A Review of Eco-innovation Concept

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Abstract. Eco-innovation has been recognised as one of the essential strategy for firms to respond to the increasing global environmental issues. In this regard, the eco-innovation concept has been an interest of scholars worldwide. Numerous studies have been carried out in their attempt to understand the concept of eco-innovation. Despite of being broadly defined in a number of diverse contexts and terminologies, they showed no general agreement on some conceptualizations of eco-innovation. This has resulted in the emergence of very broad and unclear definitions. The meaning of eco-innovation needs to be clearly understood before embarking extensive studies on it such as the drivers and barriers of the green initiatives, the impacts of eco-innovation practice, the measurement of eco-innovation performance and many more. Sound empirical studies would depend largely on the theoretical perspectives underpinning eco-innovation. A comprehensive evaluation of concepts in eco-innovation is extremely important to enrich the sustainable innovation management field of knowledge. This paper seeks to review and assess the concept of eco-innovation. It forwards an operational definition of eco-innovation to stimulate changes in environmental innovation perception and provide clear directions for further research. The future research will use this concept to assess the performance of eco-innovation practice in a manufacturing operation.

Keywords: Eco-innovation, green innovation; environmental innovation; sustainable innovation; concept review

1. INTRODUCTION

Recent expansion of value creation activities by business firms has resulted in the emergence of various global environmental degradation such as increasing greenhouse gas (GHG) emissions, resources scarcity, climate change and threat of extinction. Their efforts in meeting current society needs are compromising the sustainability of precious resources and the future generations' ability to enjoy high quality of life. In response to this, firms have shown more interest in eco-innovation which been viewed as a promising strategy for providing solutions to the pressing environmental problems.

In recent years, eco-innovation concept is increasingly connected to green growth and has heightened attention of scholars worldwide. However, they have shown no general agreement on the definition of eco-innovation (such as Miedzinski and Reid, 2008; Melece, 2015; Carillo-Hermosilla et al., 2010; Xavier, 2015). Some scholars provide precise definition while others suggested very broad ones. In addition, question has also been raised on different terminologies being used to explain innovations aiming at preserving natural resources and environment. Among the designations often employed synonymously by academics in previous publications are 'green innovation', 'eco-innovation', 'environmental innovation' and 'sustainable innovation' (Debref, 2012; Angelo et al., 2012; Schiederig et al., 2012). Thus, further clarification of eco-innovation definition and appropriate notion to describe this concept is needed in order to have a clearer picture of its specific characteristics.

This paper sheds light on the definition of eco-innovation concept. The definitions found in previous researches were analysed based on four different timeframe to see how the main focus of the definitions has developed and changed over time. Since eco-innovation is context specific, by reviewing the definitions of eco-innovation and developing an operational definition, we hope to show the

importance of having a specific and operational definition towards developing some kind of a tool for measuring eco-innovation performance. This paper is structured as follows: Section 2 describes approaches applied to compile relevant literature for analysis. Section 3 reviews definitions of eco-innovation and clarifies the relevant terminologies. Section 4 consists of operational definition of eco-innovation developed in this study. Finally, this paper closes with some concluding remarks in Section 5.

2. RESEARCH APPROACH

This paper employed literature review method which involved the critical analysis of previous published studies. In compiling literature, database searches were mainly relied whereby the published studies were identified from the Web of Science, Scopus and Google Scholar (GS) databases. We searched by topic using predetermined strings comprising of terms 'eco-innovation', 'green innovation', 'environmental innovation' and 'sustainable innovation' to ensure that all relevant published materials are considered in our analysis and not limited to the top journal publications only such as implemented by Schiederig et al. (2012). Published researches were searched and extracted in April until June 2016, limited to materials published over the past five years (i.e. 2012 to 2016).

Besides that, forward snowballing and backward snowballing techniques were applied to supplement the found literatures as suggested by Jalali and Wohlin (2012). In forward snowballing, the studies which cited the literatures found in electronic databases (i.e. the seed set) and the related articles suggested by the databases were searched (Felizardo et al., 2016; Jalali and Wohlin, 2012). While in backward snowballing, additional relevant materials were gathered by referring to list of references of the seed set (Felizardo et al., 2016; Greenhalgh et al., 2004; Jalali and Wohlin, 2012). Various types of literature were compiled using electronic databases searches and snowballing techniques which consist of journal articles, conference proceedings, book chapters, project reports and working papers. The compiled literatures were assessed and downsized based on their quality and relevancy.

Analysis of eco-innovation is done according to the different evolutionary stages from the time when the concept was recorded to have been introduced until now. There were enormous versions of eco-innovation definitions discovered in the collected literatures, but this study will focus only on the definitions in 25 studies conducted by prominent researchers in the field of sustainable innovation management. What is meant by prominent researchers are those who are leading and actively carrying out research in the area and their works cited extensively by other scholars.

3. ECO-INNOVATION DEFINED

Eco-innovation has been identified as one of the indispensable strategy for firms to react to the growing global environmental problems. However, in spite of the increasing importance of eco-innovation, there is difficulty in understanding the word 'eco-innovation' as its meaning keep on changing according to the changes in the ways the businesses are operated. Therefore, the evolution of eco-innovation definition needs to be reviewed in order to have a better understanding of the key characteristics of eco-innovation process.

Fussler and James (1996) are amongst the early scholars who introduced the concept of eco-innovation. The term eco-innovation is believed to have first appeared in their book titled *Driving Eco-innovation: A Breakthrough Discipline for Innovation and Sustainability.* Since then, a considerable amount of literature has defined eco-innovation differently according to the different perspectives and contexts it is applied. The summary of definitions together with terminologies used by authors to explain this type of innovation since 1996 to 2016, which was reviewed in this study, is depicted in Table 1. Figure 1 was developed by authors of this paper to show the main concerns characterising eco-innovation definition evolutionary.

3.1 Stage 1 (1996 – 2000) - eco-benefits oriented innovations

In early years, most authors suggested generic definitions of eco-innovation. An essential aspect that all authors shared in their definition was the highlight of benefits gained from implementing environmental-friendly changes rather than the intention of such efforts. They agreed that eco-innovation is any innovation which resulted in reducing the negative impacts of their operations on environment regardless of whether it is intended or not. These definitions are neutral in terms of no specification of content or direction of the changes. The eco-innovation term was deployed to explain initiatives related to reduction of pollution using end-of-pipe technologies which referred as solutions to cleaning up or control pollution after it has occurred without removing its causes.

Fussler and James (1996); Hemmelskamp (1997) and Rennings (2000) also recognised very limited types of innovation, namely product and process except for Kemp and Arundel (1998) who clearly classified them into technical and non-technical innovations. The latter is known as organisational innovation such as changes in the firm's techniques and system. Furthermore, Kemp and

Arundel (1998), and Rennings (2000) noted two different kind of changes: developed internally by the firm (i.e. new to the world) and application of innovation introduced by other firm (i.e. new to the firm).

3.2 Stage 2 (2001 – 2005) - cleaner technologies innovations

At this stage, the main concerns of eco-innovation have shifted from previous emphasis of mitigating ecological impacts to efficient use of resources. The definitions revealed that it refers to any new product or process development which aiming at reducing resource consumption and therefore limiting the harmful impacts on environment (Green, 2005). There was transparent movement of environmental preservation technologies from end-of-pipe technologies to cleaner production technologies or the practice of both technologies. Cleaner production technologies are proactive methods which integrated into the production processes aiming to remove causes of environmental damage (i.e. preventing pollution) and to achieve efficient resources usage (like materials and energy).

In terms of innovation benefits, the new perspective demonstrated broader expectations, beyond reducing environmental impacts but also addressing economical aspect through efficient use of resources. However, Horbach (2005) highlighted that by coupling environmental and economical improvements, a firm could also enjoy advantages of improved social and institutional performance. This means that social and institutional impacts have been introduced in this stage. It is important to note that initially eco-innovation term was applied to describe efforts on pollution abatement, and then it has gradually moved to addressing the economical, social and institutional concerns as well.

3.3 Stage 3 (2006 – 2010) - intentional/unintentional eco-innovations

During 2006 to 2010, eco-innovation concept evolved even further and intense. Wealth of ways has been identified to be effective to implement the improved green solutions such as products, service, production process, technologies, systems, procedure, management system and business method. In terms of motivation for practicing eco-innovation, nearly all scholars (Hellstrom, 2007; Miedzinski and Reid, 2008; OECD, 2009; Carrillo-Hermosilla et al., 2010) thought that eco-innovations are innovations which resulted in a reduction of environmental impact, no matter whether or not that effect is intended. In unintended eco-innovation, the main intentions can be economical (competitively priced products, meeting market force), social (safe product, better quality of life) and institutional (green product designs, corporate environmental management) aspects. Environmental benefits can be unexpectedly gained as outcome of the innovation initiatives together with other achievements which have been set as the main target. For example, in a firm's initiative in recycling heavy metals with intention of reducing costs, reduction of ecological impacts can be a side-effect of cost saving goal. On the other hand, innovation with intended environmental effects is the one which performed strategically and placing the environmental aspect as the main concern in decision making at each stage of the innovation process. In this case, ecological benefits are expected to be brought throughout the technologies' life cycle.

The inclusion of ecological issues in innovation process of a firm occurred at any stage of a product life-cycle in larger degree of novelty. The eco-innovation was defined in broader term encompasses any clean technologies which either new to the world that created internally by the firm or new to the firm innovations (developed and introduced by other firms). Two approaches new to the firm innovation are adaptation and adoption approach. Adaptation refers to the modification of readily available environmental technologies while adoption involves the use of on-the-shelf technologies without any modification. The inclusion of the word 'adoption' in definitions (like in Kemp and Pearson, 2007; Oltra et al., 2009; Mazzanti and Montini, 2009) suggested innovation could comprise of anything that has been introduced by other firm. The concept is in line with Oslo Manual definition of innovation. For instance, a company can eco-innovate by outsourcing cleaner production technology from a supplier for application in its production line (Arundel and Kemp, 2009). In short, any ecological improvement which is new and significant to the company even though it is common to other companies is counted as eco-innovation.

When compared to previous stage, eco-innovators at this stage were believed to enjoy much more benefits of practicing eco-innovation. The benefits include improvements in economical (energy and resource saving), environmental (pollution prevention, minimal use of natural resources including surface area and minimal toxic substances), social (waste minimisation and recycling) and institutional (changes in values, beliefs, knowledge, norms, and administrative acts) performances.

3.4 Stage 4 (2011-2016) - strategic eco-innovations

The next stage saw eco-innovation approach elevated to greater environmental commitment of organisations, towards supporting proactive eco-innovation process.

Proactive eco-innovator is an organisational concept with external and internal influence. Eco-innovation initiatives were integrated strategically whereby ecological aspects are the focal point in the firm's efforts to explore new opportunities with applicability in any processes performed by any departments or business units (Angelo et al., 2012). Eco-innovation activities were driven by the intention to address the environmental and societal along with economical concerns through efficient and responsible use of natural resources (Bossink, 2012; Machiba, 2013; Melece, 2015) in broad arrays of area which includes technical innovations (products, service and production process) and non-technical innovations (organizational, marketing and institutional). In other words, the efforts are supporting the achievement of improving and sustaining environment for the good of current and future society.

Most firms realised the importance of establishing a healthy and sustainable business environment where economic wealth creation, environmental preservation and social wellbeing priority should be placed on equal footing in deciding their operation strategy. In European Commission (EC) (2011) and OECD (2009), eco-innovation has been recognised as one of the driving force to achieve sustainable development whereby it was referred as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development (WCED), 1987). The concept stresses the need to establish a balanced approach between maximising economic returns, protecting environment and securing society well-being by industrial players. The industrialists at this stage obtained the greatest competitive advantages in consequence of their maximum commitment on preserving current and future environmental and societal benefits. Eco-innovation concept has grown in scope, depth and breadth than the previous understanding in which the scope extend beyond the firm's boundary.

3.5 Terminologies Clarification

Another important point to mention with regard to definition of eco-innovation is the numerous designations used by scholars to describe eco-innovation concept. This study identified four main terminologies related to eco-innovation: eco-innovation, green innovation, environmental innovation and sustainable innovation. As illustrated in Table 2, the percentage of the terms most used to explain innovation aiming at protecting the environment in the reviewed literatures for this study was recognized according to the following distribution: eco-innovation (64 percent), environmental innovation (24 percent), green innovation (8 percent) and sustainable innovation (4 percent). However, the findings do not support the previous research of Angelo, et al. (2012), who have conducted systematic literature review on Scientific articles indexed in the ISI Web of Science and Scopus and published in 2009 until 2011. They found that 65 percent of the studied literatures applying 'environmental innovation', 22 percent with 'eco-innovation' and 13 percent employing 'green innovation' term. This rather contradictory result may be due to the fact that the literatures used in both studies were extracted from different database (i.e. GS) and with different targeted publishing timeframe.

In relation to the scope of each term, Schiederig et al. (2012) stated that even though scholars used different terminologies to describe novel implementation of changes to minimise the environmental impacts, previous studies indicated that they are closely related to each other with minor differences. The use of eco-innovation tends to demand for a thorough impact analysis whereas the use of green innovation notions in literatures remained at shallow level. The eco-innovation term was said to be the most accurate to describe innovation which focusing on reducing ecological impacts and well developed concept compared to the other three terms. In comparison to the sustainable innovation notion, the main difference with the other three notions is its additional concern, which is the social dimension besides economical and ecological aspects.

In this paper, eco-innovation terminology has been opted over the other three terms (namely green innovation, environmental innovation and sustainable innovation) and used in discussions throughout the paper because it has been used most often to describe innovations which supporting sustainable development in the compiled literatures. This is supported with the findings of study by Carrillo-Hermosilla et al. (2010).

Table 2: Distribution of eco-innovation/environmental innovation /green innovation/sustainable innovation terminology

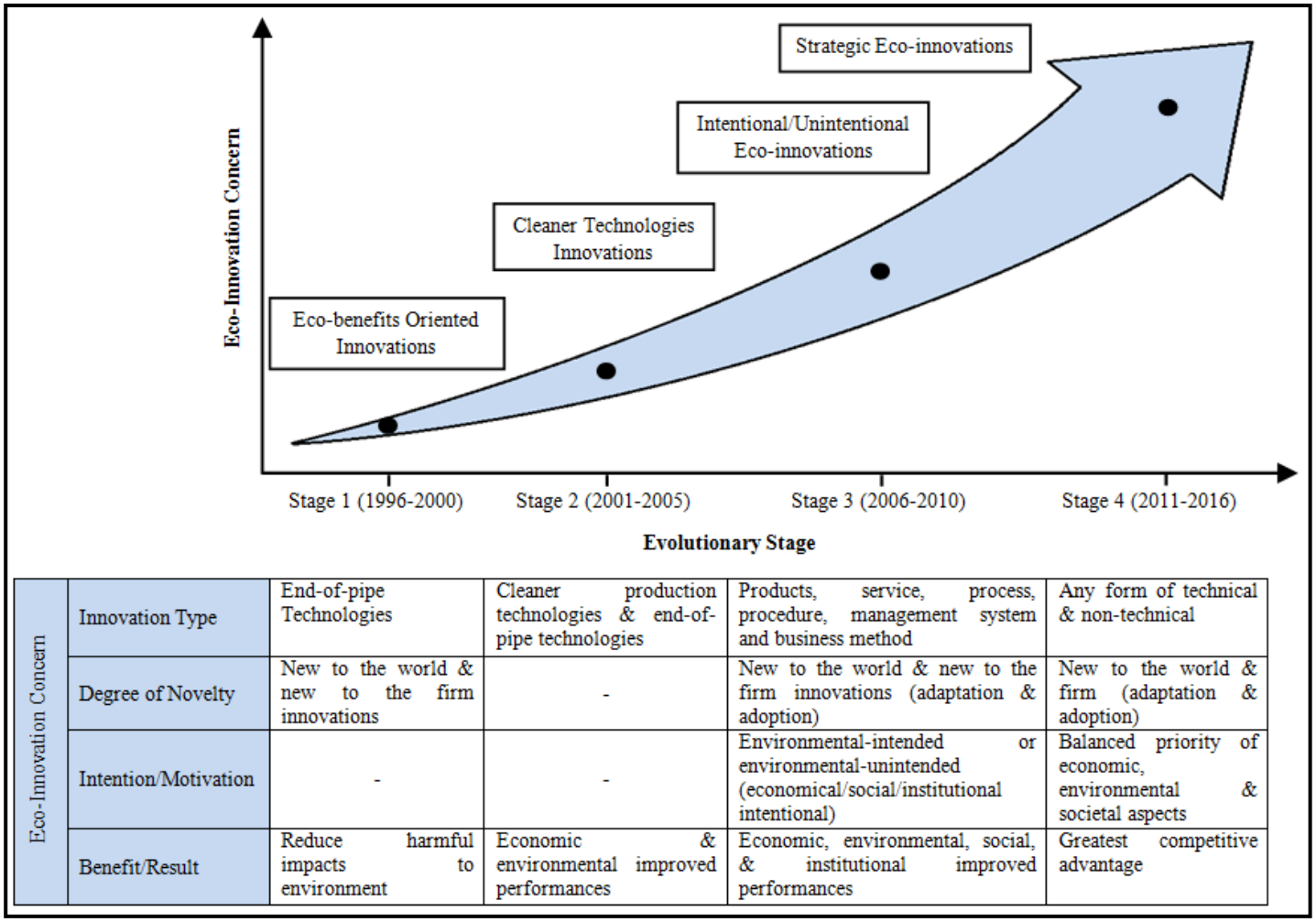
Terminology	Frequency	Percentage
Eco-innovation	16	64
Environmental innovation	6	24
Green innovation	2	8
Sustainable innovation	1	4
Total	25	100

Table 1: Definitions of eco-innovation

Scholar (s)	Terminology	Definition
Fussler and James (1996)	Eco-innovation	New products and processes which provide customer and business value but significantly decrease environmental impacts.
Hemmelskamp (1997)	Environmental Innovation	Innovations which aim at reducing the negative environmental impacts caused by production methods (process innovations) and products (product innovations).
Kemp and Arundel (1998)	Environmental Innovation	New or modified processes, techniques, systems and products (either technical or organisational innovation) to avoid or reduce environmental harms.
Rennings (2000)	Eco-innovation	All measures of relevant actors (firms, politicians, unions, associations, churches, private households) which develop new ideas, behaviour, products and processes, apply or introduce them and which contribute to a reduction of environmental burdens or to ecologically specified sustainability targets.
VINNOVA (2001)	Environmental Innovation	Innovation that serves to prevent or reduce anthropogenic burdens on the environment, clean up damage already caused or diagnose and monitor environmental problems.
Horbach (2005)	Sustainable Innovation	Innovations which aiming to reduce environmental impacts and comprise of economic, environmental, social and institutional aspects.
Green (2005)	Environmental Innovation	Processes whereby new products and processes can be developed which take account of ecological impacts and resource usage.
Chen et al. (2006)	Green Innovation	Hardware or software innovation that is related to green products or processes, including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs, or corporate environmental management.

Kemp and Pearson (2007); Oltra et al. (2009)	Eco-innovation	The production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives.
Hellstrom (2007)	Eco-innovation	Completely new products as well as products that improve human life factors apart from minimizing waste, such as safety and other quality of life aspects.
Miedzinski and Reid (2008)	Eco-innovation	The creation of novel and competitively priced goods, processes, systems, services, and procedures designed to satisfy human needs and provide a better quality of life for everyone with a whole-life-cycle minimal use of natural resources (materials including energy and surface area) per unit output, and a minimal release of toxic substances.
OECD (2009)	Eco-innovation	Innovation that results in a reduction of environmental impact, no matter whether or not that affect is intended.
Mazzanti and Montini (2009)	Eco-innovation	The production, application or use of a product, service, production process or management system that is new to the firm adopting or developing it, and which implies a reduction in environmental impact and resource use (including energy) throughout its life cycle.
Carrillo-Hermosilla et al. (2010)	Eco-innovation	Innovation that improves environmental performance, whereby the reduction in environmental impacts (whether intentional or not) is the main distinguishing feature of eco-innovation.
Andersen (2010)	Eco-innovation	Innovations which are able to attract green rents on the market.
European Commission (EC) (2011)	Eco-innovation	Any form of innovation resulting in or aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment, enhancing resilience to environmental pressures, or achieving a more efficient and responsible use of natural resources.

Bossink (2012)	Eco-innovation	The development of new initiatives in an organization to sustain, improve and renew the environmental, social and societal quality of its business processes and the products and services these business processes produce.
Schiederig et al. (2012)	Green Innovation	Innovations which aiming at reducing environmental impacts.
Debref (2012)	Environmental Innovation	Driven by market and is based on categorization as a service, process, organization, new outlet and new raw material using environmental technologies, either additive and preventive methods which are helped by life cycle assessments to reduce or to avoid environmental impacts.
Angelo et al. (2012)	Environmental Innovation	Organizational implementations and changes focusing on the environment, with implications for companies' products, manufacturing processes and marketing, with different degrees of novelty.
Machiba (2013)	Eco-innovation	Innovations which address current and future environmental problems and decreasing energy and resource consumption, while promoting sustained economic activities.
Karaarslan (2015)	Eco-innovation	New product, process, method, market, resources and organisation which primarily aim to benefit the environment.
Melece (2015)	Eco-innovation	The production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and through the development of ecological improvements benefits the environment by preventing or reducing the impact, or by more efficient and responsible use of natural resources.
Levidow et al. (2016)	Eco-innovation	Innovative practices which enhance resource efficiency by combining economic value with environmental performance.



Eco-Innovation Concern					
	Innovation Type	End-of-pipe Technologies	Cleaner production technologies & end-of-pipe technologies	Products, service, process, procedure, management system and business method	Any form of technical & non-technical
	Degree of Novelty	New to the world & new to the firm innovations	-	New to the world & new to the firm innovations (adaptation & adoption)	New to the world & firm (adaptation & adoption)
	Intention/Motivation	-	-	Environmental-intended or environmental-unintended (economical/social/institutional intentional)	Balanced priority of economic, environmental & societal aspects
	Benefit/Result	Reduce harmful impacts to environment	Economic & environmental improved performances	Economic, environmental, social, & institutional improved performances	Greatest competitive advantage

Figure 1: Main concerns characterised eco-innovation definition evolution

4. OPERATIONAL DEFINITION OF ECO-INNOVATION

The above review revealed that there is no definition that is identical. Different researchers have defined the eco-innovation term differently over the last 20 years based on what they think best describes eco-innovation process. Each of the definitions is the refinement of previous definitions by incorporating any missing aspects and according to the context it is applied. Some definitions are very brief while others are expressed in detail covering all essential aspects including those influences beyond the firm's boundary.

Definition of eco-innovation adapted for this study is developed based on the combination of main concerns which characterized the most recent definitions that emerged in stage four of the evolution. In our opinion, eco-innovation could be defined as "strategic implementation of any form of technical (product and process) and non-technical (organisational, marketing and institutional/business method) changes that are either new to the world or new to the firm (through adaptation or adoption approach), with the intention of achieving a balanced priority of economic returns, environmental preservation and society well-being resulting in sustainable economic, environmental, social and institutional benefits".

5. CONCLUSION

Based on discussion concerning the eco-innovation definition, it is important to recall that the word 'eco-innovation' has changed over the different stages of its evolution. The views on eco-innovation concerns have moved gradually from initiatives that promote a reduction in environmental impacts to strategic efforts for achieving firm's greatest competitiveness and sustainability in economic, environmental, social and institutional aspects. Apart from that, findings also showed that four different notions: eco-innovation, green innovation, environmental innovation and sustainable innovation have been used interchangeably to describe innovations with reduced environmental impact. Eco-innovation term has been used most often in the reviewed literature. For the reason, the term has been applied in discussions throughout this paper. Operational definition of eco-innovation adopted in this paper is the merger of key characteristics of definitions appeared in stage four of the evolution. The definition will be used in future research which will aim at assessing the performance of eco-innovation implementation in manufacturing firm.

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