

Green Manufacturing Adoption on SME: A review of theories

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Abstract

There are many theoretical frameworks that attempt to describe adoption of green manufacturing (GM). The literature review is one of a tool to finding the pattern of previous research and looking for research gaps, so that further researchers can further develop the field of knowledge. The objective of this paper is to provide an extensive literature review on green manufacturing adoption on SME. We have reviewed 58 articles that spread from 2001 to 2017 (16 years). We collected the articles through systematic literature review and snowball technique from Scopus database. Mendeley software was used to manage and resume the references. We have identified and reviewed this database and try to make classification using coding criteria adapted from Siva et al. (2016). The coding criteria are publication year and journal, data collection method, data analysis method, and contextual (size, country origin and type of industry). We have identified, reviewed and compared constructs theorized of green manufacturing adoption concept in SME.

Keywords

SME's adoption, green manufacturing, theory

1 Introduction

Today, many companies and organizations spend their money to improve their capabilities in environmental protection and sustainable development. Beside, companies attempt to increasing their profit by make their operations more efficient and effective. Increasing of customers awareness and pressure on the environmental practice, became one of the factors driving the company to adopt green issues (Govindan, Diabat, & Madan Shankar, 2015). One of the strategies to improve the efficiency of resources and the effective of environmental impact in manufacturing is green manufacturing (GM). The term 'green manufacturing' was first used in the article title by Dickinson et al. pada tahun 1995 (Sangwan & Mittal, 2015). In line with company attention, scholars interest increasing also. They propose many definition of GM. Shrivastava and R.L. Shrivastava stated that GM is a method for manufacturing that minimizes waste and pollution for all industries (Shrivastava & R.L., 2017). While, Govindan et al. addressed the definition of GM as a system that integrates product and process design issues with issues of manufacturing planning and control in such a manner as to identify, quantify, assess and manage the flow of environmental waste with the goal of reducing and ultimately minimizing environmental impact while also trying to maximize resource efficiency (Govindan, Diabat, & Madan Shankar, 2015). Chuang and Yang mentioned that GM as a manufacturing method that minimises waste and pollution and is a subset of sustainable manufacturing (Chuang & Yang, 2014). We can justify that the most critical thinking of GM is minimizing negative effect on environment, by eliminating waste/pollution, efficiency input/resources and product design.

Adoption and implementation of GM in the company requires considerable cost and effort. Researchers and practitioners attempt to increase the understanding of the GM adoption process. As GM is considered as innovation (Dornfeld, 2014), theories based on innovation adoption may apply in empirical studies on GM adoption. "An innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003). The most widely used theory in adoption innovation is 'diffusion of innovation theory' (Chou, Chen, & Wang, 2012). In fact, there are many theories that studied innovation adoption. Based on Wolfe, there are three research approach on innovation, diffusion of innovation (DI), organizational innovativeness (OI) and process theory (PT) (Wolfe, 1994). The differences of these three approach is presented in Table 1.

Table 1. Difference features of three research approach on innovation

Research Stream	Question	Innovation stage focus	Unit of analysis	Independent Variable	Dependent Variable	Research Model	Major data collection methods
Diffusion	What is the pattern of diffusion of an innovation through a population of potential adopters?	Adoption	An innovation	Organizational characteristics; Innovation characteristics; Promoter characteristics	Diffusion pattern; Diffusion extent; Diffusion rate	Logistic growth model.	Cross sectional surveys; Secondary data
Innovativeness	What determines organizational innovativeness	Adoption or implementation	Organizational	Organizational characteristics; Innovation characteristics; Managerial Characteristics; Environmental characteristics	Innovativeness	Variance/regression models	Cross sectional surveys
Process A-Stage	What are the stages organization go through in implementing innovations?	Adoption through implementation	Innovation process	Innovation characteristics	Stage	Stage models	Cross sectional retrospective surveys
Process B-Process	What factors explain the chain of events which result in innovation implementation?	Adoption through implementation	Innovation process	Precursor Organizational context: strategy, structure, resources, technological strength Organizational politics	Outcome The Innovation process.	Process Models	In-depth field studies

Source: (Wolfe, 1994)

Although, there are many study discuss about adoption innovation, there is still a lack of research that offers a literature review of GM adoption theory. To fill this gap, this research attempt to review the existing literature and to provide an extensive literature review on GM adoption theory. To achieve this purpose, we explore past literature on GM adoption, and theories of GM adoption for organizational adoption with factors considered to influence GM adoption. There are five steps of literature review will be presented based on studies of Tranfield, et al. (Tranfield, Denyer, & Smart, 2003) and Reyes (Garza-Reyes, 2015). **First**, question formulation, stated in section 1; **Second**, locating studies and **third**, study selection and evaluations, will be explained in section 2 that discussed about methodology, followed by the **fourth** step, analysis and synthesis on section 3 and wrapping by **fifth** step reporting and using the results, and future directions on section 4.

2 Methodology

The literature covered studies dated from 2001. The study selection criteria for the literature search were: (a) the study was a manufacturing context, we exclude study from service context, (b) it examined GM adoption in organizations. (c) The source was from reputable journal (Q1 and Q2) based on scimagojr website. We reviewed 58 relevant published studies on GM adoption. We searched from SCOPUS database with the key words ‘adoption green manufacturing’ to gather the relevant articles. Beside, we use snowball technique to enrich the finding. The overview of paper selection process is presented in Figure 1.

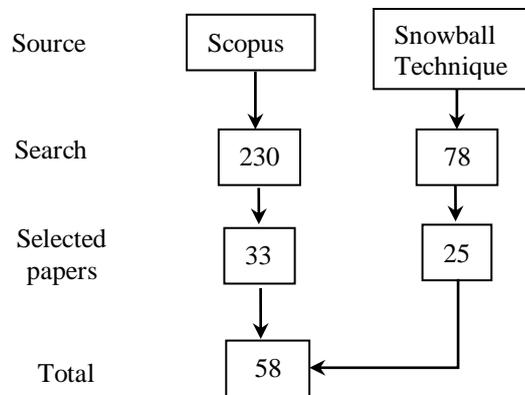


Fig. 1. Overview of paper selection process (Adapted from Siva,et al., 2016)

2.1 Research Method

This study presented an exhaustive literature search for green manufacturing adoption. We used Systematic Literature Review (SLR) that developed by Tranfield et al. (Tranfield et al., 2003), and used by many scholars (Dubey & Ali, 2015; Garza-Reyes, 2015; Geng, Mansouri, & Aktas, 2017; Geng, Mansouri, Aktas, & Yen, 2017). SLR is mapping and emphasize the boundary of knowledge (Tranfield et al., 2003). A literature review consists of a method which is systematic, explicit, and reproducible (Fink, 2005 in (Garza-Reyes, 2015)). Figure 2 embraces the systematic literature review (SLR) and step by step of the process. **First**, the authors setting the goals of research, as has been disclosed in section 1. **Second**, we were searching the articles from Scopus database. A literature search was performed on October-November 2017, using the search path ‘adoption green manufacturing’. We collected some articles from the web and continued searching by snowballing technique. **Third**, we were noted the references from the articles that appeared noteworthy and seem correlated to the topic. We reach, 308 papers and after reading the abstracts and eliminating duplicates, 58 articles from reputable journal (Q1 and Q2) based on scimagojr website were considered relevant and used in this review. Mendeley software was help to manage and resume the references. Table 2 is presented the detailed criteria of selected process. We have not distinguished the research whether in SME or large companies in this initial screening.

Table 2. Detailed Search Screening Criteria (Scopus database)

Search screening	Result
Search word	Adoption green manufacturing
Exclude Subject Area	"CENG","CHEM","PHYS","AGRI","BIOC","EART","PHAR","MEDI".
Exclude Language	Polish, Portuguese, Japanese
Include Document Type	Article, Conference Paper, Conference Review, Review, Book Chapter,

	Article in Press, Book
Initial Data	240
Refinement Data (Q1/Q2)	33

SLR Phases	Objective	Method	Tools	Paper's Section
(1) Question Formation	Describing the objective of the research for guidance			Part 1
(2) Locating Studies	Locating, selecting and evaluating relevant literature	Definition and use of Electronic Databases	Scopus database and snowball technique.	Part 2
(3) Study selection and evaluation		Definition of search period	2001- Nov 2017	
		Definition and use of search strings	adoption green manufacturing	
(4) Analysis and Synthesis	Synthesizing and analyzing selected articles	Reporting Selection of method for synthesis and analysis of qualitative research	Adaptation from Siva et al. (Siva et al., 2016)	Part 3
		Coding and extraction of data	Mendeley software	
(5) Conclusion	Reporting of findings			Part 4

Fig. 2. Systematic Literature Review (adapted from Reyes (Garza-Reyes, 2015))

3. Analysis and Synthesis

We then read the abstracts from those 58 papers and reviewed them based on various codes adapted from Siva et al., that showed in Table 3. From this review we can find that there are many term used to express the green manufacturing concepts, such as, green supply chain management, cleaner production, and eco-innovation, that shown in Table 4. This fact, appropriate with Sangwan and Mittal research that investigating and comparing eight similar frameworks (Sangwan & Mittal, 2015) and there are closely related concept between green innovation, sustainable innovation, ecological innovation and environmental innovation (Schiederig, Tietze, & Herstatt, 2012). It is showed that the GM coverage is very broad (Rehman & Shrivastava, 2013).

Table 3. Classification Criteria

Coding criteria	Description of coding
Publication Year	The year in which the article was published
Publication Journal	The Journal in which the article was published (Q1-Q2) based on scimagojr
Type of article	Empirical, conceptual or review
Data collection method	Survey, Questionnaire, review, case study, interview study, action research, experiment
Data analysis method	SEM, AHP, Fuzzy
Term used	Green manufacturing, cleaner production, eco-innovation
Contextual (Company Size)	Large, SME
Contextual (Company Origin)	US, Europe, Japan, India, China, Asia Tenggara, Others

Adapted from Siva, et al., (Siva et al., 2016)

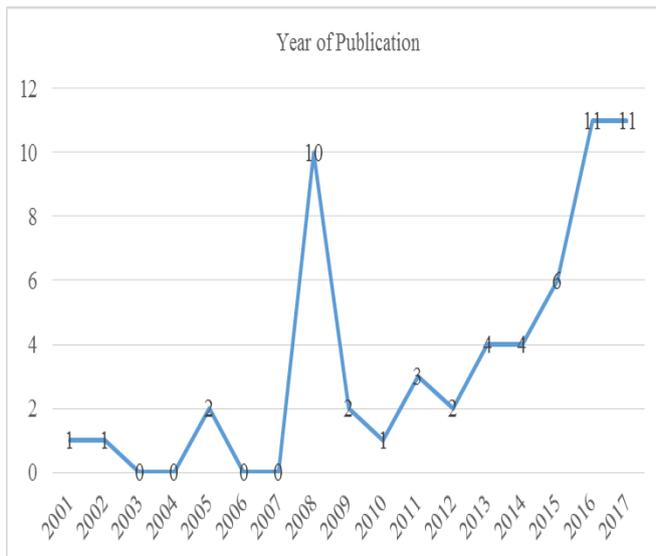


Fig. 3a. Year of Publication

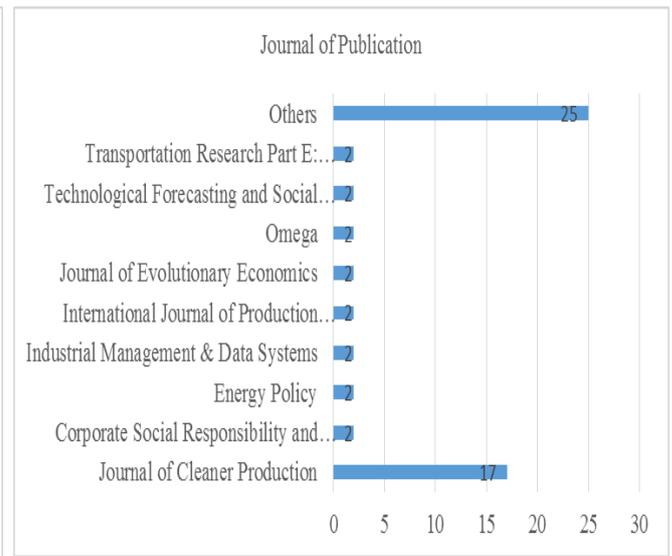


Fig. 3b. Journal of Publication

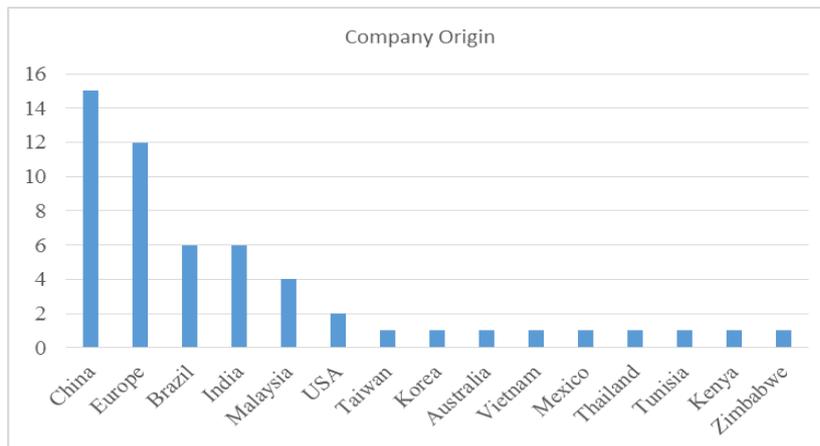


Fig. 3c. Company Origin

Figure 3a. shows the distribution year of publication. It is showed that in last two years, there is a significant increase research of green manufacturing adoption. While figure 3b. presents the proportion of the publication sources in relation to whether the articles were published by journals. In terms of the number of publications per journal, Journal of Cleaner Production was the most powerful journal that contributes in green manufacturing topic. From Figure 3c, we were surprised by the fact that the highest research is conducted in China, followed by Europe, Brazil and India. In South East of Asia, Malaysia leading for the amount of research in adoption of green manufacturing.

Data collection method is presented in Figure 4a. Questionnaire is the most familiar method that is used to collect the data, followed by interview (21%) and review literature (12%). It means that, empirical study is still dominated. From this empirical study, the majority of scholars utilize SEM to analysis the data (45%). It is shows on Figure 4b., that EFA method is in second place (20%), followed by ANOVA and AHP method (15%).

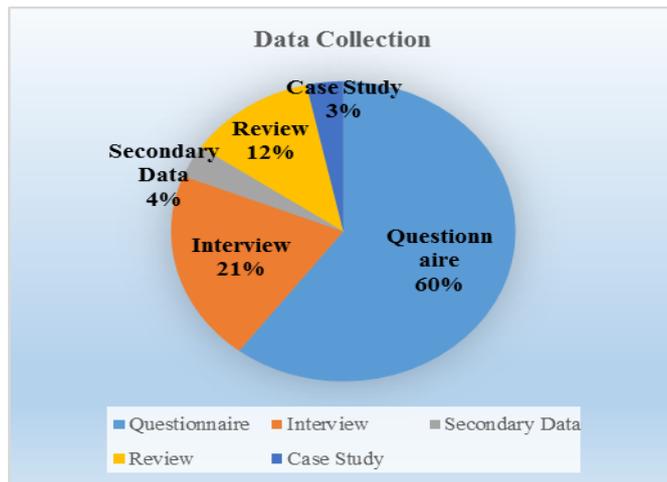


Fig. 4a. Data Collection Method

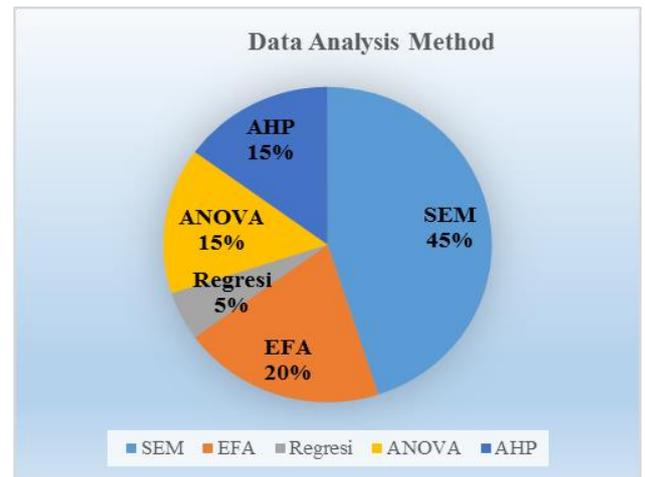


Fig. 4b. Data Analysis Method

Table 4. Term expressed 'green manufacturing' in papers

Term	Author/s
Cleaner Production	(Andrews, Stearne, & Orbell, 2002; Oliveira, Oliveira, Ometto, Ferraudo, & Salgado, 2016)
Cleaner technologies	(Foxon & Pearson, 2008; Kemp & Volpi, 2008; Montalvo, 2008; Montalvo & Kemp, 2008; Nill, 2008)
Green Supply Chain Management (GSCM)	(Hwang, Huang, & Wu, 2016; A. B. Jabbour, Jabbour, Govindan, Kannan, & Arantes, 2014; Laari, Töyli, & Ojala, 2017; Mitra & Datta, 2014; Sarkis, Zhu, & Lai, 2011; Vanalle, Ganga, Godinho Filho, & Lucato, 2017; Wang, Mathiyazhagan, Xu, & Diabat, 2015; Q. Zhu, Sarkis, Lai, & Geng, 2008; Q. Zhu, Sarkis, Cordeiro, & Lai, 2008; Qinghua Zhu, Geng, Sarkis, & Lai, 2011; Qinghua Zhu, Sarkis, & Geng, 2005; Qinghua Zhu, Sarkis, & Lai, 2008)
Green Innovation	(Antonioli, Borghesi, & Mazzanti, 2016; Guoyou, Saixing, Chiming, Haitao, & Hailiang, 2013; Huang, Ding, & Kao, 2009; Zailani, Govindan, & Iranmanesh, 2015)
Green Manufacturing	(Govindan, Diabat, & Shankar, 2015; Liu, Zhou, Zhou, & Xue, 2017; Mittal, 2017; Mittal, Sindhvani, & Kapur, 2016; Soubihia, José, Jabbour, Beatriz, & Sousa, 2015)
Green Management	(Ki-hoon Lee, 2009; Wu & Wu, 2014)
Environmental Practices	(Florida, Atlas, & Cline, 2001; Sarkis, Gonzalez-Torre, & Adenso-Diaz, 2010)
Eco Innovation	(Bonzanini, Dutra, Barcellos, & Marques, 2016; Hojnik & Ruzzier, 2016; Marin, Marzucchi, & Zoboli, 2015a)
Green	Green power (Arkesteijn & Oerlemans, 2005), Green Economy (Antonioli & Mazzanti, 2017), Green logistics (Lai & Wong, 2012), Green Operational Practices (C. J. C. Jabbour et al., 2016), Green Process Innovation (Xie, Huo, Qi, & Zhu, 2016), Green IS (Dalvi-Esfahani, Abdul Rahman, & Ramayah, 2017)
Environmental	Environmental Innovation (Antonioli, Mancinelli, & Mazzanti, 2013; Ghisetti, 2017), Environmentally sound technology (Luken & Van Rompaey, 2008), Environmentally friendlier technologies (Mickwitz, Hyvättinen, & Kivimaa, 2008), environmental management (Zeng et al., 2011), environmentally conscious manufacturing (Kumar Mittal & Singh Sangwan, 2014), Environmental technologies (Diana, Jabbour, Jabbour, & Kannan, 2017),
Sustainable	Sustainable innovation (Noppers, Keizer, Bockarjova, & Steg, 2015), Sustainable manufacturing (Shubham, Charan, & Murty, 2016)
Eco	Eco-Management (Montobbio & Solito, 2017)
Reverse Logistics	(Khor, Udin, Ramayah, & Hazen, 2016)

In general, there are differences between small and large companies. Firms size has a positive effect on green activity (Handfield, Walton, Sroufe, & Melnyk, 2002). SMEs have simple systems and procedures, and shorter decision making chain compare to large companies which make them more flexible (Liu et al., 2017). But, it is more difficulties to introducing green technologies in small and medium-sized organizations (Liu et al., 2017). From 58 papers that we have reviewed, there are only seven research conducting in small company (Andrews et al., 2002; Ki-Hoon Lee, 2009; Liu et al., 2017; Marin et al., 2015; Mittal, 2017; Oxborrow & Brindley, 2013; Zeng et al., 2011). In the next discussion, we will focused on these papers.

Table 5. Research of Adoption Green Manufacturing in SME

Author/s	Title	Research Stream	Objective	Innovation stage focus	Unit of analysis	Independent Variable	Dependent Variable	Research Model	Data collection methods
Andrews et al., 2002	Awareness and adoption of cleaner production in small to medium-sized businesses in the Geelong region, Victoria, Australia	Process A-Stage	to determine the extent of the awareness and implementation of cleaner production practices within small to medium-sized businesses	Awareness, adoption	Organization	-	-	Descriptive Model	Cross sectional surveys
Ki-Hoon Lee, 2009	Why and how to adopt green management into business organizations?: The case study of Korean SMEs in manufacturing industry	Process B-process	to explore and investigate the process of green management adoption in small and medium-sized enterprises.	Adoption through implementation	Innovation Process	organizational structure, innovation capability, human resources, cost savings and competitive advantage	The innovation proces	Process Models	in-depth interviews and document analysis
Liu et al., 2017	Energy Performance Contract models for the diffusion of green-manufacturing technologies in China: A stakeholder analysis from SMEs' perspective	Process B-process	to improve understanding of the challenge of diffusing GM technologies among SMEs.	Adoption through implementation	Innovation Process (based on stakeholder viewed)	stakeholder analysis	diffusion of GM technologies	Energy Performance Contract models	in-depth interviews and focus group discussions
Marin, Marzucchi, & Zoboli, 2015	SMEs and barriers to Eco-innovation in the EU: Exploring different firm profiles.	Innovativeness	To investigate whether the firms' engagement in eco-innovation is related to their awareness of eco-innovation barriers and difficulties	Adoption	Organization	Barriers to eco-innovation	eco-innovation adoption	Regression Model	Interview, secondary data from cross sectional surveys
Mittal, 2017	Adoption of green manufacturing in Indian manufacturing industry: A fuzzy analytical hierarchy process approach for inhibitors.	Innovativeness	to apply fuzzy AHP to rank the factors inhibiting the adoption of GM in India	Adoption	Organization	Inhibiting factor high short term costs , uncertain benefits , technological risks, low top management commitment, lack of organisation resources, lack of awareness/ information, weak legislation, low enforcement, uncertain future legislation, trade-offs, low public pressure, low customer demand	GM adoption	multi-criteria decision method (MCDM)	Experts interview
Oxborrow & Brindley, 2013	Adoption of "eco-advantage" by SMEs: emerging opportunities and constraints.	Process B-process	to identify the capabilities, resources, knowledge and awareness from exogenous and endogenous sources that enable the SME to generate competitive advantage by addressing sustainability issues	Adoption through implementation	Innovation Process	-	Adoption of eco-advantage	Process Models	Interview
Zeng et al., 2011	How environmental management driving forces affect environmental and economic performance of SMEs: A study in the Northern China district.	Innovativeness	to explore how the driving forces of environmental management affect environmental and economic performances of SMEs of different levels of pollution.	Implementation	organizational	government, market, society, and enterprise	environmental performance; business performance	Regression Model	Cross sectional surveys

(Source: Author, 2017)

Table 5 presents the seven articles that conducted green manufacturing adoption in SME. None of these authors has stated clearly, what adoption theory is used in their research.

4. Conclusion

4.1 Result

This literature research is based on Tranfield et al. study (Tranfield et al., 2003). In this review, we found that 58 articles appropriate for this study. Surprisingly, there are only seven studies conducted in small organizations. We further analyze these studies, to gather research streams and features based on Wolfe (1994). Innovativeness and process (B-process) research streams are dominant in the studies, whether diffusion stream is not studied yet. In these seven studies, they are not declared the theory clearly. Only one study based on stakeholder theory to gain an overview of the stakeholders involved in the research (Liu et al., 2017).

4.2 Conclusion, Limitations and Future Directions

In this study, we used the word 'green manufacturing' for searching, however, the results obtained various kinds of word findings, such as gscm, cleaner production, eco-innovation, green practice, green innovation, etc. This causes less focus on understanding the concept of green manufacturing in this research. But, in this literature review we emphasize on adoption term of green manufacturing. Besides, the database is limited. In future research, we suggest to broaden the database such as ISI Web of Knowledge and Google Scholar. Future study can enrich the research by extending the type of document, not only article or journal paper but also books, conference paper, newspaper, book review, report, and so on.

Empirical study is still dominated the trend of GM adoption issue. Meanwhile, questionnaire method is still the most commonly used to collect the data. This provides the opportunity for future research, to use another method such as interview, and exploratory study.

In the context of firm size, research in small business is still rare. This is evidenced by the fact that there are only seven of 58 articles covering small firms. There are many chances to explore small firms in terms of green manufacturing adoption in future studies.

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