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Effects of green manufacturing and eco-innovation on sustainability performance

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Abstract

Firms are facing growing pressure to become "greener" or more environmentally friendly. Consequently, firms have had to review their production processes as a result of pressures from the community and governments. This pilot study investigated the influence of green manufacturing and eco-innovation on corporate sustainability performance (economic, environmental, and social). Data were collected through a questionnaire-based survey across 53 companies from automotive, chemistry and electronic sectors in Turkey. The empirical model was tested using regression analysis, to verify the hypothetical relationships of the study. The results of this study indicate that the green manufacturing applications have a significant positive impact on environmental performance and social performance. Additionally, eco-process innovation has a significant positive impact on corporate sustainability. However, eco-product innovation was not found to have a significant effect on any of the three types of performance.

Keywords: Green manufacturing, eco-innovation, corporate sustainability performance, Turkey

1. Introduction

Sustainability and environmental issues are rapidly emerging as one of the most important topics for strategic business, management, manufacturing, and product development decisions. This heightened awareness of the natural environment has been reflected in the innovative and environmentally conscious products offered to consumers in recent years. Firms develop sustainable programs with the purpose of

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‘‘greening’’ their own products and processes while reducing the impact of their activities. In order to eliminate the problems of environmental pollution, the concepts of environmental management, such as green management, green marketing, green production and green innovation, etc. are now being pursued.

The rise of international environmental regulations, such as Montreal Convention, Kyoto Protocol, Restriction of the Use of Certain Hazardous Substances in EEE (RoHS), and Waste Electronics and Electrical Equipment (WEEE), and popular environmental consciousness of consumers would bring significant impacts to businesses in the world (Chen et al., 2006). Turkey has become a party to United Nations Framework Convention on Climate Change (UNFCC) on May 24 2004 and to Kyoto Protocol on August 26,2009. However, Turkey is not responsible for the reduction of greenhouse gas emission till the end of 2012. Turkish Government makes regulations to comply with the international treaties (like the waste electrical and electronic equipment directive which become valid in 2012). Hence, Turkish companies should carry out environmental protection activities to comply with international regulations of environmental protection and environmental consciousness of consumers. Businesses that adopt the proactive strategies of environmental management could integrate the goals of environmental protections with different departments in companies to meet the environmental regulations and improvements by utilizing the innovative product or process and green practices (Greeno and Robinson, 1992).

In order to achieve sustainable development, enterprises must redesign products and adapt new technology for processes. (Nidumolu etal.,2009). Shrivastava (1995) suggests that companies can differentiate their products, improve product quality and lower the cost of production through product and process innovations. Sustainability has continued to drive innovation and business growth through new product initiatives from many companies For example, “the challenge of sustainability has also stimulated new product innovation in the automobile industry and is displayed by BMW’s automobile recycling strategy, which was a preemptive action to ward off government regulation” (Hart, 1995). BMW has initiated a design for disassembly which may result in the first 100% fully recyclable car. Eco- innovation can also be a key driver of economic growth. A number of firms have begun to develop the next generation of clean technology to drive future economic growth. BP and Shell are ramping up investments in solar, wind, and other renewable forms of energy technologies with the promise that these new sources of energy could replace their core petroleum businesses in the near future (Hart & Milstein, 2003).

In this study, we examined the influence of green manufacturing and eco-innovation on corporate sustainability performance. Companies selected from the Turkish manufacturing industry provide the data to test the proposed hypotheses. Three sectors have been selected for the survey and analyses. Automotive, electronics, and chemistry sectors that are among the sectors which harm the environment the most during production and consumption will be included in the framework of the study. The proposed hypotheses aim to present the relationships between the variables including sustainability performance, green manufacturing, and eco-innovation.

2. Literature Review and Hypotheses

2.1. Corporate Sustainability

Sustainability has increasingly become important to business research and practice over the past decades as a result of rapid depletion of natural resources and concerns over wealth disparity and corporate social responsibility. The term sustainability is being defined “as the ability to meet the needs of

the present without compromising the ability of future generations to meet their needs" (Hart & Milstein, 2003). This definition can be traced back to the publication of the Brundtland Report in 1987 and the subsequent Earth Summits in Rio de Janeiro in 1992 and Johannesburg in 2002, where sustainability and environmental issues gained heightened attention "becoming one of the foremost issues facing the world" (Ambec & Lanoie, 2008). A perspective has emerged that defines sustainability to include three components: The natural environment, social, and economic performance (Elkington, 1994). This perspective is generally referred to as the triple bottom line (TBL). At the company level, these three dimensions are generally accepted as descriptive of a company's performance in sustainability.

Economic performance – at the company level, refers to a company's influences on its stakeholders' economic circumstances, as well as on economic systems at local, national, and/or international levels (GRI, 2006). Financial performance and profits no longer guarantee a company's long term survival. A company needs to include non-financial performances, such as social activities and environmental protections into decision-making and strategic planning (Orlitzky, 2008).

Environmental performance and environmental report – is defined as "the result of an organization's management of its environmental aspects" (ISO, 1999). It addresses a company's influences on "living and non-living natural systems, including ecosystems, land, air, and water". Ranganathan (1998) identified four key elements for environmental performance: (1) material use; (2) energy consumption; (3) non-product output; (4) pollutant release.

Social performance and social report – relates to corporate performance to the social systems within which a company operates (Cooper, 2004). Ranganathan (1998) identifies four key elements for social performance: (1) employment; (2) community relations; (3) ethical sourcing; and (4) social impact of product.

2.2. Eco-Innovation

Eco-innovation has become one of the important strategic tools to obtain sustainable developments in manufacturing industries because of the increasing environmental pressure. In the past, investing in environmental activities was considered as unnecessary However, strict environmental regulations and popular environmentalist have changed the competitive rules and patterns for companies.

With the emerging importance of eco-innovation since the late 1990s, researchers have addressed eco-innovation from different perspectives. First are those studies that identify factors that drive eco-innovation and the performance outcomes arising from eco-innovation, with Kammerer (2009) and Dangelico and Pujari (2010) being the more recent examples of this category. Second are those that identify the dimensions of eco-innovation, with Hermosilla et al. (2010) as one recent article in this category. Third group of studies is related with the measurement of eco-innovation (e.g., Arundel and Kemp, 2009); Cheng and Shiu, 2012).

Kemp and Pearson (2008) define eco-innovation as the production, assimilation or exploitation of a product, production process, service or management or business methods that is novel to the organization (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. Similarly, Jin et al. (2008) suggest that it involves both introduction of a good/service that is new or significantly improved and decreases negative impacts on the environment. The goal of eco-innovation is to systematically align sustainability initiatives within a company's strategy and implement this strategy throughout the supply chain, from new product and service development to consumption (Jone et al.,, 2008).

Eco- innovation (green innovation) can be classified into three main categories: eco-product innovation, eco-process innovation and green managerial innovation. In this study, we examined the eco-product innovation and eco-process innovation. Eco-product implementation brings about environmental

improvements to existing eco-products or the development of new eco-products (Cheng and Shiu, 2012). Eco-process implementation involves the improvement of existing production processes or the addition of new processes to reduce environmental impact (Cheng and Shiu, 2012).

2.3. Green Manufacturing

Green manufacturing is a relatively new concept that can be viewed as a product of the 1990s. Green manufacturing has been defined as an economically-driven, system-wide and integrated approach to the reduction and elimination of all waste streams associated with the design, manufacture, use and/or disposal of products and materials (Handfield et al., 1997). In accordance with reality of the manufacturing system, green production plan and adopt the production technology program and process route with fewer resources and energy consumption, little environmental pollution as far as possible. The standards to reach green manufacturing include zero potential safety problems, zero health threats on the operators and product users, and zero environmental pollution, waste recycling, and waste disposal during the production process as much as possible (Gao et al. 2009).

Studies on green manufacturing are very few. These can be divided into two groups, first, the works that dealt with the overall concept of green manufacturing and second, the works that provided various analytical tools and models to realize green manufacturing at different levels (Deif, 2011). Examples of the first group is the work of Mohnty and Deshmukh (1998) highlighting the importance of green productivity as a competitive edge. Jovane et al. (2003) presented sustainable and green manufacturing as a future paradigm with business model based on designing for environment using new nano/bio/material technologies. Burk and Goughran (2007) also presented another framework for sustainability to realize green manufacturing. The framework on their study was based on SME manufacturers who achieved ISO 14001 certification. Examples for the second group include the work of Fiksel (1996) which gathered different analytical tools that have emerged from product/process design research for green manufacturing. Examples of these tools include Life Cycle Analysis (LCA), Design for the Environment (DfE), screening methods and risk analysis.

2.4. Development of Hypotheses

Economic performance includes profitability, revenue growth, increase in market share, and increase in productivity (Zhu and Sarkis, 2004). A sustainable approach can lead to internal cost saving, open new markets and find beneficial uses for waste (Tsoulfas and Pappis, 2006). Adoption of green manufacturing can have a positive effect on a corporation's costs. This can cut the cost of energy consumption, reduce the cost of waste treatment and discharge, and avoid fines in the case of environmental accidents (Zhu and Sarkis, 2004). Green manufacturing also enhance corporate image, competitive advantage, and marketing exposure (Rao and Holt, 2005), resulting in improved performance.

Chien and Shih (2007) explained that environmental performance is defined as the environmental impact that the corporation's activity has on the natural milieu. Environmental performance include reduction of solid/liquid wastes, reduction of emissions, resource reduction, and decrease of consumption for hazardous/harmful/toxic materials, decrease of frequency of environmental accidents, and improved employee and community health (Geyer and Jackson, 2004; Zhu and Sarkis, 2004). Adoption of green manufacturing can produce less waste, fewer resources and energy consumption, little environmental pollution. The literature tends to support the idea that green practices have positive environmental outcomes. For instance, Zhu and Sarkis (2004) analyze data from the manufacturing sector in China and found significant positive relationships between green initiatives and

environmental performance. Angell and Klassen (1999), Kleindorfer et al. (2005), Sarkis (1998) and Shrivastava (1995) suggested that green manufacturing cause to grow economics, environmental, and social performance through reduction of waste and costs.

Sustainability performance is considered to be main factor for the environmental activities of enterprises in developing countries such as Turkey. For that reason the performance outcomes which are caused by the green practices should be better analyzed in our country.

Green products and processes innovation not only reduce the negative impact on the environment, but they can also increase company's competitive advantage (Porter and Van Der Linde, 1995). Chen et al. (2006) and Chen (2008) considered how green product and process innovation affect competitive advantage and the green image of an organization. Noci and Verganti (1999) have investigated this through a qualitative case study and Chen et al. (2006) initiated a survey in the information and electronics industry to consider how green product and process innovations affect competitive advantage. Many studies on eco-innovation show a positive role played by cost-savings as a motivation for cleaner production technologies in particular (Frondel et al., 2007; Horbach, 2008). Eco-innovations can thus be the result of other economic rationales such as increasing market share or reducing costs. As can be seen from explanations above, the contribution of eco-innovation on firm performance has also been recognized (e.g., Christmann, 2000; Klassen and Whybark, 1999). There are positive associations between eco-innovation and firm performance in the following dimensions: return on investment, market share, profitability, and sales (Cheng and Shiu, 2012). Taylor (1992) suggested that firms embark on green management and green innovation to improve environmental performance, and satisfy the demands of consumers to boost corporate image among regulators and the general public.

Despite increasing concern on the innovation processes for sustainable development in the last two decades, empirical studies on this subject are very limited. Previous studies draw attention to the market potential and economic output of the new environment-friendly products. But environmental and social outcomes of products are ignored (Yang and Chen, 2011).

Previous scholars have focused primarily on the issues of green initiatives within western markets (Hartman and Stafford, 1988; Rivera-Camino, 2007). Therefore, this study investigated the green manufacturing and eco-innovation in Turkish manufacturing industry.

Accordingly, it is hypothesized that:

Hypothesis 1: Green manufacturing has a positive relationship with corporate sustainability performance
Hypothesis 2: Eco- product innovation has a positive relationship with corporate sustainability performance.
Hypothesis 3: Eco-process innovation has a positive relationship with corporate sustainability performance.

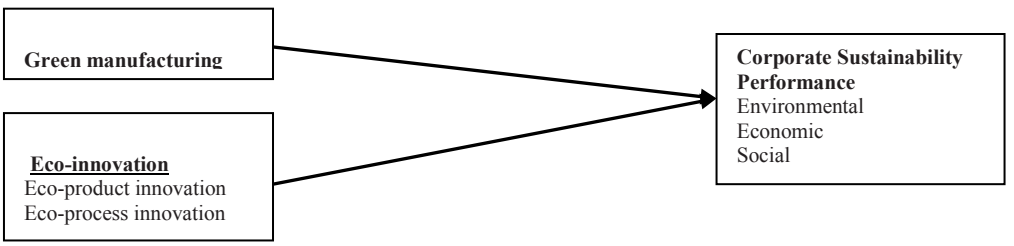

Fig. 1. Research framework.

3. Methodology

3.1. *Research Goal*

In this survey we aim to present the relationships between several variables including organizational sustainability performance, green manufacturing, and eco-innovation. To test the propositions, a field survey using questionnaire was conducted.

3.2. Sample and Data Collection

For the pilot study, a survey was conducted to obtain quantitative data for statistical testing of the hypotheses. The Turkish version of the questionnaire was pilot tested on 53 manufacturing managers from Turkey. Data obtained from those 53 questionnaires were analyzed through the SPSS statistical program and proposed relations were tested through regression analyses. The unit of analysis of the study is the individual firm. The population of this study consists of companies from automotive, chemistry and electronic industry sectors in Turkey

3.3. Analyses and Results

The questionnaires used in this research was gleaned and compiled from various validated instruments from the literature reviewed but some modifications were made to wording to suit the context of this research. Green manufacturing is adopted from Shang et al., (2010). Eco-innovation scale is adopted from Arundal and Kemp (2009) and Cheng and Shiu (2012), which uses 12 items to measure two dimensions (eco-product innovation and eco-process innovation). However, 2 items are deleted or because they showed a weak loading or loaded two different factor. In relation to the measurement of corporate sustainability, most consultants, scholars, and firms would agree that there is no common standard of measuring the triple bottom line success of one firm versus another (Leonardo Academy, 2008). Sustainability scale that was more prominent among businesses is the Global Reporting Initiative (GRI**)**. Sustainability scale used in this study was adapted from GRI(2002), Azapic (2003) and Veleva and Ellenbecker (2001). Overall, 39 items using 5 likert-type scale are used to measure green manufacturing, eco-innovation and corporate sustainability performance. The results of both factor analysis and reliability analysis are shown as follows. Factors were extracted using the principal components analysis, followed by a varimax rotation. The data were deemed appropriate for analysis, according to the Kaiser–Meyer–Olkin measure of sampling adequacy value of 0.701. The Bartlett Test of Sphericity was significant [$P< 0.001$], indicating that correlations existed between some of the response categories. Eigenvalues greater than one were used to determine the number of factors in each data set (Churchill, 1991). A reliability test based on Cronbach's alpha was used to assess whether these dimensions were consistent and reliable. Cronbach alpha values for each dimension are shown in Table 1. The reliability value of each factor was well above 0.814, suggesting consistency and reliability (Nunnally, 1978).

Table:1 Factor and Reliability Analysis Result

Green manufacturing	Factor loading	Cronbach's Alpha	Mean	Environmental Performance	Factor loading	Cronbach's Alpha	mean
YÜR3	0.856	0.814	4.2911	CP4	0.913	0.845	3.7588
YÜR6	0.848			CP6	0.822		
YÜR4	0.826			CP1	0.81		
YÜR7	0.715			CP2	0.77		
YÜR1	0.683			CP5	0.663		
YÜR5	0.664			CP9	0.558		
YÜR2	0.506			CP8	0.531		
Eco-product innovation				Economic performance			
EÜY4	0.966	0.956	3.1213	EP5	0.925	0.919	3.6745
EÜY6	0.917			EP7	0.878		
EÜY7	0.903			EP8	0.866		
EÜY8	0.897			EP4	0.807		
EÜY2	0.892			EP3	0.931		
EÜY1	0.875			EP2	0.925		
Eco-process innovation				EP1	0.833		
ESY3	0.892	0.889	3.783	EP6	0.663		
ESY1	0.873			Social performance			
ESY4	0.861			SP3	0.846	0.899	3.6173
ESY2	0.845			SP9	0.833		
				SP6	0.817		
				SP2	0.806		
				SP8	0.772		
				SP5	0.749		
				SP7	0.749		

In this study, regression analysis is also conducted to test the hypotheses and to define the direction of relations. Table 2 shows the result of the regression analysis for testing the effect of green manufacturing on corporate sustainability performance. Green manufacturing shows significant positive effect on environmental performance (F=11.846, sig=.001) and social performance (F=10.979, sig=.002). However, green manufacturing was not found to have significant effect on economic performance.

Table:2 Effects of green manufacturing 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	.434	**3.442**	.001	.187	1.360	.180	.424	**3.314**	.002
R Square	.188			.035			.177		
Adjusted R Square	.173			.016			.161		
F	11.846			1.849			10.979		
sig	.001			.180			.002		

In Table 3, it can be seen that the eco-process innovation dimensions have significant effect on the three dimensions of the corporate sustainability performance. However, eco-product innovation was not found to have significant effect on any of the three types of performance. So, regression analysis results support the hypotheses H1 and H3.

Table:3 Effects of eco-innovation 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	.023	.161	.873	-.091	-.576	.567	-.092	-.742	.462
Eco-process innovation	.514	**3.598**	.001	.373	**2.351**	.023	.719	**5.778**	.000
R Square	.278			.075			.453		
Adjusted R Square	.249			.111			.431		
F	9.623			3.107			20.728		
sig	000			.053			.000		

4. Conclusion

The regression analysis between green eco-product innovation and corporate sustainability performance (economic, environmental, social) is not significant. This implies that eco-product innovation is not as effective as eco-process innovation for improving a company's performance. This is possibly because of the firms' low levels of innovation. In addition, the result showed that the eco-process innovation had positive effects on corporate sustainability performance. Turkish firms must integrate environmental initiatives into their corporate management since they can lead to improved economic, environmental and social performance.

Green manufacturing can lead to lower raw material costs, production efficiency gains, reduced environmental and occupational safety expenses, and improved corporate image. The relationship between green practices and performance outcomes has been subject to numerous studies but the results are not conclusive. While Carter et al. (2000), Rao and Holt (2005), and Zhu and Sarkis (2004) found that green initiatives have significant positive relationship with environmental and economic performance of organizations, Vachon and Klassen (2006b) and Zhu et al. (2007) found no significant relationships between green initiatives and such performance outcomes. We reached the same conclusion like Vachon

and Klassen (2006a)'s studies. We also found no relationship between green manufacturing and economic performance. A reason for this could be that environmental applications are relatively new in Turkey.

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