Technological Aspects of Green Manufacturing's Adoption by SMEs: the role of owners

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Abstract

This study examines the role of the owners' green knowledge of technological aspects (relative advantage, compatibility, and complexity) and green manufacturing's adoption by small and medium-sized enterprise(s) (SME(s)) producing batik textiles in Indonesia. Six hypotheses are tested using partial least squares (PLS), based on the survey approach. We obtained the data from 131 owners of SMEs and used this to analyze the hypotheses. A direct relationship is tested for between three technological aspects and green manufacturing's adoption. A moderating relationship is examined between the technological aspects, green manufacturing's adoption, and the owners' green knowledge. The results suggest that relative advantage and complexity have no significant influence on green manufacturing's adoption. However, relative advantage shows a significant effect when moderated by the green knowledge of the owners of the SMEs. Compatibility has a direct and significant effect, and it gets stronger when it is moderated by the owner's green knowledge. Meanwhile, complexity does not show a significant effect on either relationship.

Keywords
Green manufacturing, SME, green knowledge, technological aspects, adoption

1. Introduction
The presence of a manager, as a leader in an organization, is vital. Leaders knit the various resources owned by the company into beautiful shapes to achieve the company's goal. In small and medium-sized enterprise(s) (SME(s)), the role of the manager is even more crucial. Their decisions are the law for their subordinates and employees. The managers decisions are based on their experience, knowledge, and various considerations, such as competition, and emotional and financial factors. In terms of environmental issues, SMEs face a dilemma related to their technology. On the one hand, they want to improve by adopting environmentally friendly technology, but on the other hand they don't have the capabilities or resources to do that. SMEs are often seen as organizations with simple characteristics, that lack financial resources and capabilties. There are many factors (both internal and external) that encourage SMEs to adopt green practices, in this case green manufacturing (GM). They have many motivations to adopt green issues. Internal factors that motivate the adoption of GM by SMEs include technology factors, and management support, especially from senior managers. In Indonesia, SMEs' managers are usually the owners. Therefore this research examines the influence of technology, moderated by the owner's green knowledge, on GM's adoption.

This paper consists of six parts. The first part is the introduction, while the second part presents a literature review of the previous research. The third part discusses the hypotheses and is followed by the research's methodology. The next part discusses the results of the study. This paper closes with the conclusion and limitations in the sixth part.

1.1 Objectives

The objectives of this research are to verify the role of the owners' green knowledge of technological aspects (relative advantage, compatibility, and complexity) and the effect of green manufacturing's adoption by SMEs. This research contributes to fill the gap in the research about the roles played by managers in GM's adoption by SMEs. This study employs Rogers' variables, relative advantage, compatibility and complexity, and the moderating effect of managers' green knowledge.

2. Literature Review

2.1 Green Manufacturing

GM was explicitly described as "environmentally conscious manufacturing" by Weissman and Sekutowski in 1992 (Weissman and Sekutowski, 1992). According to them, environmentally conscious manufacturing develops and implements manufacturing processes that minimize or eliminate hazardous chemical waste, reduce scrap, and are operationally safer (Weissman and Sekutowski, 1991, p.23). In their definition, environmentally conscious manufacturing maintains environmental sustainability by creating a cleaner industry, reducing the disposal costs, protecting workers and preventing future health risks. The term "green manufacturing" was first found in the writings of Dickinson et al. in 1995, to define "environmentally conscious (or responsible) manufacturing" (Dickinson et al., 1995). The evolution of GM can be seen in Figure 1.

From a narrow perspective, GM can be defined as fabricating green products. With a board perspective, GM can be defined as the "greening of manufacturing" (Dornfeld, Yuan, Diaz, Zhang, & Vijayaraghavan, 2013). GM is an extention of traditional manufacturing that produces environmentally benign products (output), by using raw materials and energy more efficiently (input), with processes that are safe and reduce waste (process). GM is a collection of methods for manufacturing (input, process and output) to minimize its negative effects on the environment (Atlas & Florida, 1998; Chuang & Yang, 2014; Orji & Wei, 2015; Seth, Shrivastava, & Shrivastava, 2016). GM is expected to be able to solve the environmental problems that arise in the production process of an industry, such as emissions and waste.

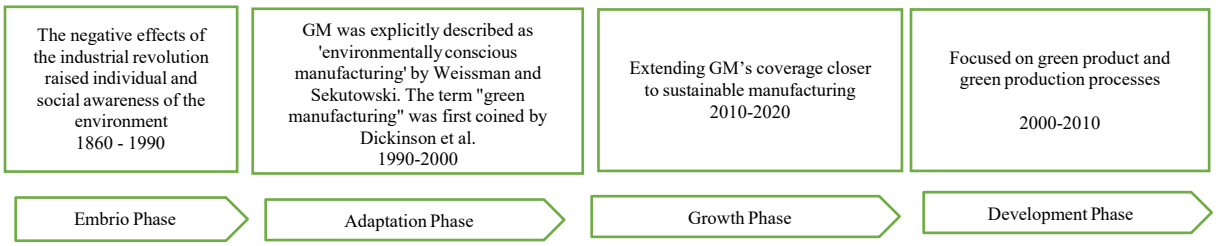

Figure 1. Evolution of GM

2.2 GM's Adoption by SMEs

SMEs in developing countries make a significant contribution to their countries' gross domestic product (GDP). In Indonesia, SMEs contributed 7.1% to Indonesia's GDP from 2010 to 2016, and employed 10.7% of the total workforce (Kurniati, Susilowati, & Suharno, 2019). Despite the positive effects on GDP, SMEs have a negative impact on the environment. SMEs' activities in Indonesia make a significant contribution to environmental pollution. In terms of water pollution, the contribution of SMEs producing such things as tofu, batik, and tapioca was around 2.3 million tons in 2013 (Purnamawati, 2014). This fact is in line with the research of Parker, Redmond, and Simpson which stated that SMEs are estimated to contribute as much as 60% of the carbon dioxide and 70% of all industrial pollution, globally (Parker, Redmond, & Simpson, 2009).

3. Methods

3.1 Technological Factors in GM Adoption

This study uses the Rogers variables in the diffusion of innovation (DOI) theory, which is relative advantage, compatibility, and complexity. The DOI theory is known as the most robust individual-level innovation adoption theory (Dalvi-Esfahani, Rahman, & Ramayah, 2017). The framework for this research is shown in Figure 2. There are six hypotheses tested from this framework.

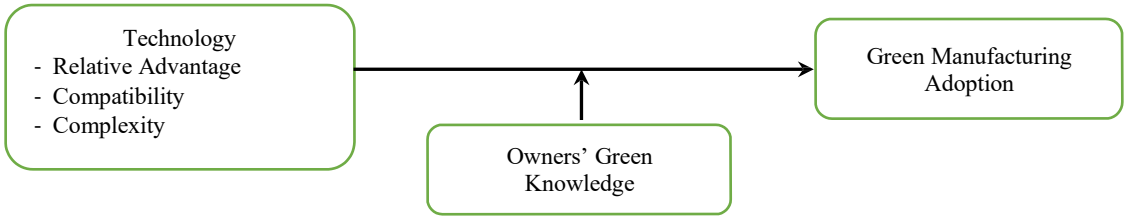

Figure 2. Research Framework

A.Technology Factors

The DOI theory has been widely adopted by previous researchers for testing its effect on the adoption of various innovations. Of the five factors offered by Rogers, three factors proved to be the most robust, namely relative advantage, compatibility and complexity. This research predicts that these three factors have some influence on the adoption of GM by SMEs (Hwang et al., 2016). Another scholar, Alshamaila et al. proved that relative advantage, compatibility, and complexity have a significant effect on the adoption of cloud computing (Alshamaila et al., 2013).

Rogers stated that among the five factors in the DOI theory, relative advantage was the strongest predictor (Rogers, 2003). Relative advantage refers to the degree to which innovation is considered better than the previous technology (Chong et al., 2009; Rogers, 2003). Compatibility indicates the degree to which the innovation is perceived to be consistent with existing values, past experiences, and the needs of potential adopters (Rogers, 2003). Complexity is the degree to which an innovation is perceived to be difficult to understand and use (Rogers, 2003).

H1: Relative advantage has a positive influence on the adoption of GM by batik SMEs.
H2: Compatibility has a positive impact on the adoption of GM by batik SMEs.
H3: Complexity has a negative effect on GM's adoption by batik SMEs.

B. Owners' Green Knowledge

Thong and Yap examined innovation managers for their knowledge of IT, and their attitude toward IT's adoption, to see if those had an influence on innovation's adoption (Thong & Yap, 1995).

H4: The relationship of the relative advantage to adopting GM is stronger for managers with high green knowledge.
H5: The relationship of the compatibility of adopting GM is stronger for managers with high green knowledge.
H6: The relationship of the complexity of adopting GM is stronger for managers with high green knowledge.

4. Data collection

Data were obtained from textile companies in Indonesia. The sample of the selected respondents was based on a purposive sample, with certain criteria. The requirements for the respondent in this research were they must be: (1) the SME's owner; (2) the SME is a manufacturing concern; (3) have 5 to 99 workers. They were asked to rate the questionnaire, on a Likert scale of one to five, one being "strongly disagree" and five "strongly agree." The research instrument was prepared based on the literature. We compiled a questionnaire in English, and then translated it into Indonesian.

5. Results and Discussion

5.1 Respondent Characteristics

The questionnaires were distributed to the respondents using a paper-based survey tool. We sent the questionnaires to 200 respondents, as the participants. However, only 131 questionnaires from 131 eligible owner/respondents could be further analyzed. The characteristics of the respondents are presented in Table 1.

Table 1. Characteristics of Respondents

Education	n	%
Elementary	15	11.5
High School	72	55
Universities	44	33.5
Age		
≤ 30 years old	15	11.5
40 ≤ years old > 30	31	23.6
50 ≤ years old > 40	36	27.5
> 50 years old	49	37.4
Gender		
Male	83	63
Female	47	37

5.2 Data Analysis

The data from 131 SME owners were processed with the WarpPLS software. Partial least squares (PLS) was used to examine the hypotheses. PLS was used to presume the relationship between technological aspects and GM's adoption, which was moderated by the manager's green knowledge. There were two steps for the PLS analysis, testing the measurement models (outer models), and measuring the structural model (inner model). This study has five constructs, green manufacturing's adoption, relative advantages, compatibility, complexity, and manager's green knowledge.

Measurement Models (Outer Model)

The measurement model was tested for reliability and validity. The reliability analysis was seen from the Cronbach's alpha (α) value and the composite reliability (CR) (see Table 2). Table 2. shows the Cronbach's alpha values of this study all were above 0.7, which means that there was high internal consistency. Likewise, the CR value was also above 0.7, which indicates a reliable measuring instrument.

Six hypotheses were tested in this study, from the reflective indicators perspective. There were two evaluations in the reflective indicators of the outer model, which were convergent validity and discriminant validity. Convergent validity can be assigned from the composite reliability that is seen in Table 2. Internal consistency's reliability, from the composite reliability (CR), must be higher than 0.7. The second evaluation was for the discriminant validity; this was considered eligible if the value of the square root of average variance extracted (AVE) for each construct was greater than the correlations among the constructs (Table 3.).

Table 2. Cronbach Alpha and Composite Reliability Score

Constructs	Construct Identifier	Cronbach's Alpha	Composite Reliability
GM Adoption	GM	0.824	0.878
Relative Advantage	RA	0.83	0.876
Compitability	ComPt	0.837	0.885
Complexity	ComPx	0.866	0.918
Owner's Green Knowledge	Know	0.907	0.942
Knowledge*Relative Advantage	Know*RA	0.943	0.95
Knowledge*Compatibility	Know*CPt	0.958	0.962
Knowledge*Complexity	Know*CPx	0.944	0.953

Table 3. Discriminant Validity Results

	RA	ComPt	ComPx	GM	Know	Know*RA	Know*CPt	Know*CPx
RA	**0.736**							
ComPt	0.571	**0.780**						
ComPx	0.244	0.580	**0.889**					
GM	0.284	0.450	0.269	**0.769**				
Know	0.275	0.415	0.240	0.477	**0.918**			
Know*RA	-0.153	-0.301	-0.083	-0.275	-0.403	**0.724**		
Know*CPt	-0.302	-0.208	0.002	-0.118	-0.377	0.782	**0.794**	
Know*CPx	-0.108	-0.014	0.151	0.018	-0.206	0.478	0.724	**0.833**

Structural Model (Inner model)

The second step using the PLS tool was to evaluate the structural model. The objective of this step was to analyze the significance of the model. The result of the second step of this research is shown in Table 4. It can be concluded from Table 4 that there were significant precursors for GM's adoption, explaining 25.3% of the variance. It means that the predictor's strength was considered to be medium (Chin, 1998).

Table 4. Conclusions of the Hypotheses

Dependent Variable	**GMA**	**R^2 = 25.3%**
Independent Variables		
RA	0.13*	
ComPt	0.301***	
ComPx	0.027	Not supported
Know		
Know*RA	-0.38***	
Know*ComPt	0.265***	
Know*ComPx	0.021	Not supported

* $p < 0.1$; **$p < 0.05$; ***$p < 0.001$

This study finds that relative advantage is a predictor of GM's adoption, so (H1) is supported ($p < 0.10$). The hypothesis of compatibility being a predictor of GM's adoption (H2) is also supported. The hypothesis of complexity as a predictor of GM's adoption (H3) is not statistically significant ($p > 0.1$) and this hypothesis (H3) is not supported. The moderating aspect on H4 and H5 is supported, while on H6 it is not supported.

5.3 Discussions

The findings of this research reinforce the position of relative advantage, as a construct that influences the adoption of innovation and GM, according to the previous research (Alshamaila et al., 2013; Ramdani et al., 2013a). The results of this study show that the owner's green knowledge strengthens the effect of relative advantage on GM's adoption by SMEs.

In this research, complexity does not have a significant effect on green manufacturing's adoption. The moderating effect of the owner's green knowledge, which is expected to strengthen GM's adoption, is not supported either. This finding is parallel with Premkumar and Roberts' research (Premkumar & Roberts, 1999). Hypothesis H3 is not supported, indicating that SMEs have the perception that green manufacturing is easy to adopt. This finding is in line with the previous research, which stated that GM's practices are easy (Kendall et al., 2001).

The owner, who is usually the top manager, has the important role of moderating the technology factor's drivers for the adoption of GM (Gandhi, Thanki, & Thakkar, 2018). They face responsibilities for various problems, including environmental issues. Sometimes they don't have enough time to deal with these problems. Therefore, it requires prioritization and good knowledge so that the role of the managers can strengthen GM's adoption by SMEs. In addition, as stated at the beginning of this paper, the task of a leader is to manage the various existing resources, in

order to generate organizational strength. Therefore, it requires good communication with all the stakeholders in the company (Usilaner, 1993).

6. Conclusion

The goal of this research is to predict the role of the owners' green knowledge in moderating the relationship of technological aspects (relative advantage, compatibility, and complexity) and green manufacturing's adoption by textile SMEs in Indonesia. A theoretical framework, based on the DOI theory, was prepared to reach the objectives of this study. The findings of this study reinforce the role of the SMEs' owners in moderating the two constructs, relative advantage and compatibility, for GM's adoption. The results of this study may differ from similar research due to differences in the characteristics of the respondents and the type of industry.

Through these findings, we can get an overview of the important role of technology in GM's adoption in general, and the owners' moderation in particular. It is hoped that the owners of SMEs can use various strategies and increase their green knowledge to increase the adoption and implementation of GM.

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