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Research Paper

STUDY ON INNOVATION, RESEARCH AND RECENT DEVELOPMENT IN TECHNOLOGY FOR GREEN MANUFACTURING

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The present paper gives the survey of green manufacturing, through this paper an attempt has been made to visualize the recent developments and innovations and researches to implement the green manufacturing techniques, this study is helpful to aware about what is green manufacturing why it is needed and keys of green Manufacturing that reduces the undesired waste and even pollution. The paper mainly focuses on the green manufacturing design of components without harming the nature. The main objective of this paper is to bringing the attention of the manufacturer who is manufacturing the product with the mass production toward green manufacturing. It has been observed that lot of waste are being produced during manufacturing in different industries which can be minimized by implementing the green manufacturing techniques. The results of this study indicate that the green manufacturing applications have a significant positive impact on environmental performance and social performance.

Keywords: Green manufacturing, Sustainable manufacturing, Innovation

INTRODUCTION

Green manufacturing is the part of the sustainable manufacturing and can be defined as a form of pollution prevention that integrates environmental considerations in the production of goods, employing environmentally-friendlier manufacture processes, converging energy and natural resources, and reducing negative environmental impacts. In this global world, resources and population are major problems. Environment is crucial one with and change in climate at any point leads to imbalance of the earth. Due to this the green manufacturing comes into virtue and now a days, it is becoming the need to develop the country without being harming the nature. The ISO has proposed the new quality management system for products and even for Environment

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management system. The main era is to minimize the environmental damage due to industries. Tan *et al.* (2002) there is a need of new manufacturing process, i.e,. Green Manufacturing which is suitable and sustainable development strategic. Nancy Diaz-Elsayed *et al.* (2013).

Greem manufacturing has several benifits, it facilitates the increased production efficiency, which can be achieved by reducing resource consumtion and improving the organization of the manufacturing system.In this paper an attempt has been made to visualize and bring the impact of innovations and development in different technologies acquired by the manufacturers so that the production would be without harming the natureit also object to bringing the attention of the manufacturer who are manufacturing the product with a bulk production. It has been observed that a lot of energy in terms of heat and electricity is using day by day and lots of waste is produced, the waste are highly hazardous and can lead the human being to a termination point.

Toxic hazards are really crucial factors to be concern for the human being. This paper points all the technological and the methodology aspects of green manufacturing that we can applied and can reduce the wastage and increase the yield with the use of sustainable energy. The implementation of Green Manufacturing may not only be good for the environment—it is often good business too, as well. The same is often true of other efforts to reduce the energy consuption- and material-intensiveness of manufacturing processes; what is good for the environment is typically good for the balance sheet as well.

LITERATURE REVIEW

Nowadays, the role of green operation is being widely used in green manufacturing processes leading environmental consequence that are considered strategically essential for business operations with the aim to reduce costs and develop quality products. The scope of green operations spans from product development to management of the entire product life cycle involving such environmental practices as eco-friendly design, clean production, reuse, and recycling with a focus on minimizing the expenses associated with manufacturing, distribution of products, there uses.

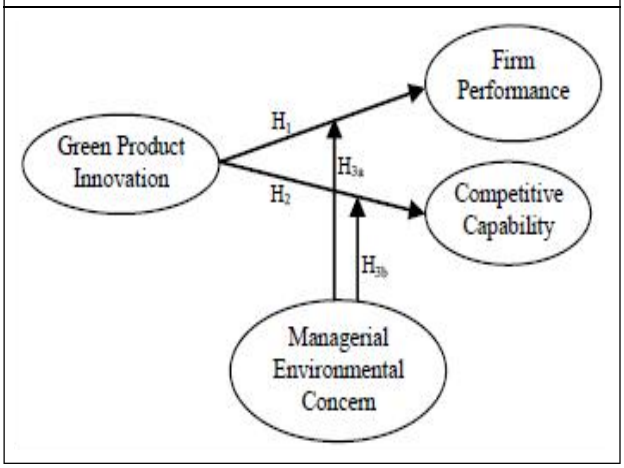
Rogers and Tibben-Lembke (2001) and Ferguson and Toktay (2006) has explained In product management that, Green operation ensures quality and environmental conformance, preventing negative corporate reputation by environmentally negligent products. In case of process management, Green operation more emphasizes on closed-loop operations involving practices like recycling and recuperation with the objective is to reduce the waste, capture residual value of products, and deploy environmental technology and cleaner transportation system in the downstream supply chain for prevention of pollution. These two distinct components of Green operations are helpful for firms to comply with environmental regulations, reducing the risk of legal fees, fines, liability of costs (Hunt and Auster, 1990).

A recent study by Lee and Klassen (2008) highlighted the importance of Environmental Management Capabilities (EMC) of suppliers, which reflect the ability of suppliers to improve their performance on environmental issues. Nevertheless, how such capability influences

the Green operation of buying firms was not considered. While the negligent behaviors of suppliers can devastate the Green operation of their downstream partners Preuss (2001), a systematic investigation on supplier role in Green operation is timely and an important environmental management topic. The green manufacturing can lead to shorten the life cycle of product and this reduces the cost of the product. Due to environmental and ecological responsibility, enterprises are trying to reuse, remanufacture and recycle the used products to reduce the negative impact on environment, especially the manufacturers of the electrical consumer products. Therefore, the reverse manufacturing problem, which is strongly related to all stages of a product development Porter (1991) has found that organizations can further reduce production costs and increase economic efficiency by applying environmental related initiatives. The increase in green sales, as a percentage of total sales, was achieved primarily by focusing on products with a significantly lower environmental impact throughout its lifecycle. In this point, green innovation is becoming increasingly important for companies to raise their environmental awareness by producing products that do not contain hazardous and toxic substances (Chiou *et al.*, 2011). With the increasing of this environmental trend, green innovation becomes a critical factor for companies to obtain sustainable development (Lin and Chang, 2009) and it contributes to the transformation towards a sustainable society (Carrillo-Hermosilla *et al.*, 2010).

Kemp and Arundel (1998) has defined the innovation in green manufacturing as all the measures taken by relevant stakeholders to promote the development and application of improved or new, process, products, techniques and management systems that contribute to negative environmental impacts and attain specific ecological goals.According to Chen *et al.* (2006) green innovation can be classified into three main categories as green product innovation, green process innovation, and green managerial innovation. This classic division allows creating a focus for the eco-innovation concept and suggesting possible areas of application. This study focuses on green product innovation and analyzes the relationships between green product innovation, firm performance, and competitive capability using managerial environmental concern through moderator variable as can be seen in Figure 1.

Figure 1: Affecting Parameters of Green Product Innovation



Porter and Van der Linde (1995) proposed that the competition between the firms on adequate environmental management has become a critical competitive advantage and it can be a source of profits for the firms. Furthermore, they indicated that firms that focus on product innovation as priority can achieve competitive advantage over

competitors. Firms which use environmental applications to differentiate their products from others gain a competitive capability according to Reinhardt (1998) and Chen *et al.* (2006) found that green product innovations are positively associated with competitive advantage of firms.

Findings of Carrillo-Hermosilla *et al.* (2010) suggested that the capacity of eco-innovations provides new business opportunities. The empirical results of the study conducted by Chen (2008) showed that the intellectual capital about green innovation had positive effect on competitive advantages of firms. Yalabik and Fairchild (2011) developed an economic analysis in order to examine the effect of competitive pressure on firm investments in environmentally friendly production. Their results showed that competition over environmentally sensitive customers can improve the effectiveness of environmental innovations. d environmental aspects of products as bases for corporate greening and identified three main motivations for the companies within environmental technology sector. According to its empirical results, competitive advantage is one of these motivations. Therefore, engaging in green product innovation actively has positive influence upon corporate competitive capability.

According to the survey results of Lin and Ho (2008), organizational encouragement exhibit significant influences on the willingness to adopt green practices. The results of the study by Jansson *et al.* (2010) showed that values, beliefs and norms determine willingness for eco-innovation adoption. Findings of Buyukkeklit *et al.* (2010) study pointed out that although Turkish managers begin to be sensitive about environmental subjects, it does not reflect to their environmental innovation practices. Lin and Chang (2009) explored the mediation effect of corporate environmental ethics between green relationship learning and green innovation performance in the Taiwan manufacturing industry. Moreover, Qi *et al.* (2010) found that managerial concern is the most important driver for the adoption of green practices based on their analysis on Chinese construction industry.

GREEN MANUFACTURING

Green manufacturing is part of the sustainable manufacturing and can be defined as a form of pollution prevention that integrates environmental considerations in the production of goods, employing environmentally-friendlier manufacture processes, conserving energy and natural resources, and reducing negative environmental impacts. Many countries in the world, including developed and developing ones, have started to implement new policies for green technologies. The sustainable innovations could play an important role for the economic and technological development of transportation (Walz, 2011). For example, in the United States, the Obama administration has set a goal of one million plug-in vehicles on the road by 2015 and has introduced laws and policies supporting this goal (Kemp and Arundel, 1998). Turkey is one developing country whose government has Tried to implement similar policies across the country as well. In 2011, the government passed a Regulation for the registration of EVs. Additionally, some car manufacturers in Turkey are planning to introduce new EV models to

the domestic market in 2012.Turkey's Ministry of Industry and Trade has been studying the trend towards electric and hybrid-powered vehicles and aims to make the country a leading EV manufacturer. Incentives will be granted by the government for EV manufacturers and investments will be made in R&D (Deloitte, 2010). Charging stations will be introduced, while agreements and special arrangements will be made with electric distributors and oil stations.

Defining green innovation is not an easy task although several attempts have been made in the literature (Carrillo-Hermosilla *et al.*, 2010). Klemmer *et al.* (1999) determined the environmental innovations as a subset of innovations that lead to an improvement of ecological equality. Chen *et al.* (2006, p. 332) defined green innovation as software or hardware innovation that is related to green products and processec including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs, or According to Halila and Rundquist (2011), the term, eco-innovation (environmental innovation, green innovation or sustainable innovation), is often used to identify those innovations that contribute to a sustainable environment through ecological improvements.

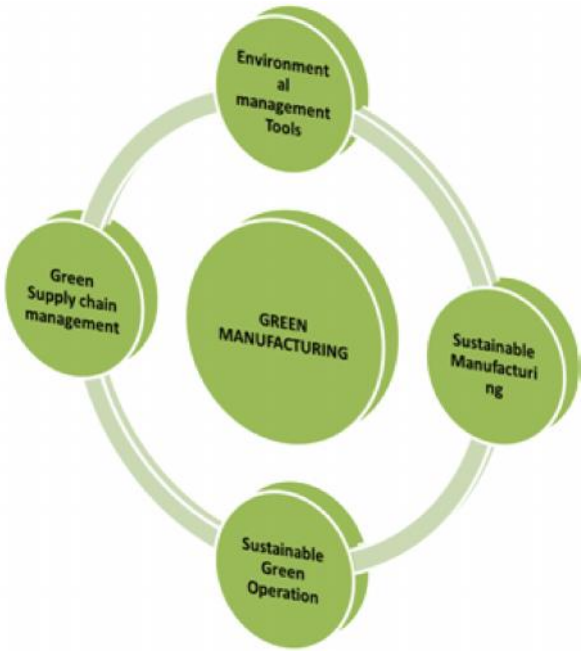
Keys of Green Manufacturing

Green manufacturing and innovation in technology lurk behind basically four parameters, which has been shown through the Figure 2.

Environmental Management Tool

The environmental management tools include. Mass balance, i.e., consideration of input and outputs of a process and to determine its effectiveness and wastage. Full cost accounting is related with the costs of materials, energy, labour, waste disposal and other sundry item cost. Product life cycle is also an important part of these tools less the life cycle less is the environment loss. The systematically engineering process of a product consists of three stages:

Figure 2: Keys of Green Manufacturing



- Conceptual, preliminary and detail design.
- Production construction.
- Operational use and system support Blanchard and Fabrycky (1997).

In the development of this study, the relevant cost functions are derived in sequence with a point view of systematical engineering process. Imposing extended producer responsibility on manufacturers is a means to achieve a critical leverage point between environment and business benefits.

Manufacturers have the unique ability to facilitate product recovery and remanufacturing by designing their products for easier disassembly and reuse of component. Through the product life-cycle value design, the suitable materials are selected and those decisions (such as employing easily recyclable materials and avoiding the unusual materials, components and hazardous materials) can reduce the negative impacts on environment Toffel, (2002). The supplier's component life-cycle design cost, Y (MT) is a function of MT, where T is the product life cycle. Although there are many parameters influencing the design and production cost of a component, from the product design life point of view, it is appropriate to take it as a function increasing with product-design life.

Sustainable Manufacturing

The concept of sustainability emerged from a series of meetings and reports in the 1970s and 1980s, and was largely motivated by environmental incidents and disasters as well as fears about chemical contamination and resource depletion. As pointed out in the 1987 Brundtland Report, Our Common Future David Dornfeld *et al.* (2013). The phrase sustainable manufacturing is sometimes used carelessly to describe the actions related to characterizing and reducing the environmental impacts of manufacturing. Sustainability, however, implies a great deal more than the simple act of analyzing and modifying the environmental performance of manufacturing processes and systems.

Sustainable Green Operation

Sustainable green operations as an innovative environmental management approach, Green Operation serves to ensure the quality and environmental compliance of electronics manufacturers' inputs (e.g., electronics components and metals) and outputs (e.g., finished products, carbon emission, waste) Zhu *et al.* (2007). Green Operation emphasizes product-and process- oriented environmental practices to balance and improve financial performance as well as pollution reduction. Product-oriented environmental practice of Green Operation, also referred to as product steward-ship, is concerned with reducing environmental burden with less use of hazardous and non renewable materials in products development, considering the environmental impact in product design, packaging, and material used Snir (2001). Specifically, it promotes recycling and reuse of product components with eco-design, and us in green cycle parts and packaging Lamming and Hampson (1996) and Reinhardt (1998). Product stewardship of electronics manufacturers considers the environmental impact of products and their packaging from raw materials acquisition to end-of-life product disposal Dechant and Altman (1994). Such practice is geared towards reducing the environmental damage arising from all product-related parts and components Christina Wong *et al.* (2012).

Green Supply Chain Management

GSCM is defined to be the addition of green issues into supply chain management Hervani *et al.* (2005). In addition, Zhu and Sarkis (2004) state that Green Supply Chain Management involves from suppliers to manufacturers, customers and reverse logistics throughout the so called closed-loop supply chain. Hervani *et al.* (2005) indicate there are various

activities involving GSCM such as reuse, remanufacturing, and recycling which are embedded in green design, green procurement practices, total quality environmental management, environmentally friendly packaging, transportation, and various product end-of-life practices. In the global economy, the automobile industry transforms rapidly with the dramatic expansion of leading automobile manufacturers (e.g., Honda, Toyota, General Motor, Ford, Daimler Chrysler, Suzuki, Hyundai, and Fiat) into the Asia region Kumar and Bali Subrahmanya (2010). Greening the automobile industry has been disputed in international energy and environmental policy studies. Green supply chain in automobile industry has become the main interest in many industrial fields. The evaluation and measurement of its performance is essential when environmental issues have been addressed all over the world Olugu *et al.* (2010).

However, there have been few studies exploring the issue of GSCM performance evaluation. Hence, applying green concepts into automobile manufacturing is essential to reduce environmental impacts, enhance market competition, and ensure regulation compliance Gan (2003). Zhu *et al.* (2008) claim that the automobile manufacturing industry in developing countries is a potential and promising industry because it creates a huge market, especially after entering WTO. However, automobile supply chains are lagging. For instance, Zhu *et al.* (2007) indicate that Chinese automobile industry is quite nascent and the recycling of used cars is not paid enough attention to. Facing environmental burdens, the Chinese government has enacted tighten environment regulations Zhu *et al.* (2007). Hence, Chinese automobile enterprises have started to study GSCM experiences from international partners Zhang and Peng (2000). Other example is that Malaysia government has not been addressed environmental issues, especially end-of-life vehicles recovery Amelia *et al.* (2009). Since Malaysian automobile industry develops rapidly, GSCM forces local automobile manufacturers and government to become concern about their environmental burdens Eltayeb *et al.* (2011). For these reasons, GSCM is emerging as an important approach to reduce environmental risks and brings economic benefit to manufacturers Diabat and Govindan (2010).

CONCLUSION

So finally the aim of our study was to gather the recent innovation and developments in technologies for accomplishing the green manufacturing. During study it is observed that Constant arrival of innovation is positively associated with firm performance and competitive capability. So, in the past, much innovation research was undertaken for these constructs. But there is a limited research which focuses on relationship between green product innovation, firm performance, and competitive capability. The objective of this study was to provide additional insight into the relationship between green product innovation, firm performance, and competitive capability by examining the moderator effect of managerial environmental concern. In this context, firstly, the evidence presented in this paper highlights the relationship between green product innovation, firm performance, and competitive capability. It showed that

green product innovation is generally positively affects firm performance and competitive capability.

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