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Critical Factors Influencing Decision to Adopt Digital Forensic by Malaysian Law Enforcement Agencies: A Review of PRISMA

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Abstract

The technological advancement in today's era has been characterized by a proliferation of digital devices and system. This scenario is seen significant in bringing a great impact to the increasing needs of digital forensic to be recognized as a crucial tool and yet an investigative procedures in facilitating today's organizations especially the law enforcement agencies to react into the cybercrime cases that fall under their respective jurisdiction. However, in a context of a developing country, the adoption nature towards digital forensic by Malaysian law enforcement agencies is unfavorable which ultimately affects an efficient, timeliness, cost-effective, and less-impact of digital evidence investigation. The purpose of this paper is to examine the factors affecting the decision of Malaysian law enforcement agencies to adopt digital forensic. The study employed PRISMA as a reference methodology to identify the factors and developing the initial adoption model. The methodology has revealed 12 factors that influence the adoption decision of digital forensic. These factors are organized into three dimensions under the premise of TOE framework namely technological, organizational and environmental. The study is contributing by addressing the key driving factors that delineate an understanding towards the context of digital forensic as an innovation adoption at the organizational level in which further will be exploited to formulate the adoption model.

Keywords: Digital Forensics, Digital Forensics Adoption, Innovation adoption, Law Enforcement Agencies, TOE.

1. Introduction

A rapid evolution of information era nowadays has been characterize by a proliferation of digital devices and system. This has led to an increasing need of digital forensic (DF) as an effective tool in facilitating organizations to respond towards various cyber associated crimes as well as to provide admissible digital evidence through a legitimate evidence investigation. However, despite the notable benefits that can be derived from DF technology, the pace towards DF adoption into the technology structure in an organization of developing countries is unfavorable (Aswami, Jill & Husin, 2012; Kasun, Keerthi, & Ravith, 2016; Khuram et al., 2014; Obwaya, 2011; Sommer, 2005). In a context of a developing country, Malaysian law

enforcement agencies are considered as a focal point to any reported incidents that need for digital investigation in relation to matters that fall within their respective jurisdiction. Yet, very few of these agencies have incorporated DF into their technology structure to enable a timeliness, cost-effective, efficient and low-impact digital investigation (Aswami et al., 2012; Aswami & Izwan, 2008).

The increasing number of requests for DF investigation and referred incident cases encountered by Cyber Security Malaysia (CSM) in which an agency that established under the Ministry of Science, Technology and Innovation who serves as one of the authority body in cyber and digital security matters has been reported by Rafizah & Aishah, (2013). This situation has drawn a picture of the agencies' reliance on DF technical support. In this case, the situation has been aggravated by an issue that leads to incompetency in the conduct of DF investigation (Aswami et al., 2012; Aswami & Izwan, 2008; Sarah, Miratun, & Zabri, 2018) as the processes involved become very time consuming which later resulted in delay on the actions taken in response to the reported incidences. At this point, the incompetency also refers to the productivity of the agencies which is affected due to the interruption of their business operation during the process taken for the investigation. Indeed, Danielsson & Tjostheim (2004) also raised the privacy concerns if the DF function is outsourced to a third party. Therefore, it is important for today's organizations to recognize the importance of DF in their organizational environment. Having DF in place will enhance the organization's capacity to give a fast respond to the security occurrences (Elyas et al., 2015; Suhaila et al., 2011; Mankantshu, 2013; Saleh, 2013). When incidents occur, DF investigation attempts to be conducted efficiently to react to the incidents without delays (Mouhtaropoulos, Li & Grobler, 2014; Mouhtaropoulos et al., 2013).

In general, the lack of coherent understanding and guidance on DF practices is found to be the causal of the sluggish adopting nature of DF among the organizations (Hamdi, 2011; Suhaila et al., 2011). In Malaysian context, the issues of DF are fairly explored (Aswami et al., 2012; Aswami & Izwan, 2008) primarily to provide the coherent understanding on the potential factors to assist organizations namely the enforcement agencies towards the adoption of DF. Hence, the acknowledgement of these factors is expected to address the above mentioned issues. Consequently, as a part of this study, it is an attempt to develop a framework that looks into the drivers influencing Malaysian law enforcement agencies' decision to adopt DF.

The proposed model is expected to support the Malaysian enforcement agencies in using DF and at the same time to serve as a guideline for the decision makers of the agencies to gain an understanding in evaluating DF to be adopted in their organizations. Additionally, as DF is mostly being studied in technical perspective, therefore, this study is hoped to complement the scarcity of DF domain in organizational adoption context. In response to Pangalos, Ilioudis & Pagkalos, (2010) the present endeavor is aligned with the recommendation made by them who advocated that, the scope of forensics needs to be expanded into another domain in order to encompass the perspectives difference and to ensure the continuation of maturity of this discipline. Thus, the model developed is expected to be utilized by the community of the discipline for the expansion of the body of knowledge for all the growing importance of DFs. The next section will look at the related studies, the theoretical foundations for the study's framework, methodology, proposed framework and the conclusion of this paper.

2. Related Studies

The adoption of DF has been studied by some researchers namely in Hamdi (2010) and Obwaya (2011). However, both studies are lacking in providing a comprehensive factors affecting the adoption of DF as according to Yang, Sun, Zhang, & Wang (2015), it is necessary to consider technological, organizational and environmental factors in studying organizational innovation adoption to reflect the basis of innovation characteristic. For instance, Hamdi (2011) performed a quantitative study to investigate the variation in digital forensic practice adopted by large local police agencies in the United States, however the study was solely focused on the organizational factor and the environmental constraint. Hence, this study covers on the theoretical perspective which offers a broader combination of influential factors that reflect a particular adoption context.

3. Technology-Organization-Environment framework (TOE)

Considering three theoretical perspectives of technology, organization and environment in the study in order to provide a comprehensive basis of innovation characteristics, Technology-Organization-Environment framework (TOE) has been identified as the most influential theory used to guide the expansion of research and supporting the technology-innovation-adoption discourse (Zhu et al., 2004). Tornatzky & Fleischer, (1990) advocated the technology–organization–environment (TOE) framework to be used in conducting a study on innovation adoption. Inclusion of technological, organizational and environmental variables has made TOE advantageous over other adoption models in studying innovation adoption, innovation use and value creation from the innovation (Hossain & Quaddus, 2011; Oliveira & Martins, 2010; Ramdani et al., 2009; Zhu & Kraemer, 2005). Also, it is flexible regardless the size of an industry and organization (Wen & Chen, 2010). Hence, it provides a holistic picture for user adoption of innovation, its implementation, foreseeing challenges, its impact on value chain activities, the post-adoption diffusion among firms, factors influencing business innovation-adoption decisions and to develop better organizational capabilities using the innovation (Wang et al., 2010; Salwani et al., 2009; Lin & Lin, 2008; Zhu et al., 2004).

Moreover, Oliveira & Martins (2011) in their study proved that TOE framework has a solid theoretical basis, consistent empirical support, and the potential of application to technological innovation domains, though specific factors identified within the three contexts may vary across different studies. There are three types of contexts that may influence the innovation adoption. a) Technological context describes both the internal and external technologies relevant to the firm. This includes current practices and equipment internal to the firm (Starbuck 1976) as well as the set of available technologies external to the firm (Thompson, 1967; Khandwalla, 1970; Hage, 1980). (b) Organizational context refers to descriptive measures about the organization such as scope, size, and managerial structure. (c) Environmental context is the arena in which a firm conducts its business, competitors, and dealings with the government (Tornatzky & Fleischer, 1990).

A consistent empirical support in TOE usage to study the adoption of innovation was also found by Yi, Hsie, Ci, & Ding, (2016) Abdullah and Stanier, (2015), Ahmadi et al., (2014), Hsiu (2014), Oliveira & Martins (2011), Oliveira, Thomas, & Espadanal (2014), Wang et al., (2010). Owing to the consistency of TOE framework in the aspects of empirical works, literature review as well as theoretical perspectives, considering TOE framework in this study will provide an appropriate comprehensive foundation for studying the factors influencing adoption of DF in a setting of organizational level.

4. Methodology

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement of Moher et al., (2010) is used in the study to review and analyse DF and technology adoption literature and finally to develop an initial theoretical model in investigating factors influencing the evaluation of DF adoption by Malaysian law enforcement agencies. The structured review provides an integrated result of included studies through a systematic and explicit approach and also via the use of statistical techniques (Moher et al., 2010).

This methodology has been widely conducted in various fields of studies for the purpose of gathering a comprehensive literature review (Mojtaba et al., 2016). There are four main phases involved in PRISMA methodology conducted in the present study. This phase consists of identification (Phase 1), screening (Phase 2), eligibility (Phase 3), included (Phase 4). The activities of Phase 1 involve literature searching using a keyword as a descriptor, paper gathering and the creation of reference database.

Five online databases were selected in regard to their relevance in the field of DF, Forensic science, information system, information security and computer science. The chosen online databases were Science Direct, IEEE, Taylor and Francis, Springer and Emerald Publishers. The following keywords were used to run the queries against the database: “Digital Forensic, Digital Forensic adoption, DF technology adoption, computer forensic, computer forensic adoption, forensic computing, and technology adoption”.

The screening and the selection of study for eligible papers occurred in phase 2 and phase 3 in which the screening process involved in Phase 2 included the removal of duplicated papers with redundant content. At the same phase, the screening then was performed on the titles and the abstracts and the removal of irrelevant studies was made. In the next phase (Phase 3), a manual skimming was carried out on the full text papers extracted from the previous phase for the eligibility purposes.

In the final phase of methodology (Phase 4), the activities included data extraction and summarization. At this phase, the remaining papers were summarised, and significant potential factors were derived in which reflecting the basic premise of the TOE framework. To ensure the quality value of the papers, the screening, skimming and selection were carried out according to the predetermined inclusion criteria as depicted in Table 1.

Table 1: Systematic Review Inclusion Criteria

Inclusion Criteria	<ul style="list-style-type: none"> Thus, the articles were gathered between the years of 2005 to present (DF is relatively new; therefore there is no restriction on the period of time considered in the searching)
	<ul style="list-style-type: none"> Papers published in academic journals and international conferences only
	<ul style="list-style-type: none"> The presence of keyword in title or abstract
	<ul style="list-style-type: none"> Full text article
	<ul style="list-style-type: none"> Papers discussed the factors of DF adoption as well as DF practices, implementation and technology adoption at organizational level. (a review of prior research works has been extent to technology adoption literature to compliments the limited numbers of prior studies on DF adoption)

The whole process involved in reference methodology was supported by software package namely Mendeley to build references database and to support citing and referencing. The summary of activities and phases involved in the systematic review of PRISMA was mapped out in Figure 1.

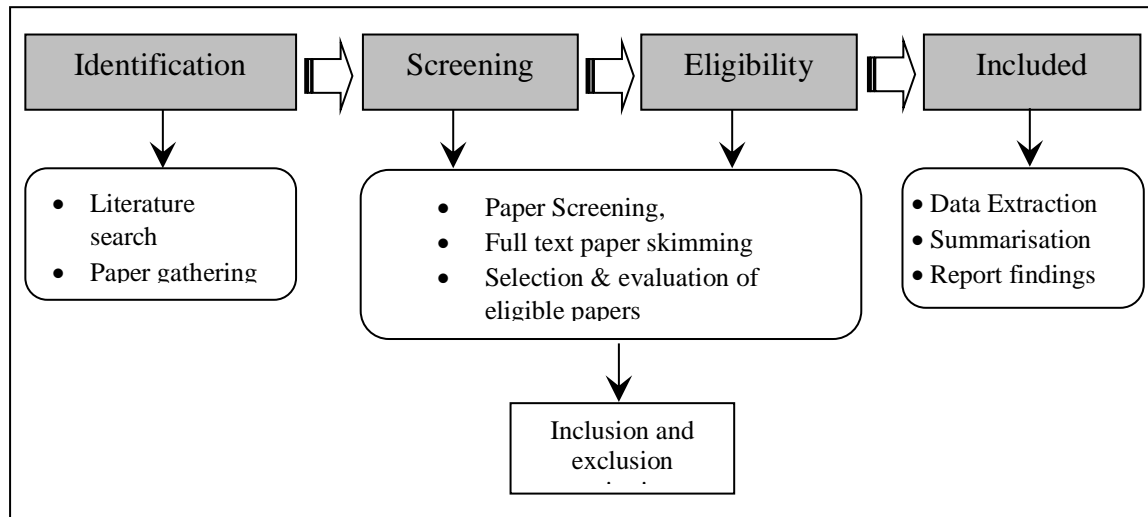


Figure 1: Summary of the systematic review approach

5. Discussion

The searching has revealed a total number of 337 scholarly articles. Based on the exclusion criteria, the screening process was guided. The screening resulted in the remaining of 211 potentially articles after the removal of identical papers with duplicated information. The next screening process then was continued by filtering the titles and abstracts. Any titles and the abstract with no relation to DF adoption and other domain of technology adoption factor were removed. Yet, guided by inclusion and exclusion criteria, manual full paper skimming was performed for 87 potentially relevant primary studies.

Finally, this review resulted in 33 articles used for main primary studies. Phase 1 aims to capture any literature that discussed about technology adoption notably DF practices and adoption factors, the analysis was then performed to identify the factors that influence the adoption behaviour at organizational level. In the third phase, the data extraction was conducted to scrutinise the relevant findings using three dimensions of multiple perspectives that reflect the rooted premises of TOE framework. Finally, the extracted data was proposed and summarised into frequency as a finding report. The exclusion and explicit inclusion criteria were used to provide a rigor reliability and eligibility of the studies finding and review approach. The overall study finding of potential factors influencing the decision to adopt DF by Malaysian law enforcement agencies and a brief description of each factor are described in Table 2 and Table 3.

Table 2: Factors Influencing the Decision of DF Adoption by Malaysian law Enforcement Agencies

Author	Innovation/ Technology Studied	Dimensions/Factors										
		Technology			Organisation				Environment			
		Relative Advantage	Complexity	Compatibility	Size of Agency	Top Management Support	Infrastructure	Culture	Governance	Coercive Pressure-Government	Normative Pressure	Vendor Support
Barbara et al. (2007)	DF						√		√			
Chang et al. (2007)	Electronic Signature		√		√							√
Quaddus & Hofmeyer (2007)	E-Commerce											√
Barske et al. (2010)	DF						√		√			
Grobler et al. (2010)	DF	√					√	√	√			√
Ming et al. (2010)	RFID	√	√				√					
Yu et al. (2010)	RFID		√	√	√						√	
Hamdi (2011)	DF				√					√	√	
Chung (2011)	Tele care	√		√		√						
Chinyao et al. (2011)	Cloud Computing	√			√	√					√	
Angela & Nan (2012)	Cloud Computing	√	√	√								
Chi et al. (2012)	HL7		√	√	√					√	√	
Pooe & Labuschagne (2012)	DF						√		√			
Abdollahzadeh ganet al. (2013)	Cloud Computing	√	√	√	√	√						
Morgan & Conboy (2013)	Cloud Computing	√	√	√								
Makena (2013)	Cloud Computing	√	√			√						
Edwin & Peter, (2014)	E-Commerce	√			√		√			√		
Hui et al. (2014)	RFID	√	√	√	√	√	√			√	√	√

Hsiu (2014)	e-Supply Chain Management (e-SCM)	√	√			√						
Jiunn et al. (2014)	Cloud Computing			√		√	√			√		
Alkhater et al. (2014)	Cloud Computing	√	√	√	√	√						
Oliveira et al. (2014)	Cloud Computing	√			√	√						
Hossein et al. (2015)	HIS	√			√		√			√		√
Elyas et al. (2015)	DF					√	√	√	√			
Kazadi (2015)	DF			√								
Mitha & Venter (2015)	DF			√								
Muhammad Zulkifly (2015)	DF						√					
Rahayu & Day	E-Commerce	√		√			√					
Cassandra (2016)	Records Mgmt System and Broad band Networking		√							√		
Mohammed et al. (2016)	Cloud Computing	√	√	√		√	√					
Al-isma'ili et al., (2016)	Cloud Computing	√		√	√	√						
Yi et al. (2016)	Mobile Hotel Reservation System (MHRS)			√	√		√					
Hossein et al. (2017)	HIS	√		√	√		√					√
<i>Frequency / Support</i>		18	13	16	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{5}$	2	5	7	5	6

An integration of factors considering comprehensive dimension is important to provide a holistic and inclusive understanding of innovation characteristics (Grover, 1993; Zhaojun Yang et al., 2015). Hence, the identification of factors that influence the adoption decision of DF is reviewed using TOE framework to help decision makers of the enforcement agencies in allocating the technological, organizational and environmental resource.

Table 3: Description of Factors

Factors	Description
Relative advantage	The degree to which DF is perceived as being better technology in providing greater benefit than its precursor.
Complexity	The degree to which DF is perceived as being relatively difficult to understand and use.

Compatibility	The extent to which DF fits with the agencies' need, goals, corporate culture and value as well as current agencies' infrastructure such as laboratory systems and networks.
Agency Size	The degree and extension of resources own and able to be provided by the agencies includes number of human resources and infrastructure.
Top Management Support	Support of DF by the senior management of an organization.
Infrastructure	A physical resource and system design to facilitate the agencies in maximizing the DF capability.
Culture	A set of shared values, beliefs, assumptions and practices that shape and direct organizational members attitudes and behavior towards DF.
Governance	The practices and structures in the organisation that enable forensics
Coercive Pressure	Formal influence of the government on an innovative technology that will considerably affect the adoption of DF in the agency.
Normative Pressure	An influence from those that exerted by professional organizations that dealing with the agencies to adopt the similar innovation.
Vendor Support	The level of support provided by the external DF vendor during and after the adoption.

6. Initial Model

6.1 Technological Dimension

As elucidated by Oliveira and Martins (2011), the technological includes both the internal and external characteristics of technologies relevant to the firm. In the context of DF, it represents the characteristic of technologies used in the agencies, that is a highly specialised software tools or physical hardware tools that specifically used for forensic purposes.

Reflecting the technological characteristics of digital forensic with the systematic review of literature in Table 2, the factors considered under this dimension are relative advantage, complexity and compatibility. Relative advantage refers to the degree of potential benefits on digital forensic perceived by the decision makers of the agencies that describes greater advantages of digital forensic as new technology adoption replacing the traditional scientific and investigative problem-solving approaches (Mark, 2010; Suhaila et al., 2011). Complexity is described as the challenges inherited in digital forensic, the dissimilarity elements of the forensic tools which required a sophisticated and a costly digital forensic tool to overcome the issues of technical incompatibility as well as lack of standardised procedure on digital forensic implementation, and the need for a new and updated skills and expertise to perform digital forensic (Karie & Venter, 2015). The compatibility refers to an extent to which this technology fits with the agencies' values and beliefs, goals, current agencies' practices and also with current agencies' infrastructures (Rogers, 1995).

6.2 Organisational Dimension

Organisational dimension represents the characteristics of the organization that can be internally measured that is top management support, infrastructure, culture, governance, and size of agency. Top management support is referring to the degree to which a group of people engaged with the strategic decision making understand the importance of the innovative

technology adoption which later building a great influence on the adoption of digital forensic in the agencies.

Infrastructure is described as forensic physical structure which includes a well architecture network and a well-equipped laboratory with the admissible and accepted hardware and software (tools) to enable the agencies to conduct the digital forensic activities particularly for investigative and non-investigative purposes (Elyas et al., 2015; Grobler et al., 2010). Culture in a context of the current study is defined as a set of shared values, beliefs, assumptions and practices that shape and determine the direction of organizational members' motivation towards digital forensic which further will affect the extent to which the agencies are willing to adopt the innovation.

Governance is considered as a distribution of decision authority to manage the activities of digital forensic as the factor of governance was found essential to the state of digital forensic in an organization (Mankantshu, 2013). Size of the agency refers to the extension of resources owned and able to be provided by the agencies including the number of technical staff and infrastructure.

6.3 Environmental Dimension

The environmental factors are referred to both the internal and external factors (Olutoyin & Flowerday, 2016) that could exist in a form of pressure or support (Marimuthu et al., 2011) which comes from the environment that comprises the government, suppliers, vendors, and customers. Likewise, Hamdi (2011) contended this dimension as an external pressure that has brought the largest impact on the adoption of digital forensic by the enforcement agencies in the United States.

This dimension represents the current operating environment of the Malaysian enforcement agencies which may affect the adoption of digital forensics in their working place. In the context of this study, the external factor of the agencies includes the external pressures of coercive and normative as well as the external support that is vendor support. Coercive pressure is referred to an external force that originated from the government entities as an authorize body that holds the control upon the enforcement agencies as well as the agencies' wellbeing. In this case, the sovereigns' value influences the decisions of the agencies to adopt structures or practices that serve the interests of the government as an exerting entity (Sila, 2013).

In this study, a normative pressure to adopt digital forensic may be present as the enforcement agencies are interrelated to each other generally under the direct purview of sovereigns. A normative pressure is highlighted as an influence that is exerted by suppliers, customers, and business, trade and professional organizations to adopt a certain innovation (DiMaggio & Powell, 1983). In the setting of the organizational adoption studies, normative pressures take place upon professionalism in which an organization's behaviors are subjected to the shared values and the norms of other organizations through relational channels of their social network (Alsaad et al., 2014; Hamdi, 2011; Oliveira & Martins, 2011; Yang et al., 2013).

The present study defines vendor support as the level of ability of the external digital forensic vendor to provide services that may include technical and training support as well as a full-scale consultancy engagement. As being a new and growing technology in the industry, digital forensic presented several challenges to its practicing organization (Hoss & Carver, 2009; Karie & Venter, 2015; Nance & Ryan, 2011). Therefore, relying upon vendors for such assistance on technical, training and advice are indispensable.

Despite offering and supplying subsequent updates and new technical needs, the agency would rely on vendor for specific forensic skill and software training (Derek, Francine, Ewa, & Oscar, 2008; Trenwith, 2013). Perceived technical competence reflects the capability of technical employees in the agency (Jiunn et al., 2014) as well as the skills and the knowledge possessed by the employees on the innovative technology (Hosseini, Mehrbakhsh, & Othman, 2015; Jiunn et al., 2014; Rahayu & Day, 2015).

In the context of this study, perceived technical competence refers to the degree of which the employees possess sufficient knowledge and specialised skills on digital forensic to perform the forensic tasks in order to achieve the forensic initiatives.

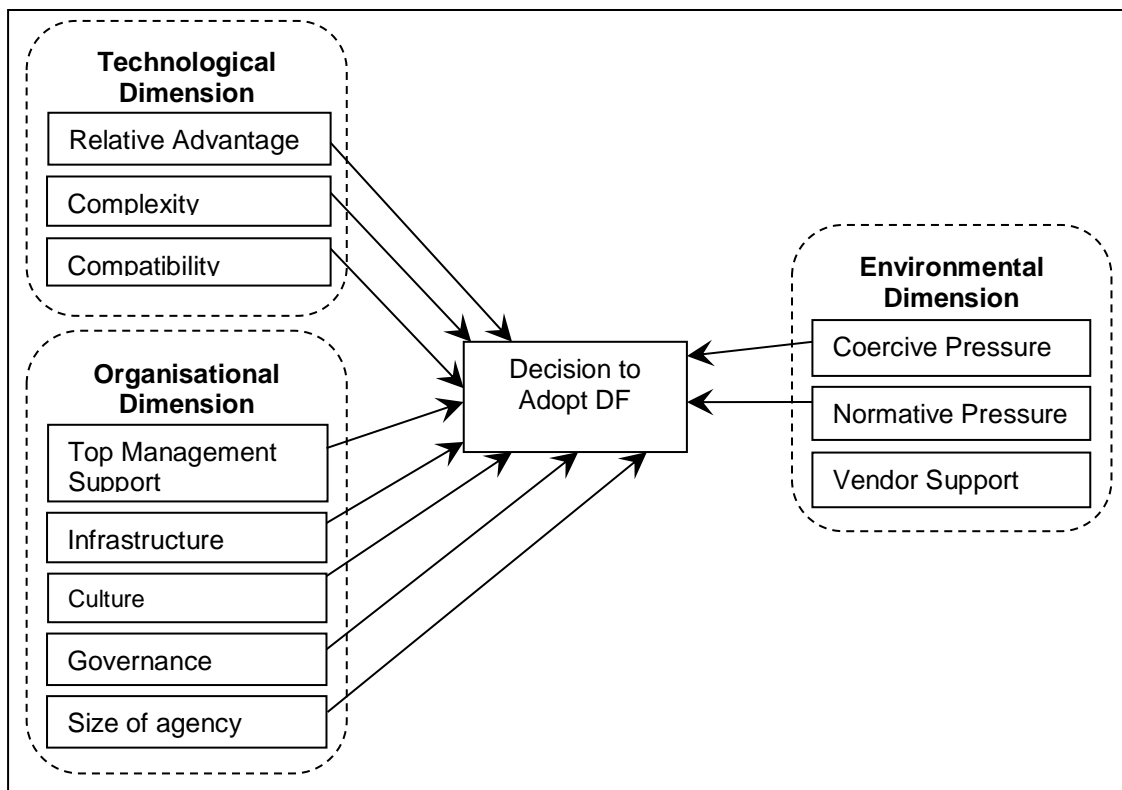


Figure 2: Initial digital forensic adoption model

7. Conclusion

The aim of this paper is to provide a comprehensive understanding of the factors influencing the digital forensic adoption's decision by Malaysian law enforcement agencies. Using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach, the study revealed 12 factors that needed to be considered by the decision makers of the agencies in evaluating the adoption of digital forensic to be in placed in their organization. These factors were categorized into three dimensions (Technological, Organizational, and Environmental) to formulate the initial digital forensic adoption model.

As a part of an ongoing study, the initial model will be developed using a quantitative descriptive study approach in which law enforcement organizations as a unit of analysis. It has been discovered that quantitative approach is prevalent in studying technology adoption issues at organizational level (Choudrie & Dwivedi, 2005). Hence, this study works on

identifying factors that will critically contribute to the decision of Malaysian law enforcement agencies to adopt digital forensic as well as running a theoretical analysis. Finally, the theoretical model proposed will be validated using a survey via an instrument of questionnaire that will be distributed to the decision makers of the agencies.

This paper plays a part in the expansion of the body of knowledge by addressing the driving factors that affect the evaluation process of digital forensic innovation adoption thus contributing to the development and the proposition of a framework that works to serve as a guidance and idea for the decision makers of an organization to better understand on the adoption decision of digital forensic.

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