

Factors Affecting Implementation of Green Manufacturing for Malaysian Automobile Manufacturers: A Literature Review from 2010 Until 2015

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Abstract: In the global market of today business, manufacturers are being pushed by an unseen driving force to go green in order to grab a share of this emerging market. This study attempts to explore the most impactful factors which contribute to the implementation of green manufacturing by automobile manufacturers. Based on the underlying Technological, Organisation, Environment (TOE) theory and sustainable models the key factors that affect the adoption of green manufacturing practices are identified through an intensive review of literature. Literature review only concentrated on journal published within the year 2010-2015 regarding key factors of green manufacturing practices in automobile industry. Insight acquires from the study is particularly essential for Malaysia automobile industry in developing an effective green manufacturing system into their business activities. In addition, this study aims to assist government agencies in building up relevant and effective green manufacturing policies and guideline. Factors identified in this study will be further investigated in the next research to establish an evaluation tool for measuring green performance level.

Key words: Green manufacturing, factors, automobile manufacturers, evaluation, performance

INTRODUCTION

Malaysia is strategically located at the center of Southeast Asia where recently has become a platform for countries around the world to expand their businesses in this region. In today's marketplace, there is an invisible impetus urging almost every manufacturer to embrace sustainable and green principles into their business operations to compete internationally.

In Malaysian automobile industry, the government has announced national automobile policy 2014 to urge local automobile manufacturers to produce Energy Efficient Vehicles (EEVs) with the aim to protect environment and promote efficiency as well as establish Malaysia as a regional automobile hub in a sustainable way. Vivek Vaidya, a vice-president of Frost and Sullivan for Asia-Pacific said that Malaysia is considered as the most advanced in development of EEVs among Asia countries. In Malaysia, 5% out of 666,456 units of vehicles sold in year 2015 are hybrid and electric cars.

Additionally, as the organization relies on global market there are forces moving to make it extremely difficult and expensive to continue "business as usual" with respect to environmental impacts of manufacturing

around the world. Consequently, it becomes a trend to join the bandwagon of implementing green manufacturing in the business to stay competitive in the current market. Therefore, constant study in the field is required for manufacturers to adapt to the evolving green issues.

Countless studies have been conducted on green practices in the western countries to tackle the rising environmental issues. For instance, Govindan revealed in their study that there is an enormous difference in the results acquired from developed countries and developing countries due to the nature of geography as well as the economic capacity of the countries. Most of the research conducted in the context of developing countries only explored the sub-domains instead of the complete framework of sustainable manufacturing practices throughout product life cycle (Nordin *et al.*, 2014; Pallaro *et al.*, 2015). A recent research published by Balasubramanian *et al.* (2015) has identified 8 influencing factors for successful implementation of green manufacturing, however factors are not systematically categorized according to existing theory.

In view of the prevalent trend, this research aims to find out the key factors associated with the implementation of green manufacturing based on TOE

framework as it is crucial to understand the elements in order to succeed the entire green manufacturing system.

LITERATURE REVIEW

Green manufacturing conceptualization: Melnyk and Smith defined green manufacturing 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”. In general, green manufacturing describes a new paradigm of manufacturing method evolved in 1990s that generate output effectively and efficiently by maximizing the yield while minimizing waste at a minimal or even zero negative impact on the environment throughout product’s life cycle (Deif, 2011; Ghazilla *et al.*, 2015; Rehman *et al.*, 2013; Zhou *et al.*, 2013). Figure 1 illustrates elements of green manufacturing from design to product’s end of life (Frost and Sullivan, 2009).

Prior studies used terms green manufacturing and sustainable manufacturing interchangeably, however, both terms are conceptualized differently by the theory of triple bottom line. The theory suggested that green manufacturing (that covered environmental and social, aspect) is transcending to sustainable manufacturing which comprised of economic, environmental and social aspect. Albeit the different conceptualization of terms both concepts shared most of the operationalization criteria such as greening of production process, green innovation, green human resource management and so on. Accordingly, this study will focus on green manufacturing practices to achieve green performance in advance of the implementation of sustainable manufacturing.

Based on the definition provided by US. Environmental protection agency website, sustainable manufacturing refers to “the making of manufactured products through economically-sound processes that minimalize negative environmental impacts while saving energy and natural resources not forgetting protects the safety of employee, community and consumer”. Therefore, it is clear that sustainable manufacturing aimed to achieve equilibrium for the three pillars. Figure 2 displays the relationship between three pillars of sustainability and lean, green as well as sustainable manufacturing.

Sustainability manufacturing is located at the center of the figure which shares the same level of importance among the three pillars. Nonetheless, it is very challenging to succeed in three aspects simultaneously in reality. Thus, lean and green manufacturing act as initiatives towards sustainable manufacturing.

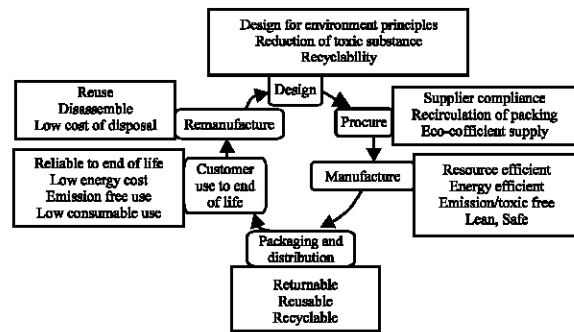


Fig. 1: Green manufacturing conceptualization

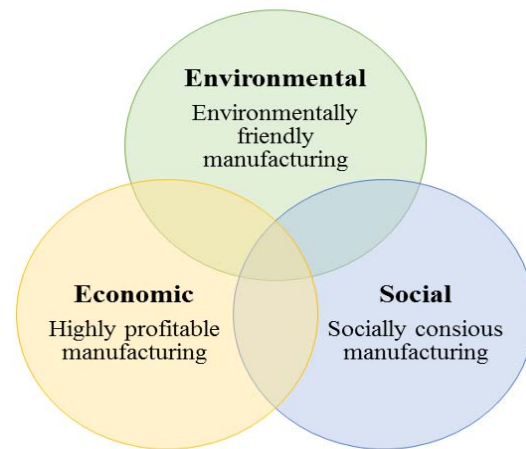


Fig. 2: Manufacturing in relation to the three pillars of sustainability

THEORETICAL FRAMEWORK

After prudently reviewing the literature, Technological-Organisational-Environmental (TOE) framework constructed by Tornatzky is the most suitable framework for this study. Nevertheless, many researchers argued that TOE framework should be expanded to include task characteristics and individual factors in the studies of adoption. Culture and human resource aspect has a vital role to succeed the implementation of green manufacturing as they engaged in every decision making to support the entire manufacturing process. But, there is inadequate analysis involving human resources within the original TOE framework. Therefore, culture and human capital is recommended to complement TOE aspect for green manufacturing practices. This contributes a holistic view of green drivers that influence the adoption of green manufacturing practices among Malaysian automobile companies.

In this research, vital factors that are impactful to the implementation of green manufacturing practices are gathered through extensive literature reviews on topics

about green strategies in automotive sector summarized in Table 1. Journals collected only include journals within 2010-2015 to ensure information is up to date because Malaysia started green development with Green Technology Policy in 2009. Every factor are categorised into four main domains proposed for this study which comprised of technological, organisational, environmental, culture and human capital aspect based on its characteristics. Factors identified are furthered described in Table 2.

Technological aspect: This aspect refers to tangible support such as machines and infrastructures to assist in achieving “green” in the whole process (Sierzchnla *et al.*, 2012).

Organizational aspect: Outlines the communication and linkage with external stakeholders such as customers and

suppliers to produce eco-friendly products through product design and material selection. In addition, this aspect also included company’s capabilities in terms of “what the company can do” to achieve its core business.

Environmental aspect: Outline the arena where company runs its business which includes company’s green initiatives on environmental and social responsibility, government’s legislation and regulations as well as environmental certification.

Culture and human capital aspect: Outline capability and management of internal human resources to succeed green strategy of the company. This aspect represents “how” things are done.

Table 1: Factors identified from various authors who worked on green practices in automobile industry from 2010-2015

Researchers	Technological			Organisational		Environmental			Culture and human capital	
	1	2	3	4	5	6	7	8	9	10
Mishra and Sharma (2010)	-	-	-	-	✓	-	-	-	-	-
Nunes and Bennett (2010)	✓	✓	✓	✓	-	-	-	-	-	-
Azevedo and Machado (2011)	✓	✓	-	✓	-	-	✓	-	-	-
Olugu (2011)	-	✓	-	✓	-	-	-	-	✓	-
Lin <i>et al.</i> (2011)	✓	-	-	✓	-	-	✓	-	-	-
Zakuan <i>et al.</i> (2011)	✓	✓	-	-	-	✓	✓	-	-	-
Kuo <i>et al.</i> (2012)	-	✓	-	✓	-	✓	-	-	✓	-
Penna and Geels (2012)	-	-	-	✓	✓	✓	-	✓	✓	-
Shrikanth and Raju (2012)	-	-	-	-	✓	-	-	-	-	-
Sierzchula <i>et al.</i> (2012)	✓	✓	-	-	-	-	-	-	-	-
Siriwardena <i>et al.</i> (2012)	-	-	-	-	✓	-	-	-	-	-
Caniels <i>et al.</i> (2013)	-	-	-	✓	-	-	-	-	-	-
Diabat <i>et al.</i> (2013)	✓	✓	-	✓	✓	-	✓	-	✓	-
Jabbour <i>et al.</i> (2013)	-	-	-	-	-	-	-	-	-	✓
Mathiyazhagan <i>et al.</i> (2013)	-	-	-	✓	-	-	-	✓	✓	-
Lin <i>et al.</i> (2013)	-	✓	-	-	-	-	-	-	-	-
Jayant and Azhar (2014)	-	-	-	✓	-	-	-	-	✓	✓
Martin <i>et al.</i> (2014)	✓	-	-	-	✓	-	-	-	✓	-
Abduaziz <i>et al.</i> (2015)	-	-	-	✓	-	-	-	-	-	-
Habidin <i>et al.</i> (2015)	✓	-	-	✓	-	-	-	✓	-	-
Kushwaha and Sharma (2015)	-	✓	-	✓	✓	-	-	-	-	-
Zailani <i>et al.</i> (2015)	✓	✓	-	-	-	✓	-	-	✓	-
Total	9/22	10/22	1/22	13/22	7/22	4/22	4/22	3/22	8/22	22

1: Green process innovation; 2: Green product innovation; 3: Green building; 4: Green supply chain; 5: Green marketing; 6: Legislation and regulations; 7: Environmental certification; 8: Corporate Social Responsibility (CSR); 9: Management commitment and collaboration; 10: Green Human Resource Management (HRM)

Table 2: Description of each factor based on different aspects

Factor/definition	Elements	Malaysia initiatives
Green process innovation		
The main objectives of green process are to increase efficiency, prevent and control pollution, decrease the consumption of hazardous and non-renewable resources (Habidin <i>et al.</i> , 2015; Nunes and Bennett, 2010)	Pollution prevention practices Environment friendly technologies Effective and efficient manufacturing process Remanufacturing	One of the green technologies being used in Malaysia automobile industry is wastewater treatment equipment that purifies wastewater before discharged to the environmental Purifying wastewater is vital in automobile industry because nearly 40,000 gallons of water is used to produce each car

Table 2: Continue

Factor/definition	Elements	Malaysia initiatives
<p>Green product innovation Green product innovation refers to inventing new or significantly upgraded products such as extending product's life-cycle in response to environmental concerns (Kushwaha and Sharma, 2015; Zailani <i>et al.</i>, 2015)</p>	<p>Design for reduction or elimination of environmentally hazardous materials Design for remanufacturing Design for recycling Design for reuse Design for resource efficiency Quality improvement</p>	<p>Honda brought in their hybrid technology to Malaysia and start their production of Hybrid Honda Jazz on shore In 2014 Perodua Axia marketed the first vehicle that qualifies with EEV standards in Malaysia Proton Malaysia has also introduced its first electric vehicle-Iriz EV with zero emission in September 2015</p>
<p>Green building Green building indicates the construction of buildings that is environmentally friendly and resource-efficient to promote sustainable life Benefits include increase in productivity, decrease in health, safety and maintenance costs, conserve water and energy and improve waste management(Nunes and Bennett, 2010)</p>	<p>Energy efficiency Indoor environmental quality Sustainable site planning and management Material and resources Water efficiency Innovation</p>	<p>In Malaysia, Green Building Index (GBI) was launched in 2009 to promote sustainable development in building industry</p>
<p>Green supply Chain The intention of Green Supply Chain Management (GSCM) is to integrate environmental aspects into decision making at every level within the organization (Seman, 2012)</p>	<p>Green logistics Green purchasing Environmental awareness of supplier Supplier commitment Green dealer Reverse logistics</p>	<p>Green supply chain is still in infancy stage in Malaysia because many local suppliers do not conform to any environmental certification yet. However, some global suppliers are certified with ISO14001</p>
<p>Green marketing Green marketing refers to promoting products that are environmental friendly produced (Shrikanth and Raju, 2012). Green marketing can help develop green corporate image as it covers a broad range of business activities (Kushwaha and Sharma, 2015; Mishra and Shanna, 2010)</p>	<p>Eco-labelling of products Company's goals, values and mission</p>	<p>SIRIM has released Eco-Labeling Scheme to position products as environmentally friendly products. However, this scheme is not popular in automotive industry yet Nevertheless, Malaysian automobile manufacturers such as Proton have set goals to save energy while reducing environmental impact</p>
<p>Legislation and regulations Environmental legislation and regulations is a collection of government laws aimed to protect natural environment from harmful human activities (Zakuan <i>et al.</i>, 2011)</p>	<p>Environmental regulations Industry specific regulations</p>	<p>Malaysian automobile manufacturers are complying with environmental acts, laws and regulations to continue their businesses for example, producing ecological vehicle to comply with EEV requirements</p>
<p>Environmental certification Environmental certification is a type of voluntary certification that provides systematic approach in environmental regulation</p>	<p>ISO 14001 ISO 50001</p>	<p>Themostpopular environmental certification in Malaysia is ISO14001 standard. Some Malaysia automobile manufacturers such as Proton and Honda is certified with ISO14001</p>
<p>Corporate Social Responsibility (CSR) CSR refers to company's effort to go beyond what is required by law and take considerations on company's influence on environmental and social wellbeing</p>	<p>Public opinion Company's image</p>	<p>CSR in environmental aspect is growing gradually. For example, Proton practiced a policy in which trees are planted based on the number of researchers in the factory</p>
<p>Management commitment and collaboration Management commitment refers to management willingness to dedicate in green philosophy and collaborates with departments to adopt green practices (Ezutah Olugu and Wong, 2011; Zailani <i>et al.</i>, 2015)</p>	<p>Top management commitment Cross-functional cooperation for environmental improvements Technical knowledge and capabilities Organizational culture</p>	<p>Proton Malaysia has outlined 5 key aspects to conserve energy while minimizing pollution. Proton also established a Green Project Team to specially deal with green practices implemented in different departments</p>
<p>Management (GHRM)Green Human Resource Green HRM is the combination of HRM and green philosophy, policies and practices with an intention to conserve ecological balance as well as protect environment (Jayant and Azhar, 2014)</p>	<p>Training Recruiting and selection Performance evaluation Rewards</p>	<p>In Proton Malaysia, training is provided for current workers to grasp knowledge in the latest and available green technique</p>

CONCLUSION

This study aims to determine the factors that contribute to the implementation of green manufacturing.

After reviewing literatures in the scope of green manufacturing in automobile industry, 10 most discussed factors are discovered in their studies. Each of the factors is further categorized into technological, organizational,

environmental as well as culture and human capital aspect. Green process innovation, green product innovation and green building are classified into technological aspect while green supply chain and green marketing are classified into organizational aspect. Whereas, environmental aspect includes legislation and regulations, environmental certification and Corporate Social Responsibility (CSR). Lastly, culture and human capital aspect consists of management commitment and collaboration as well as green human resource management.

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REFERENCES

- Abduaziz, O., J.K. Cheng, R.M. Tahar and R. Varma, 2015. A hybrid simulation model for green logistics assessment in automotive industry. *Procedia Eng.*, 100: 960-969.
- Azevedo, S.G., H. Carvalho and V. Cruz Machado, 2011. The influence of green practices on supply chain performance: A case study approach. *Transp. Res. Part E: Logist. Transp. Rev.*, 47: 850-871.
- Balasubramanian, D., D. Kher, M. Dinesh, G. Madan and S. Shekharan *et al.*, 2008. Factors influencing successful implementation of green manufacturing. *Aims Intl. J. Manag.*, 9: 1-16.
- Caniels, M.C., M.H. Gehrsitz and J. Semeijn, 2013. Participation of suppliers in greening supply chains: An empirical analysis of German automotive suppliers. *J. Purchasing Supply Manage.*, 19: 134-143.
- Chuang, S.P. and C.L. Yang, 2014. Key success factors when implementing a green-manufacturing system. *Prod. Plann. Control*, 25: 923-937.
- Deif, A.M., 2011. A system model for green manufacturing. *J. Cleaner Prod.*, 19: 1553-1559.
- Diabat, A., R. Khodaverdi and L. Olfat, 2013. An exploration of green supply chain practices and performances in an automotive industry. *Intl. J. Adv. Manuf. Technol.*, 68: 949-961.
- Frost and Sullivan, 2009. Getting serious about green manufacturing. Frost & Sullivan, San Antonio, Texas.
- Ghazilla, R.A.R., N. Sakundarini, S.H. Abdul-Rashid, N.S. Ayub and E.U. Olugu *et al.*, 2015. Drivers and barriers analysis for green manufacturing practices in Malaysian SMEs: A preliminary findings. *Procedia CIRP.*, 26: 658-663.
- Habidin, N.F., A.F.M. Zubir, N.M. Fuzi, N.A.M. Latip and M.N.A. Azman, 2015. Sustainable manufacturing practices in Malaysian automotive industry: Confirmatory factor analysis. *J. Global Entrepreneurship Res.*, Vol. 5.10.1186/s40497-015-0033-8
- Jabbour, C.J.C., D.S.A.B.L. Jabbour, K. Govindan, A.A. Teixeira and D.S.W.R. Freitas, 2013. Environmental management and operational performance in automotive companies in Brazil: The role of human resource management and lean manufacturing. *J. Cleaner Prod.*, 47: 129-140.
- Jayant, A. and M. Azhar, 2014. Analysis of the barriers for implementing Green Supply Chain Management (GSCM) practices: An Interpretive Structural Modeling (ISM) approach. *Procedia Eng.*, 97: 2157-2166.
- Kuo, T.C., C.W. Hsu, K.C. Ku, P.S. Chen and C.H. Lin, 2012. A collaborative model for controlling the green supply network in the motorcycle industry. *Advanced Eng. Inf.*, 26: 941-950.
- Kushwaha, G.S. and N.K. Sharma, 2016. Green initiatives: A step towards sustainable development and firm's performance in the automobile industry. *J. Cleaner Prod.*, 121: 116-129.
- Lin, R.J., K.H. Tan and Y. Geng, 2013. Market demand, green product innovation and firm performance: Evidence from Vietnam motorcycle industry. *J. Cleaner Prod.*, 40: 101-107.
- Lin, R.J., R.H. Chen and T.H. Nguyen, 2011. Green supply chain management performance in automobile manufacturing industry under uncertainty. *Proc. Soc. Behav. Scie.*, 25: 233-245.
- Martin-Pena, M.L., E. Diaz-Garrido and J.M. Sanchez-Lopez, 2014. Analysis of benefits and difficulties associated with firms environmental management systems: The case of the Spanish automotive industry. *J. Cleaner Prod.*, 70: 220-230.
- Mathiyazhagan, K., K. Govindan, A. NoorulHaq and Y. Geng, 2013. An ISM approach for the barrier analysis in implementing green supply chain management. *J. Cleaner Prod.*, 47: 283-297.
- Mishra, P. and P. Sharma, 2010. Green marketing in India: Emerging opportunities and challenges. *J. Eng. Sci. Manag. Educ.*, 3: 9-14.
- Nordin, N., H. Ashari and M.G. Hassan, 2014. Drivers and barriers in sustainable manufacturing implementation in Malaysian manufacturing firms. *Proceedings of the 2014 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, December 9-12, 2014, IEEE, Kedah, Malaysia, ISBN:978-1-4799-6411-6, pp: 687-691.

- Nunes, B. and D. Bennett, 2010. Green operations initiatives in the automotive industry: An environmental reports analysis and benchmarking study. *Benchmarking: Int. J.*, 17: 396-420.
- Olugu, E.U. and K.Y. Wong, 2011. A study on the validation of green supply chain performance measures in the automotive industry. *Commun. IBIMA.*, 2011: 1-14.
- Olugu, E.U., K.Y. Wong and A.M. Shaharoun, 2011. Development of key performance measures for the automobile green supply chain. *Resour. Conserv. Recycl.*, 55: 567-579.
- Pallaro, E., N. Subramanian, M.D. Abdulrahman and C. Liu, 2015. Sustainable production and consumption in the automotive sector: Integrated review framework and research directions. *Sustainable Prod. Consumption*, 4: 47-61.
- Penna, C.C. and F.W. Geels, 2012. Multi-dimensional struggles in the greening of industry: A dialectic issue lifecycle model and case study. *Technol. Forecasting Social Change*, 79: 999-1020.
- Rehman, M.A.A., R.R. Shrivastava and R.L. Shrivastava, 2013. Validating Green Manufacturing (GM) framework for sustainable development in an Indian Steel Industry. *Univ. J. Mechan. Eng.*, 1: 49-61.
- Seman, N.A.A., N. Zakuan, A. Jusoh, M.S.M. Arif and M.Z.M. Saman, 2012. Green supply chain management: A review and research direction. *Int. J. Manag. Value Supply Chains*, 3: 1-18.
- Shrikanth, R. and D.S.N. Raju, 2012. Contemporary green marketing-brief reference to Indian scenario. *Intl. J. Social Sci. Interdiscip. Res.*, 1: 26-39.
- Sierzchula, W., S. Bakker, K. Maat and V.B. Wee, 2012. Technological diversity of emerging eco-innovations: A case study of the automobile industry. *J. Cleaner Prod.*, 37: 211-220.
- Siriwardena, S., G. Hunt, M.F. Teisl and C.L. Noblet, 2012. Effective environmental marketing of green cars: A nested-logit approach. *Transp. Res. Part D. Environ.*, 17: 237-242.
- Wooi, G.C. and S. Zailani, 2010. Green supply chain initiatives: investigation on the barriers in the context of SMEs in Malaysia. *Int. Bus. Manage.*, 4: 20-27.
- Zailani, S., K. Govindan, M. Iranmanesh, M.R. Shaharudin and Y.S. Chong, 2015. Green innovation adoption in automotive supply chain: The Malaysian case. *J. Clean. Prod.*, 108: 1115-1122.
- Zakuan, N., M.M. Saman and A.R. Hemdi, 2012. Critical Success Factors of Green Design Implementation for Malaysia Automotive Industry. In: *Advanced Materials Research*, Fan, W. (Ed.). Trans Tech Publications, Bangkok, Thailand, pp: 3395-3402.
- Zhou, M., Y. Pan, Z. Chen and W. Yang, 2013. Optimizing green production strategies: An integrated approach. *Comput. Ind. Eng.*, 65: 517-528.
- Zhu, Q., J. Sarkis and K.H. Lai, 2007. Green supply chain management: Pressures, practices and performance within the Chinese automobile industry. *J. Clean. Prod.*, 15: 1041-1052.