Feasibility of Green Manufacturing in Corporate Sustainability

Md. Sagar Islam Khan, Md Junnun Bashar Khan, Sourav Paul and Ibrahim Prince

***Abstract*—**Firms are becoming more "greener" day by day because of pressures from both government and society. This pilot study examined the impact of green manufacturing and eco-innovation on the performances in corporate sustainability (economic, environmental, and social). Data were collected by using a structured questionnaire-based survey of 34 companies in Bangladesh's Food & Beverage, Cement, and RMG sectors. To check the study's conceptual relationships, the empirical model was evaluated using regression analysis. The findings of this study suggest that the environmental performance and social impact of green manufacturing applications are substantially positive. Besides, creativity in the eco-process has a significant positive effect on corporate sustainability. Nonetheless, eco-product innovation was found to have no significant impact on any of the three performance forms.

***Keywords*—** Green manufacturing, eco process, eco-product, corporate sustainability.

I. Introduction

Environmental and sustainability concerns are proliferating as one of the priorities for the strategic company, management, manufacturing, and product design. Green manufacturing deals with the preservation of the natural, economic, and social objectivities of sustainability in the production domain. Reducing toxic pollution, minimizing unnecessary use of energy and recycling can be examples of the sustainable green manufacturing practice. Companies need to reinvent goods and apply modern technologies to achieve sustainable growth in their process. Companies can differentiate their products, increase product quality, and lessen the cost of production by means of process and production innovations [1], [2]. Feasibility has continued to drive creativity and market development through new company product initiations.

This study is done to examine the influence of green manufacturing and eco-innovation on the performance of corporate feasibility. Selected companies provided the data to test the hypothesis. The number of selected sectors for survey and analysis is three, which are food industry, cement industry, and RMG industry. The hypothesis proposed aims at presenting a relationship between variables of green manufacturing, eco-innovation, and corporate sustainability.

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II. Literature Review And Hypothesis

A. Corporate Sustainability

Sustainability is described "as the ability to meet present needs without sacrificing future generations ' ability to meet their needs" [3]. There is a viewpoint that describes sustainability to include three components: natural environment, social performance, and economic performance [4]. In general, this viewpoint is called the triple bottom line (TBL). These three dimensions are widely recognized at the enterprise stage.

Economic performance - at the business level, refers to the impacts of a business on the economic circumstances of its stakeholders, as well as on local, national and/or international economic structures [5].

Environmental performance and environmental reporting - is described as ' the product of the management of its environmental aspects by an organization [6].

Social success and social report - refer to the social structures under which an organization works. Ranganathan (1998) recognizes four main social performance factors: Employment; community relations; Ethical sourcing; and Product social effects [7].

B. Eco-innovation

Eco-innovation is "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" [8]. During the past, investments during environmental programs were considered unnecessary. Strict environmental legislation and common environmentalists, however, have changed the rules and patterns of competition for businesses. Since the late 1990s, scholars have approached eco-innovation from three different viewpoints, including the growing value of eco-innovation. First are those studies that describe factors that drive eco-innovation and the output outcomes resulting from eco-innovation, with the latest examples of this group being Kammerer (2009) and Dangelico and Pujari (2010) [9], [10]. Second, are those defining the eco-innovation aspects, with

Hermosilla et al. (2010) being one recent article in this group [11]. The third category of studies is linked to eco-innovation measures (e.g., Arundel and Kemp, 2009); (Cheng and Shiu, 2012). [12], [13].

Eco-innovation (green innovation) can be divided into three major categories: innovation in eco-products, innovation in eco-processes, and innovation in green management. Through this analysis, we looked at innovation in the eco-product and innovation in the eco-process. Implementation of eco-products leads to environmental changes for current eco-products or the production of new eco-products (Cheng and Shiu, 2012) [13]. The application of the eco-process includes upgrading current manufacturing processes or introducing new environmental impact management processes (Cheng and Shiu, 2012) [13].

C. Green manufacturing

The term green manufacturing was coined to reflect the new manufacturing paradigm that employs various green strategies (objectives and principles) and techniques (technology and innovations) to become more eco-efficient. Green manufacturing has been described as an economically motivated, system-wide, and integrated approach to reducing and eliminating all waste streams associated with product and material design, manufacture, use, and/or disposal (Handfield et al., 1997) [14].

There are very few research on green manufacturing. These can be divided into two groups: first, the works dealing with the general definition of green manufacturing and second, the works offering different analytical methods and models for realizing green manufacturing at various levels (Deif, 2011) [15]. Examples from the first category are Mohanty and Deshmukh's (1998) research, which illustrates the value of green efficiency as a competitive edge [16]. Examples for the second category include Fiksel's work (1996), which gathered various analytical tools that emerged from the research on product/process design for green manufacturing [17]. Examples of these methods include Life Cycle Analysis (LCA), Environmental Design (DFE), screening methodologies, and risk analysis.

D. Hypothesis Development

Green manufacturing improves corporate identity, competitive advantage, and brand reach (Rao and Holt, 2005), contributing to improved results [18]. Economic success includes profitability, sales growth, market share rise, and productivity increase (Zhu and Sarkis, 2004) [19]. Chien and Shih (2007) Explained that environmental performance is described as the environmental effect that the activities of the organization have on the very nature [20]. Environmental performance involves a reduction in solid/liquid waste, emissions reduction, decrease in the use of resource and a reduction in the use of hazardous/harmful/toxic products, a reduction in the number of environmental accidents and increased employee and community wellbeing (Geyer and Jackson 2004); (Zhu and Sarkis, 2004) [21], [20]. Sustainability performance in developing countries such as Bangladesh is considered to be a critical factor for the environmental activities of corporations. Therefore, the performance effects generated by green practices in our country should be better evaluated. Previous studies draw attention to the consumer potential and economic efficiency of the emerging goods that are environmentally friendly. Yet environmental and social consequences are overlooked regarding products (Yang & Chen, 2011) [22]. Previous scholars mainly focused on the problems of green policies in Western markets (Hartman and Stafford, 1988); (Rivera-Camino, 2007) [23], [24]. This research, therefore, explored green production and eco-innovation in the Bangladeshi manufacturing industry.

Accordingly, it is hypothesized that:

Hypothesis 1: Green manufacturing has a positive connection to the performance of corporate sustainability.

Hypothesis 2: Eco-product innovation has a negative connection to with the performance in corporate sustainability.

Hypothesis 3: Eco-process innovation has a positive influence on corporate sustainability performance.

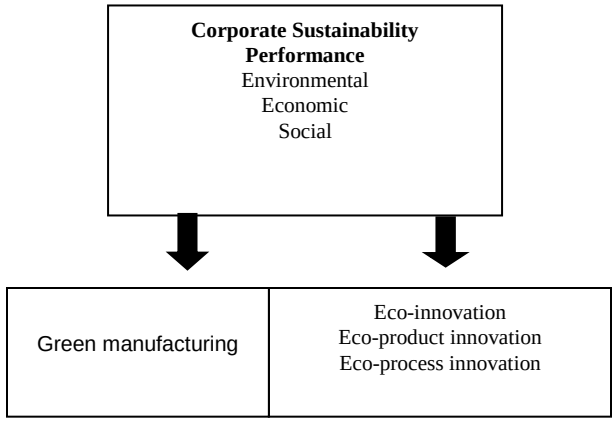

Fig. 1 Research framework

III. METHODOLOGY

A. Research objective

In this survey, we aim to present the relationships between various variables like performance in organizational sustainability, green manufacturing, and eco-innovation.

B. Data collection & Sample

A field survey was conducted for the pilot study to get quantitative data for statistical hypothesis testing. Using the SPSS statistical method, data collected from 53 questionnaires were analyzed, and proposed relations were evaluated using regression analysis. The analytical unit of the research is the individual firm. The population of this study includes companies from the Food & Beverage, Cement, and RMG industries in Bangladesh. The questionnaires used in this research have been gleaned and collected from various

validated instruments from the literature reviewed. Still,

some wording changes have been made to fit the context of this research. Green manufacturing has been being adopted from Shang et al., (2010) [25]. From Arundal and Kemp (2009) and Cheng and Shiu (2012), eco-innovation scale is adopted which utilizes 12 items to measure two dimensions (eco-product innovation and eco-process innovation) [12], [13]. However, 2 items are deducted because they showed a weak loading or loaded two different factors. In total, 39 elements with a scale of 5 Likert-type are used to calculate green manufacturing, eco-innovation, and performance in corporate sustainability

IV. Result & Discussion

The findings of both factor analysis and an analysis of reliability are shown as follows. Factors were derived using the analysis of main components, followed by varimax rotation. The data were declared appropriate for analysis, according to the Kaiser Meyer Olkin measure of sampling adequacy value of 0.701. The Bartlett Test of Sphericity was important [P< 0.001], showing that correlations existed between some of the response categories. Eigenvalues greater than one were utilized to calculate the number of factors in each data set (Churchill, 1991). A reliability test based on Cronbach's alpha has been used to assess whether these parameters were consistent and authentic. Cronbach's alpha values for each dimension are shown in Table I. The reliability value of each factor was well beyond 0.714, suggesting consistency and authenticity (Nunnally, 1978) [26].

TABLE I: Factor and Reliability Analysis Result

Green manufacturing	**Factor loading**	**Cronbach's Alpha**	**Mean**	**Environmental Performance**	**Factor loading**	**Cronbach's Alpha**	**mean**
YÜR3	0.732	0.714	3.942	CP4	0.885	0.785	2.9882
YÜR6	0..659			CP6	0.784		
YÜR4	0..812			CP1	0.69		
YÜR7	0..698			CP2	0.712		
YÜR1	0.625			CP5	0.5672		
YÜR5	0.563			CP9	0.3978		
YÜR2	0.495			CP8	0.467		
Eco-product innovation				***Economic performance***			
EÜY4	0..863	0.828	2.7623	EP5	0.623	0.856	3.1548
EÜY6	0..777			EP7	0.553		
EÜY7	0.803			EP8	0.493		
EÜY8	0.775			EP4	0.778		
EÜY2	0.796			EP3	0.876		
EÜY1	0.675			EP2	0.897		
Eco-process innovation				EP1	0.798		
ESY3	0.653	0.795	2.895	EP6	0.623		
ESY1	0.633			***Social performance***			
ESY4	0.682			SP3	0.795	0.763	3.2467
ESY2	0.789			SP9	0.789		
				SP6	0.801		
				SP2	0.754		
				SP8	0.707		
				SP5	0.749		
				SP7	0.749		

Regression analysis is also conducted in this study to test the hypotheses and to define the direction of connections. Table II depicts the regression analysis results to examine the effect of green manufacturing on the efficiency of company sustainability. Green manufacturing shows significance and positive impact on environmental performance (F=10.984, sig=.001) and social performance (F=10.326, sig=.002). But, Green manufacturing has not been found to have a significant effect on economic performance.

TABLE II
GREEN MANUFACTURING EFFECT ON CORPORATE SUSTAINABILITY PERFORMANCE

	Dependent variable								
Independent variables	Environmental performance			Economic performance			Social performance		
	Beta	t	Sig	Beta	t	sig	Beta	t	Sig
Eco-product innovation	.011	.115	.823	-.085	-.576	.567	-.079	-.691	.423
Eco-process innovation	.495	3.263	.001	.326	2.351	.023	.695	5.456	.000
R Square	.220			.052			.396		
Adjusted R Square	.195			.106			.323		
F	8.926			2.845			20.163		
sig	000			.032			.000		

Table III depicts that; it can be seen that the eco-process innovation dimensions have a significant effect on the three aspects of the performance of the corporate feasibility. But eco-product innovation was not found to have a substantial impact on any of the three types of performance. So, regression analysis results support the hypotheses H1, H2 and H3.

TABLE III:
ECO-INNOVATION EFFECTS ON CORPORATE SUSTAINABILITY PERFORMANCE

	Dependent variable								
Independent variables	Environmental performance			Economic performance			Social performance		
	Beta	t	Sig	Beta	t	sig	Beta	t	Sig
Green manufacturing	.395	**3.136**	.001	.187	1.360	.180	.424	**3.235**	.002
R Square	.125			.023			.121		
Adjusted R Square	.129			.016			.113		
F	10.984			1.849			10.326		
sig	.001			.180			.002		

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V. CONCLUSION

The regression analysis between performance in corporate sustainability and green eco-product innovation (economic, environmental, social) is not so significant, which implies that eco-product innovation is not so effective as eco-process innovation for upgrading a company's performance. This is possible because of the organization's lower level of innovation. Moreover, the result displayed that the eco-process innovation had positive effects on the performance in maintaining corporate sustainability. Bangladeshi companies need to incorporate environmental measures into their corporate management, as they can contribute to improving cultural, environmental, and social performances.

Green manufacturing will result in lower raw material prices, productivity improvements in production, reduced environmental and occupational health prices, and enhanced corporate image. Numerous studies have been performed on the relationship between green practices and performance outcomes, but the findings are not definitive. While Carter et al. (2000), Rao and Holt (2005), and Zhu and Sarkis (2004) found that green initiatives have meaningful positive relationships with organizations ' environmental and economic performance, Vachon and Klassen (2006b) and Zhu et al. (2007) found that green initiatives and these success results had no vital relationship [27], [18], [19], [28]. We have arrived at the same conclusion as Vachon and Klassen's (2006)'s studies. We also found no link between green manufacturing and success in economic performances [29]. One explanation for that could be that in Bangladesh, environmental technologies are relatively new.

REFERENCES

[1] Nidumolu, Ram, Coimbatore K. Prahalad, and Madhavan R. Rangaswami. "Why sustainability is now the key driver of innovation." *Harvard business review* 87.9 (2009): 56-64.

[2] Shrivastava, Paul. "The role of corporations in achieving ecological sustainability." Academy of management review 20.4 (1995): 936-960. https://doi.org/10.5465/amr.1995.9512280026

[3] Hart, Stuart L., and Mark B. Milstein. "Creating sustainable value." Academy of Management Perspectives 17.2 (2003): 56-67. https://doi.org/10.5465/ame.2003.10025194

[4] Elkington, John. "Towards the sustainable corporation: Win-win-win business strategies for sustainable development." California management review 36.2 (1994): 90-100. https://doi.org/10.2307/41165746
[5] Arndt, Hans-Knud, et al. "Sustainability Reporting Using the eXtensible Business Reporting Language (XBRL)." EnviroInfo. 2006.
[6] ISO (1999). Environmental management Environmental performance evaluation Guidelines (ISO 14031: 1999). Brussels:European Committee for Standardization /International Standards Organization.
[7] Murty, B. S., and S. J. M. R. Ranganathan. "Novel materials synthesis by mechanical alloying/milling." International materials reviews 43.3 (1998): 101-141. https://doi.org/10.1179/imr.1998.43.3.101
[8] Reid, Alasdair, and Michal Miedzinski. "Eco-innovation." Final report for sectoral innovation watch. Europe Innova. Technopolis group (2008).
[9] Kammerer, Daniel. "The effects of customer benefit and regulation on environmental product innovation.: Empirical evidence from appliance manufacturers in Germany." Ecological Economics 68.8-9 (2009): 2285-2295. https://doi.org/10.1016/j.ecolecon.2009.02.016
[10] Dangelico, Rosa Maria, and Devashish Pujari. "Mainstreaming green product innovation: Why and how companies integrate environmental sustainability." Journal of business ethics 95.3 (2010): 471-486. https://doi.org/10.1007/s10551-010-0434-0
[11] Carrillo-Hermosilla, Javier, Pablo Del Río, and Totti Könnölä. "Diversity of eco-innovations: Reflections from selected case studies." Journal of cleaner production 18.10-11 (2010): 1073-1083. https://doi.org/10.1016/j.jclepro.2010.02.014
[12] Arundel, A., and R. Kemp. Measuring eco-innovation. United Nations University. MERIT, Working Paper Series, 2009.
[13] Cheng, Colin C., and Eric C. Shiu. "Validation of a proposed instrument for measuring eco-innovation: An implementation perspective." Technovation 32.6 (2012): 329-344. https://doi.org/10.1016/j.technovation.2012.02.001
[14] Handfield, Robert B., et al. "'Green'value chain practices in the furniture industry." Journal of Operations Management 15.4 (1997): 293-315. https://doi.org/10.1016/S0272-6963(97)00004-1
[15] Deif, Ahmed M. "A system model for green manufacturing." Journal of Cleaner Production 19.14 (2011): 1553-1559 https://doi.org/10.1016/j.jclepro.2011.05.022
[16] Mohanty, R. P., and S. G. Deshmukh. "Managing green productivity: some strategic directions." Production Planning & Control 9.7 (1998): 624-633. https://doi.org/10.1080/095372898233614
[17] Fiksel, Joseph R. Design for environment. 1996.
[18] Rao, Purba, and Diane Holt. "Do green supply chains lead to competitiveness and economic performance?." International journal of operations & production management (2005) https://doi.org/10.1108/01443570510613956
[19] Zhu, Qinghua, and Joseph Sarkis. "Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises." Journal of operations management 22.3 (2004): 265-289. https://doi.org/10.1016/j.jom.2004.01.005
[20] Chien, M. K., and Li-Hsing Shih. "An Empirical Study Of The Implementation Of Green Supply Chain Management Practices In The Lectrical And Electronic Industry And Their Relation To Organizational Performances." (2007): 383-394.
[21] Geyer, Roland, and Tim Jackson. "Supply loops and their constraints: the industrial ecology of recycling and reuse." California Management Review 46.2 (2004): 55-73. https://doi.org/10.2307/41166210
[22] Yang, Cheng Jung, and Jahau Lewis Chen. "Accelerating preliminary eco-innovation design for products that integrates case-based reasoning and TRIZ method." Journal of Cleaner Production 19.9-10 (2011): 998-1006. https://doi.org/10.1016/j.jclepro.2011.01.014
[23] Inman, R. Anthony. "Environmental management: new challenges for production and inventory managers." *Production and Inventory Management Journal* 40.3 (1999): 46.
[24] Rivera-Camino, Jaime. "Re-evaluating green marketing strategy: a stakeholder perspective." *European journal of marketing* (2007). https://doi.org/10.1108/03090560710821206
[25] Shang, Kuo-Chung, Chin-Shan Lu, and Shaorui Li. "A taxonomy of green supply chain management capability among electronics-related manufacturing firms in Taiwan." *Journal of environmental management* 91.5 (2010): 1218-1226. https://doi.org/10.1016/j.jenvman.2010.01.016
[26] Nunnally, Jum C. *Psychometric theory 3E*. Tata McGraw-Hill Education, 1994.
[27] Carter, Craig R., Lisa M. Ellram, and Kathryn J. Ready. "Environmental purchasing: benchmarking our German counterparts." *International Journal of Purchasing and Materials Management* 34.3 (1998): 28-38. https://doi.org/10.1111/j.1745-493X.1998.tb00299.x
[28] Vachon, Stephan, and Robert D. Klassen. "Extending green practices across the supply chain: the impact of upstream and downstream integration." *International Journal of Operations & Production Management* 26.7 (2006): 795-821. https://doi.org/10.1108/01443570610672248
[29] Vachon, Stephan, and Robert D. Klassen. "Green project partnership in the supply chain: the case of the package printing industry." *Journal of Cleaner production* 14.6-7 (2006): 661-671 https://doi.org/10.1016/j.jclepro.2005.07.014