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Green Manufacturing: Green Dynamic Capabilities and Absorptive Capacity Matter

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Abstract.
Various environmental issues have attracted the attention of many parties, including manufacturing companies. This encourages manufacturing companies to implement green manufacturing into their business operations. Implementation of green manufacturing is not easy to do. For this reason, companies must have the capability to be able to adapt to the rapidly changing business environment. This paper discusses how the green dynamic capability affects the implementation of green manufacturing in manufacturing companies. The study was conducted on 34 manufacturing companies regardless of their industrial sector. The research model describes the relationship between green manufacturing, green dynamic capabilities, and absorptive capacity. The results of model testing (measurement models and structural models) showed that green dynamic capability has a positive and significant effect on green manufacturing practices in manufacturing companies. Absorptive capacity directly affects green dynamic capability, and indirectly affects green manufacturing. This shows that the green dynamic capability plays an important role in the implementation of green manufacturing and must be a concern for the company's management, especially in the implementation of green manufacturing.

Keywords: Green Manufacturing, Green Dynamic, Environmental Issue.

1. INTRODUCTION

The manufacturing industry is one of the important sectors for economic development. In addition to employing a large workforce and producing a variety of daily products, it also supports other industrial sectors. On the other hand, the manufacturing industry is one of the biggest contributors to environmental damage due to its production activities [1]. Various environmental issues such as limited natural resources and energy, global warming, environmental pollution, increasing consumer awareness of green issues, and demands to meet various strict environmental regulations, encourage industries to adopt green manufacturing [2,3]. Green manufacturing is a new paradigm for the industrial environment by applying various strategies and techniques in its operations to be more efficient [4]. This paradigm relates to the production process with minimal use of resources and minimizes negative impacts on the environment and society but is economically feasible [5,6]. Green manufacturing is a manufacturing practice that meets consumer needs and environmental regulations simultaneously [5]. Green manufacturing consists of various activities to prevent pollution, reduce energy, water, and material consumption, reduce waste, reuse and recycle products, and recycle water. In addition, the use of renewable energy, environmentally friendly materials, product and process redesign, and employee training on green practices, are categorized as green manufacturing practices as well [7].

Green manufacturing has been widely discussed by previous research, both discussions of the concept of green manufacturing and green manufacturing practices in various industries. Green manufacturing is influenced by external

and internal factors. External factors that influence green manufacturing include changes in consumer behavior, pressure from the government regarding environmental regulations, and demands from the business environment, suppliers, or supply chains [7]. Meanwhile, internal factors related to the practice of green manufacturing include organizational style [7] and the ability to change the company's operations by considering environmental aspects. In addition, to develop an effective green manufacturing strategy, it is necessary to understand the interrelationships between internal factors and resources that influence green manufacturing, including knowledge as an intangible resource. A general reference model for green manufacturing that describes all elements, levels, activities carried out, and functions of green manufacturing is formulated by Zhang et al. [8].

The main challenge in implementing green manufacturing is integrating it with the company's capabilities and constraints of natural, human, and organizational resources [9]. Adoption of green ideas requires changes in operational capabilities and utilization of resources in companies [10]. Green manufacturing requires continuous innovation in products and processes by considering environmental issues throughout the product life cycle. Therefore, articles on green manufacturing in the perspective of internal capabilities are often associated with the term green innovation. Green innovation performance is influenced by green dynamic capabilities [11,12], namely the ability to identify change opportunities, seize these opportunities, and reconfigure resources to respond to these changes, especially those related to environmental aspects. Another study describes the relationship between dynamic capabilities, capacity to absorb knowledge, and green innovation performance in a conceptual model [13]. Based on these previous studies, this article discusses the relationship between a company's capacity to absorb knowledge, green dynamic capability, and green manufacturing.

The research model built refers to the model proposed by Albort-morant et al. [11] and Amaranti et al. [13].

2. METHODS

2.1. Conceptual Model and Hypothesis

This article describes the relationship model between the company's capacity to absorb knowledge, the company's dynamic capabilities, and the company's green manufacturing practices.

Green manufacturing differs from sustainability although they are often used interchangeably. The word "green" can be interpreted as anything that does not harm the environment, whether related to products or processes or both. Green manufacturing practices require changes to the way companies conduct their business. The success of green manufacturing does not depend on the framework or technology used, but also on how green improvements can be adopted in the company's operational environment [14,15]. Green ideas should be treated as part of a business strategy and carried out comprehensively, not only interpreted as waste reduction or pollution prevention activities [15]. The implementation of green ideas should be carried out throughout the value chain so that the benefits of green initiatives can be transferred properly to all stakeholders.

Green practices are related to innovation and adoption of cleaner technologies [16]. Therefore, green manufacturing requires the company's capability to innovate products and processes to be greener, so that companies can adapt quickly to various demands related to green issues. Green issues come not only from consumer demands, but also demands to comply with various environmental regulations and green standards.

Dynamic capabilities mediate the effect of absorptive capacity on innovation performance. Absorption capacity describes the company's ability to obtain external knowledge and use it in the company. This capability consists of the company's ability to acquire knowledge, assimilate, transform that knowledge to fit existing knowledge, and utilize that knowledge. Referring to Zahra and George [17] and Chang and Pai [18] distinguish absorption capacity into the ability to acquire and assimilate knowledge and the company's ability to transform and exploit that knowledge.

Based on previous studies, the variables in the research model are green manufacturing as the dependent variable, absorption as an independent variable, and green dynamic capability as a mediating variable. Green manufacturing practices in the research model consist of green design and green process. Absorption capacity will be described as potential absorption capacity and realized absorption capacity, while green dynamic capability reflects sensing, seizing and reconfiguration capabilities. The relationship between these variables is described in a conceptual model as shown in Fig. 1. and is translated into four hypotheses as follows:

1. Hypothesis 1: The green dynamic capabilities have a positive effect on the green manufacturing practices.
2. Hypothesis 2: The potential absorptive capacity has a positive effect on green dynamic capabilities.
3. Hypothesis 3: The realized absorptive capacity has a positive effect on green dynamic capabilities.
4. Hypothesis 4: The potential absorptive capacity has a positive effect on the company's realized absorptive capacity.

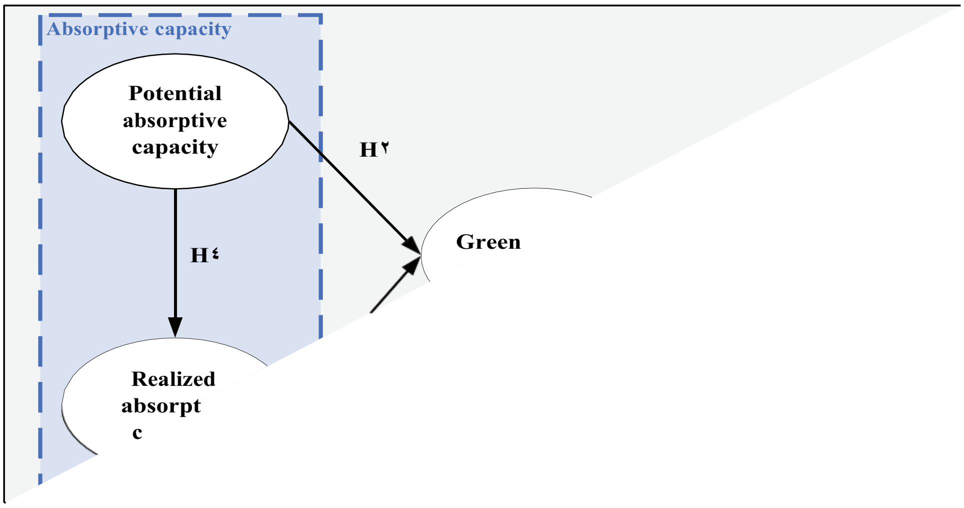

Figure 1: Conceptual model.

2.2. Data Collection and Sample

Data collection was carried out by distributing online questionnaires which were carried out for approximately 5 weeks (in February-March 2021). The number of questionnaires distributed is approximately 100 companies and 34 data that can be used for data analysis.

The questionnaire consists of two parts, namely the part regarding the identity of the respondent and company information and the part about the research model. The questionnaire uses a Likert scale of 1-7 with "1" indicating strongly disagree and "7" indicating strongly agree. The question about green manufacturing consists of 11 measurement indicators (related to green design and green process). Green dynamic ability was measured by 12 questions describing sensing, seizing, and reconfiguration abilities. Meanwhile, absorption is measured by 14 questions including potential absorption and realized absorption.

2.3. Data Analysis

The research model and hypotheses were tested using Partial Least Squares (PLS), a variance-based structural equation model. Some of the reasons for using PLS for analysis in this study are as follows: (i) the research model has reflective variables that are used to define the situation; (ii) the data used were not tested for normality and the amount of data was relatively small; and (iii) this study uses exploratory analysis. Data analysis with PLS was performed using Smart PLS 3.0.

3. RESULTS AND DISCUSSION

3.1. Respondent Profile

Respondents in this study are employees who have a role in green manufacturing with various positions and tenures. A total of 35.3% of respondents are staff in departments related to environmental management and 64.7% are managers and heads of sections. Respondents also have a long work experience, as many as 73.53% of work experience more than 5 years and 26.47% less than 5 years. Therefore, respondents are considered to have sufficient knowledge to become respondents in this study. Most of the companies that became respondents were private companies (88.24%) and 11.76% were state companies. A total of 85.29% of companies have a blue compliance rating, which means that most companies have met the minimum requirements of environmental standards.

3.2. Measurement Model

The measurement model test is basically a test on the outer model. This test is a reliability and validity test, consisting of indicator reliability test, internal consistency test, convergent validity test, and discriminant validity test. The reliability of the indicators is tested based on the outer loading value of each indicator. Indicator reliability describes the level of similarity between indicators and those captured by the construct. The outer loading value of an indicator must be above 0.7. In the indicator reliability test, there are 3 indicators that are omitted from the tested model, namely GreenDC2 (outer loading: 0.456), PotAC3 (outer loading: 0.643), and GreenP2 (outer loading: 0.534). Internal consistency testing is carried out based on the composite reliability value. The results of the reliability test showed that all constructs had met the requirements of internal consistency. Convergent validity test was conducted to see the magnitude of the correlation of an indicator with other indicators in the same construct. Convergent validity is tested based on the average variance extract (AVE) value, provided that the AVE value must be greater than or equal to 0.5. The results of convergent validity indicate that all constructs have met the requirements of convergent

validity (AVE > 0.5). Table 1 describes Cronbach's alpha, composite reliability, and AVE values for each construct.

The last test of the measurement model is the discriminant validity test, which is a test to ensure that a construct is empirically different from other constructs. The discriminant validity test was carried out using two measures, namely the Fornell-Lacker Criteria and the Heterotrait-monotrait Ratio. The results of the discriminant validity test show that the PotAC construct shows low validity, but this construct still meets the HTMT value limit of 0.90 so it is considered to have passed the discriminant validity test. The results of the discriminant validity test are described in Table 2.

Table 1: The internal consitensy test and convergent validity test.

Construct	**Cronbach's Alpha**	**Composite Reliability**	**Average Variance Extracted (AVE)**
Green Manufacturing	0,939	0,949	0,651
GreenDC	0,940	0,949	0,628
PotAC	0,893	0,917	0,650
RealAC	0,929	0,943	0,705

3.3. Structural Model

The coefficient of determination test was carried out to describe the variance in the endogenous constructs described by the appropriate exogenous constructs. R^2 ranges from 0 to 1 which represents the predictive power of the sample. In this study, benchmark R^2 values of 0.75, 0.50, or 0.25 was used to describe a substantial, moderate, or weak

Table 2: The discriminant validity test.

	Fornell-Larcker Criterion				Heterotrait-Monotrait Ratio (HTMT)			
Construct	Green manufacturing				Green manufacturing			
		GreenDC	PotAC	RealAC		GreenDC	PotAC	RealAC
Green manufacturing	**0,807**							
GreenDC	0,782	**0,793**			0,815*			
PotAC	0,645	0,703	0,806		0,686*	0,759*		
RealAC	0,739	0,782	0,820	**0,840**	0,793*	0,820*	0,874**	
					*HTMT$_{.85}$; **HTMT$_{.90}$			

relationship [19]. In this research model, all constructs show a moderate relationship with R^2 values above 0.6 (described in Table 3).

The next test of the structural model is the path coefficient test which describes the strength of the relationship between constructs in the research model. The path coefficient is between -1 and +1, provided that +1 indicates a strong positive relationship (usually also statistically significant), and vice versa for a value of -1. In this study, the path coefficient test was carried out using the bootstrap technique on SmartPLS with a sample size of 1000 and a significance level of 5%. The test results show that hypothesis 2 is not significant (path coefficient= 0.191; p= 0.404, p>0.05). This shows that the potential absorption does not have a significant effect on the green dynamic capability. For other paths, it shows a significant direct effect. The path coefficient test results are described in Table 4 and Fig. 2.

Table 3: Determinant coefficient test.

Construct	R^2	Relationship
Green manufacturing	0,612	Moderate
GreenDC	0,623	Moderate
RealAC	0,672	Moderate

Table 4: The path coefficient test.

Path	Path coefficient	Standard Deviation	T Statistics	P Values	Sig.	Support
Hypothesis 1: GreenDC -> Green manufacturing	0,782	0,063	12,420	**0,000**	*	yes
Hypothesis 2: PotAC -> GreenDC	0,191	0,229	0,835	**0,404**	n.s	no
Hypothesis 3: RealAC -> GreenDC	0,625	0,207	3,021	**0,003**	**	yes
Hypothesis 4: PotAC -> RealAC	0,820	0,051	16,110	**0,000**	*	yes
n.s: not significant; *p<0,001; **p<0,005						

*p<0,001; **p<0,005

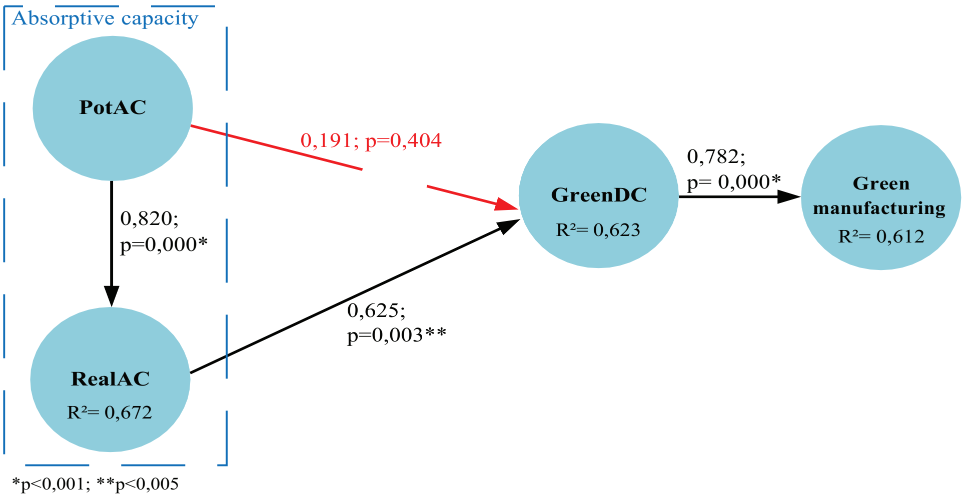

Figure 2: Structural model.

4. CONCLUSION

The results show that the company's capacity to absorb external knowledge has a positive effect on the company's green dynamic capabilities. Then the company's green dynamic capabilities have a positive and significant effect on green manufacturing. This means that absorptive capacity affects green manufacturing indirectly through the company's green dynamic capabilities as a mediator. Implementation of green manufacturing in companies requires the company's ability to identify opportunities and challenges related to green issues, seize these opportunities, and reconfigure company competencies and resources to implement green manufacturing. The greater the green dynamic capabilities, the better the company's green manufacturing practices.

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