30]	RMDevOps: A Road Map for Improvement in DevOps Activities in Context of Software Organizations

2.2 *Quality Appraisal*

The quality of 14 articles (Table 2) was assessed by two reviewers focusing on the abstract, method, and main results. Reviewers should qualitatively evaluate the quality of the articles by classifying them into low, moderate, and high categories, according to Petticrew and Roberts [31]. Only articles of high or moderate quality are included. The reviewers are guided by these four criteria for assessing an article's quality in accordance with Hong *et al.* [32]: (1) Are there clear research questions?; (2) Do the collected data allow to address the research questions?; (3) Are the articles' main aims related to DevOps adoption?; and (4) Are the articles discussing on DevOps adoption model? The reviewers have three options for the response for each set of criteria: yes, no, or can't tell. If the articles meet four criteria, the reviewers conclude that they are of high quality; if they meet three criteria, they are labelled as moderate in quality; and if they meet just one or two criteria, they are of low quality. The reviewers of this study agreed that six articles met the requirement (high or moderate) and decided to include these six articles in the review (Table 3). This study conducted a thematic synthesis of the selected articles, emphasising factors influencing DevOps adoption. The approach entailed identifying recurrent themes and summaries the findings of primary studies under these themes [33]. Figure 1 shows the articles removed from each stage and the selection of articles.

Table 3. Six articles decided from quality appraisal

Author/Articles	**Approach Type**	**Methodological quality criteria**				**Reviewer A**	**Reviewer B**	**Need discussion / Second opinion**	**Decision/ Decision after discussion**
		1. Are there clear research questions?	2. Do the collected data allow to address the research questions?	3. Are the articles' main aim related to DevOps adoption?	4. Are the articles discussing on DevOps adoption model?				
[23]	Quantitative	Yes	Yes	Yes	Yes	High	High	-	**Accepted**
[11]	Qualitative	Yes	Yes	Yes	Yes	High	High	-	**Accepted**
[26]	Qualitative	Yes	Yes	No	No	Low	Low	-	Rejected
[27]	None	No	No	No	No	Low	Low	-	Rejected
[29]	None	No	No	No	No	Low	Low	-	Rejected
[28]	Qualitative	No	No	No	No	Low	Low	-	Rejected
[12]	Qualitative	Yes	Yes	Yes	Yes	High	High	-	**Accepted**
[19]	Qualitative	No	Yes	Yes	Yes	Moderate	Moderate	-	**Accepted**
[24]	Quantitative	No	Yes	Yes	Yes	Moderate	Moderate	-	**Accepted**

Author/Articles	**Approach Type**	**Methodological quality criteria**				**Reviewer A**	**Reviewer B**	**Need discussion / Second opinion**	**Decision/ Decision after discussion**
		1. Are there clear research questions?	2. Do the collected data allow to address the research questions?	3. Are the articles' main aim related to DevOps adoption?	4. Are the articles discussing on DevOps adoption model?				
[20]	Qualitative	No	No	No	No	Low	Low	-	Rejected
[25]	None	No	No	No	No	Low	Low	-	Rejected
[22]	Quantitative	Yes	Yes	Yes	Yes	High	High	-	**Accepted**
[30]	Mixed Methods	Yes	No	Yes	No	Low	Low	-	Rejected
[21]	None	No	No	No	No	Low	Low	-	Rejected

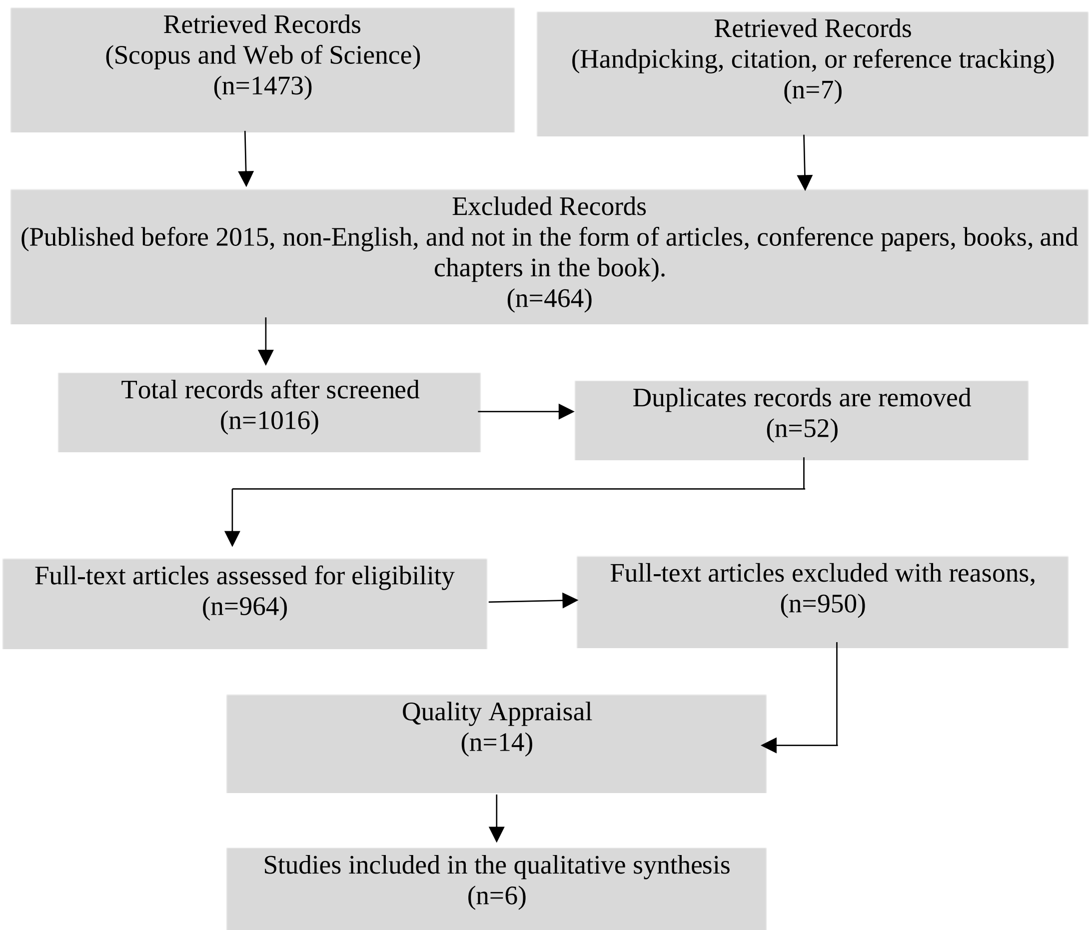

Fig. 1. The flowchart of articles selection

3. Results

3.1 RQ1: What are the existing DevOps adoption models in the literature?

This study has extracted any data that assist in answering the research questions [16]. From the quality appraisal, six (6) DevOps adoption models were identified as depicted in Table 4.

Table 4. Identified DevOps adoption models

Author	Title	Models	Document Type
[23]	Simplifying the DevOps Adoption Process	Simplified DevOps Adoption Process	Conference Paper
[11]	Adopting DevOps in the real world: A theory, a model, and a case study	DevOps Adoption Model	Article Journal
[12]	Towards the adoption of DevOps in software product organizations: A maturity model approach	Maturity Model Approach	Article Journal
[19]	Toward a unified DevOps model	Unified DevOps Model	Conference Paper
[22]	On the Impact of Mixing Responsibilities Between Devs and Ops	Mixing Responsibilities	Conference Paper
[24]	Closing the IT development-operations gap: The DevOps Knowledge Sharing Framework	DevOps Knowledge Sharing Framework	Conference Paper

The model by Luz, Pinto, and Bonifácio [11] has been successfully implemented within a Brazilian government institution and [24] was evaluated at a small IT Service firm and a large financial services company. The evaluation supports the general applicability of the model in both companies. Meanwhile, there is no evidence that other DevOps adoption models [12][22][19] have been tried and tested in any organisation and the public sector. Likewise, the [23] model has not yet been determined if it benefits large enterprises.

Practitioners have different views on how to adopt DevOps [13-14]. Most companies do not use the existing DevOps adoption models in adopting DevOps [34], and this was proved by [34-39] in their study, as summarised in Table 5.

Table 5. A Summarised Previous Study on DevOps adoption model

Previous Studies	Tasks	DevOps Adoption Models						DevOps adoption approach/practices
		[23]	[11]	[12]	[19]	[22]	[24]	
[35]	Comprehensive interviews with six DevOps practitioners from one multinational organisation.	×	×	×	×	×	×	It did not mention how the practitioners adopted DevOps.
[36]	An industrial survey to get insights into how performance	×	×	×	×	×	×	It did not mention a specific model for adopting DevOps. Instead, it noted that the vast majority use

Previous Studies	Tasks	DevOps Adoption Models [23]	[11]	[12]	[19]	[22]	[24]	DevOps adoption approach/practices
	was addressed in industrial DevOps settings.							tools such as Git (77%) for version control systems and Jenkins for continuous builds (77%) and deploy their software (65%).
[37]	Cumulated data via 30 interviews with DevOps practitioners from 9 different industry domains and ten countries.	×	×	×	×	×	×	IT Service Management (ITSM) processes.
[38]	Conducted interviews at companies with DevOps practitioners.	×	×	×	×	×	×	Did not specify the model in adopting DevOps. Instead, it mentioned the necessity of automation. - Using open-source configuration tools such as Chef.
[39]	Was done a multi-case study of five companies that adopted DevOps concepts.	×	×	×	×	×	×	Amazon Web Services (AWS) cloud platform.
[34]	Analyzed the practice of DevOps in various software development companies.	×	×	×	×	×	×	DevOps cross-organisation approach - a DevOps team helps others according to their necessities.

This research revealed that adopting DevOps is challenging and not straightforward. Each practitioner's perspective on implementing DevOps is based on their goal and objective in software delivery. Consequently, no two enterprise-adopted DevOps approaches would be similar as each enterprise has unique characteristics and requirements [40].

3.2 RQ2: What factors influence DevOps adoption highlighted in the DevOps adoption models?

The main objective of this study is to identify the factors influencing DevOps adoption. The factors are derived from the selected DevOps adoption models since the authors have dealt with experienced DevOps practitioners when developing the models. It is crucial to understand the factors influencing the decision-making in comprehending the decisions that impact the outcomes [41]. Before implementing DevOps, agencies need to understand the factors influencing DevOps adoption in their organisation for better decision-making and strategic planning [23]. The influence factors highlighted in the models are automation, collaboration, sharing, measurement, resilience, agility, develop and deploy cloud-based application, quality, continuous improvement, and leadership, as depicted in Table 6.

Table 6. Factors Influencing DevOps adoption

Factors	**DevOps Adoption Models**						**Frequency in the models**
	[23]	[11]	[12]	[19]	[22]	[24]	
Automation	√	√	√	√	√	√	**6**
Collaboration							**6**
- Collaboration	√				√	√	
- Collaborative culture		√					
- Culture and collaboration			√				
- Collaboration culture				√			
Quality							**5**
- Quality	√			√		√	
- Quality assurance		√					
- Higher quality			√				
Measurement							**3**
- Measurement	√					√	
- Continuous Measurement		√					
Sharing							**5**
- Sharing					√	√	
- Sharing and Transparency		√					
- Shared responsibility				√			
- Knowledge Sharing	√						
Agility							**2**
- Agility		√					
- Agility and Process Alignment			√				
Resilience		√					**1**
Develop and deploy cloud-based application			√			√	**2**
Continuous improvement			√			√	**2**
Leadership					√	√	**2**

Table 6 shows that authors use different names to explain the factors but still have the same concepts; for example, to describe how collaboration could break down the silos between development and IT operation, the authors use the term collaborative culture [11], collaboration [22-24], collaboration culture [19], and culture and collaboration [12]. Same as quality, the authors use the term quality [19][23][24], quality assurance [11], and higher quality [12] to explain the product quality or standard quality. For measurement, which aims to help measure the progress of the adoption process, the authors use the term measurement [23, 24] and continuous measurement [11]. While describing sharing, the authors use the terms sharing and transparency [11], shared responsibility [19], knowledge sharing [23], and sharing [22, 24]. Lastly, the authors use the term agility and process alignment [12] and agility [11] to explain agility.

Regarding factors influencing DevOps adoption, automation and collaboration are the most significant factors highlighted in the selected DevOps adoption models. Quality and sharing are also substantial factors highlighted. This is followed by measurement, agility, develop and deploy cloud-based application, continuous improvement, and leadership. Resilience is less significant and highlighted once in the models.

All the authors [23][11][12][19][22][24] agreed that automation and collaboration are essential in DevOps. Automation reduces the software process cycle time, rework, and risk of human failures, especially in infrastructure provisioning. Moreover, automation is a crucial driving force in adopting DevOps to cater to fewer resources in software development and maintenance issues [23]. Besides, it enables backward traceability to source code and facilitates comprehensive testing [24]. At the same time, collaboration breaks down silos and barriers between development and operational teams and activities. The separated software development and deployment created conflict between the teams and affected the software delivery process. They should frequently collaborate to improve the software process and deliver product value continuously [23][11][12][19][22][24]. Establishing and strengthening a collaborative culture is the most important step toward adopting DevOps [11]. Besides, early IT operations involvement and cross-collaboration with software development in the software process are essential to minimise handover challenges [24].

For the quality and sharing factor, continuously delivered software needs control over the product quality or quality standards. DevOps focuses highly on quality, and software development and IT operations should carry out quality assurance [24]. It is impossible to design a system without control over product quality [11]. Problems in the software process must be detected early to improve software quality and the developer's capabilities [12, 19]. Besides, the documentation process and structure also must update based on gathered experience and quality requirements [23]. At the same time, sharing concepts in DevOps seems to weaken the silos and develop team trust. Software development and IT operation should be incorporated into the software development process, teaching and learning each other [23][11][19][22]. They should share knowledge, tools, goals, incentives, and the responsibility to deliver high-quality products [24].

Measurement is required in the implementation of DevOps. It will help measure the progress of the adoption process in terms of cycle time, mean time to detect, mean time to repair, and quality at the source, whether there is any improvement [24]. Consequently, continuous measurement helps the teams be proactive and resilient [11, 23].

Meanwhile, agility has reduced deployment risk and become a significant outcome of DevOps adoption [11]. All stakeholders are incorporated into a single agile process, thus becoming more flexible toward the customer [12]. Since Devs and Ops defined shared goals, deployment procedures, and technological solutions, good leadership is essential in DevOps adoption [12]. Moreover, full leader support leads to continuous delivery and helps the organisation gain value more quickly [24]. To ensure continuous improvement in application and customer experience as well as enhancing the product constantly, monitoring information (e.g., incident handling) and user feedback can be leveraged [12, 24]. DevOps and cloud services are interrelated [24]. Even though it is not a prerequisite of DevOps, it is a significant part of most DevOps initiatives. DevOps requires developing and deploying a cloud-based application in a continuous deployment environment to ensure each check-in is submitted to production after it has passed all automated tests [12].

Resilience is a less significant factor in DevOps adoption and was highlighted once in the models. Nevertheless, DevOps often improves application resilience, where the applications and infrastructure can recover themselves in case of failures [11].

4. Conclusion

This research used the SLR process to identify six articles that discuss the DevOps adoption model as primary studies. This SLR aimed to investigate the factors influencing DevOps adoption in the specified DevOps adoption model. Automation, collaboration, sharing, measurement, resilience, agility, develop and deploy cloud-based application, quality, continuous improvement, and leadership are the influenced factors highlighted in the models. The answers to the research questions are considered the primary outcome of this study. We believe the results will familiarise the researchers and practitioners with the existing DevOps adoption model and assist them in focusing on the significant factor for successfully adopting DevOps practices. There are some limitations of the study. First, the SLR process should use more databases for searching sources to gauge more articles related to the DevOps adoption model. Second, future research could validate the factors in the relevant context to ensure their validity.

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