ENVIRONMENTAL TECHNOLOGY ADOPTION: A STUDY ON FOOD AND BEVERAGE INDUSTRY IN PENINSULAR MALAYSIA

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ABSTRACT

The environmental technology is recognized as an important key factor in achieving a better environmental performance of firms and economy. Although the business firms are continuously adopting the technology that reduces the impact of their operations on natural environment, they do so at different rates. There is a wide range of factors that speed up or slow down the adoption of environmental technologies. This paper provides an analysis of factors influencing the adoption of environmental technology among food and beverage firms in Peninsular Malaysia. The main purpose is to determine the relationships of three non-regulatory factors namely technology performances, communication networks and economic factors on environmental technology adoption. This paper begins with an introduction and literature review, followed by the hypotheses statements. To examine these hypotheses, Pearson Correlation analysis was applied. A sample of 76 Malaysian food and beverage firms was used for investigation. The results of the analysis confirmed the hypotheses that there were significant relationships between the three factors and environmental technology adoption.

***Keywords*:** Environmental technology; technology adoption; technology performances; communication networks; economic factors.

INTRODUCTION

The emissions of pollutant from the manufacturing industries are main determinants for general pollution affecting environment (Mazzanti and Zoboli, 2006). As concern of environmental protection is growing within all sector of society, industrial firms are being forced to become more accountable for their action (Dupuy, 1997). In Malaysia, the onus of monitoring and enforcing environmental standard had been given to the Department of Environmental (DOE) under the Ministry of Science, Technology Environment (MOSTI). Government policies, in the form of environmental standards, have been designed to reduce the level of toxic pollutants being discharge by firms. Some of the environmental programs that have been launched in Malaysia are cleaner technology, clean production, pollution prevention, adoption of Environmental Management System (EMS), and the ISO 14000 certification (Hoay, 2001).

Although the strategy for controlling pollution which is promoting the voluntary adoption of environmental technologies has drawn considerable attention in policy circles, empirical research on the adoption of environmental technologies in developing countries is limited (Blackman, 2005). Environmental technologies are different from other technologies, where generally the incentive for firms to develop, or to adopt environmental technologies comes from the regulatory pressure (Rothenberg and Zyglidopoulos, 2003; Bernauer, 2006, Saint-Jean, 2006). Additional environmental improvements are often seen as non-essential to the functioning of the organization once the regulatory requirements are met. However, the adoption of environmental technologies is not just because of response to regulation. Like other technologies in general, there are many other factors that govern environmental technologies.

The literature on the determinants of technology adoption is vast. Yet, most of this literature focuses on particular determinants of technology, and only small parts of this literature focus on environmental

technology (Bernauer et al., 2006). Therefore, there is a need for an investigation on factors influencing environmental technology adoption. This paper provides a brief overview of the theoretical background of environmental technology adoption and associated hypotheses. The methodology employed to empirically analyse the data is explained. The findings from the study are presented. The paper concludes with a discussion of the significance and implications of the results.

LITERATURE REVIEW

The survey on literature initiated that most study on environmental technology adoption have tended to focus on industries such as pulp and paper, chemical, iron and steel (Rothenberg and Ziglidopoulos, 2003; Gonzalez and Moran 2005; Blackman 2005; Mazzanti and Zoboli, 2006; Sung Park, 2005 among others). The research done on food and beverage which generate organic waste is still lacking. The food and beverage industry is potentially a green industry, and food wastes are quite safe and bio-friendly. Nevertheless, these wastes can pose serious environmental problems if not managed properly (Mandikar & Naranjan, 1995). A large percentage of the country's total wastewater effluent is released by food processing companies (Nooi, Loo and Boon, 1998). The findings mentioned above evident that there is a high demand on the research on factors influencing environmental technology adoption in food and beverages industry. This is supported by Bates and Philips (1999) who suggested that research within food and beverage industry should be intensified to improve efficiencies in waste treatment, and to minimise waste in food processing and manufacturing operations.

With the insights gained from the literature, this study looks into the three following non-regulatory factors: (1) technology performances; (2) communication networks; (3) economic factors. These factors are commonly cited as important for environmental technology adoption throughout the literature (e.g King and Rollins, 1995; Dupuy, 1997; Blackman, 2005; Weber, 2005; Ganzalez and Moran, 2005; Bernauer, 2006; Oltra and Jean, 2007). The factors are well mentioned in the literature but not well tested. There are numbers of studies that conclude these factors affect the adoption of environmental technology but far fewer studies set out to test these relationships empirically (e.g Khanna et. al, 2005; Sung Park, 2005; Mazzanti and Zoboli, 2006). Responding to this circumstances, there are still gaps in determining whether these factors significantly provide impact on the adoption of environmental technology.

A Brief Overview of Food and Beverage Industry

Processed food industry has been identified by the government as one of the major growth sectors of the economy under the ninth Malaysia Plan. Since 2003, Malaysia has been a net exporter of processed food and food-related products (MATRADE, 2006). Products with high quality and uniformity are now being manufactured due to the advancement of food science and general introduction of hygienic, applied microbiology, mechanical engineering, chemical engineering, electronic engineering and high-polymer technology. The mass production of excellent quality processed food without using unnecessary food additives has been made possible by grading and inspecting the processed materials, carrying out proper inspections of processed food, and advances in processing technology, installation and packaging technology and materials (UNIDO, 1995).

Nevertheless, food processing operations produce many varied types of waste which include solid and liquid effluents. The food and beverage industries (together with other sub-sectors such as rubber-based, metal finishing, and paper industries) had difficulties in complying with requirements of the Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979 (Nooi, Loo and Boon, 1998). The most common reason for failure to comply with regulations was absence or lack of proper wastewater treatment equipment installed. Those who have treatment systems face operation and maintenance

problems and the systems often do not work efficiently.

Environmental Technology

Environmental technology usually means cleaning technology and, pollution and waste treatment technology in the technology foresight study (Borup, 2003). In some studies, the concept is used in wider sense. It includes new or modified processes, techniques, practices, systems and products, the use of which helps reducing the environmental harm as compared to other relevant alternatives, taking into account the different stages of the production-consumption chain from resource extraction to final services (Kemp 1998; Renning and Ziegler, 2005; Weber, 2005). Environmental technologies and innovations not only comprise technical components and systems, but also the organisational innovations and the embedding institutional innovations needed to realise environmental technologies.

Environmental technologies have changed in terms of basic approach over the past years (Weber, 2005). According to Borup (2003), it is relevant to draw on the perspective of the well-known classification of technologies in relation to environmental issues: 'End-of-pipe' technologies and add-on solutions; Cleaner technology and integrated solutions; System changes for sustainability. Klessen and Whybark (1999) characterized the technology into three general categories: pollution control technologies, pollution prevention technologies and management systems.

This paper discussed on pollution prevention technology which is defined as structural investments in operations that involve fundamental changes to a basic product or primary process. Pollution prevention technologies can be further characterized as product or process adaptation (Weber, 2005). Product adaptation encompasses all investments that significantly modify an existing product's design to reduce any negative impact on the environment during any stage of the product manufacture, use, disposal, or reuse. The focuses of this paper is on the adoption of cleaner production strategies which is part of pollution prevention technology. Clean production strategies are the continuous application of an integrated, preventive environmental strategies applied to process, products and services to increase overall efficiency and reduce risks to humans and the environment. Clean production includes conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes before they leave a process (Weber, 2005).

Factors Influencing Clean Strategies Adoption

Several studies had analysed the factors leading to the adoption and diffusion of environmental technologies in different sectors and countries. Most of the studies focus on socio-political aspects of the environment, such as stakeholder demands, regulatory pressure, and external relationships (Delaplace and Kabouya, 2001; Dupuy, 1997; Mazzanti and Zoboli, 2006; Kemp, 1997; Khanna, Deltas & Harrington, 2005; among others). There is lack of study on the aspects of the worth of the technology that lead to technology adoption.

Technology Performance

When it comes to technology, the meaning of performance is different to different users and all of them are important. Performance here refers to the measurable results of a company's processes, such as work-in-progress and production cycle time, and their business impact share and customer satisfaction. This broad definition covers the scope of performance in manufacturing, organizational and business performance (Klessen & Whybark, 1999). Weber (2005) stated that, meeting technological performance criteria under certain economic requirements and process design standards still represent as a major technological barrier.

To be adopted an environmental technology must be competitive with conventional technologies on the non-environmental criteria. Many theoretical and empirical works in particular Porter and Van de Linde (1995), Kemp (1997), Sartorius and Zundel (2005), and Oltra and Saint Jean (2005), show that in order to be adopted by firms an environmental technology must combine environmental performances with productive efficiency (in terms of productivity and cost) (Oltra and Saint Jean, 2007).

According to Klessen and Whybark (1999), the composition of environmental technology portfolio is expected to have implication for both environmental and manufacturing performance. Hence, this research concentrated on two constructs of technology performance. Firstly, it focused on the relationship of environmental technology adoption with environmental performance and secondly, the study is on the relationship of environmental adoption with improvement activity which is the technical or manufacturing performance. Manufacturing performance usually defined in terms of cost, quality, speed and flexibility while environmental performance with pollution prevention and control index.

H_1 Manufacturing performance and environmental performance have significant influence on cleaner production strategy adoption.

$H_{1.1}$ Manufacturing performance has positively significant influence on the adoption of cleaner production strategy adoption.

$H_{1.2}$ Environmental performance has positively significant influence on the adoption of cleaner production strategy adoption.

Communication Networks

Communication is a two-way process in which data and information are sent and received between two or more parties, each with an inherent knowledge and understanding about how the data and information is to be used (Castello & Braun, 2006). Through communication networks, people, firms and institutions are linked together to promote and enable mutual learning and generate, share and use environmental-related technology, knowledge, skill and information. Poor linkages between research and advisory services will cause a very slow adoption of technology by firms. The integration of educators, researchers and the private sectors to harness knowledge and information from various sources is significant to the effectiveness of the communication networks.

The availability of information is one of the factors that lead to environmental technology adoption. This is because, in order to adopt new technologies, firm must first acquire the requisite technical and economic information (Blackman, 2005). Through information, potential adopters are educated and alerted. Besides, communication networks enhance the process of getting relevant information about new technologies. This is supported by King & Rollin (1995), who state that information sources and communication networks describe the adoption of most innovation because they create awareness and educate potential adopters about an innovation.

Communication networks in this study refer to the presence of cooperation with other firms and cooperation with research institutes across environmental realms. The investigation on communication networks in this study focused on membership and the capacity of the communication networks which suggests that firms which have a wider and stronger communication networks have more intention to adopt the technologies.

H_2 Membership and capacity of communication network have significant influence on cleaner production strategy adoption.

$H_{2.1}$ *Membership of communication networks has positively significant influence on the adoption of cleaner production strategy.*

$H_{2.2}$ *Capacity of communication networks has positively significant influence on the adoption of cleaner production strategy.*

Economic Factors

Karki and Bauer (2004) stated that, the economic potential of new technology in terms of yields, cost of production and profit are also very important factor for adoption decision. This is supported by Green, McMeekin and Irwin (1994), who emphasize that the objectives of expending market share and costs saving are determining factors of environmental product and process innovations. Switching costs to new environmentally more friendly processes can be very high, in particular due to uncertainties about consumer acceptance and perception of product quality (Weber, 2005). Short-term profitability requirements result in low tolerance for longer payback periods of equipment investment.

Environmental technologies may lead to lower production costs if materials and energy consumption are reduced. Economic usefulness requires that benefits occur from using an innovation and that benefit contribute to economic growth. Environmental benefits need to be combined with private costumer benefits for products to be successful in the market (Bernauer, 2006). Dupuy (1997) in his study on the diffusion of environmental technology found three of the seven firms indicated an increase in the proportion of their sales for export suggesting that their competitive position has improved as a result of adopting particular pollution control technologies.

Innovation is important either to enhance efficiency or to improve product quality. Benefits and cost of technological adoption influence the degree and speed at which adoption takes place (Gondalez & Moran, 2005; King & Rollins, 1995). The adoption of environmental technology may lead to significant cost saving for the adopter. Cost savings are related to the substantial reductions in material or energy consumption and in water pollution, which lead to lower payments for water discharges. The green marketing literature predicts market success primarily for environmentally improved products that have bundled customer benefits and/or provide credible information on their environmental quality, however empirical studies focusing on these factor are sparse, the most promising environmental technology, from the perspective of firms, are those that offer a triple benefit: for the environment, the customer, and the producer alike (Bernauer, 2006). The influence of the economic factors namely cost and market on environmental technologies adoption are tested in this study.

H_3 Cost reduction and market improvement have significant influence on cleaner production strategy adoption.

$H_{3.1}$ *Cost reduction has positively significant influence on the adoption of cleaner production strategy adoption.*

$H_{3.2}$ *Market improvement has positively significant influence on the adoption of cleaner production strategy adoption.*

METHODOLOGY

The Sample and Data

A survey was conducted in a field setting using a set of questionnaire to collect cross sectional data on food and beverage manufacturing firms located in peninsular of Malaysia. A total of 144 food and beverage manufacturing firms were selected randomly as samples in order to represent overall population of 236 food and beverage firms which are registered with Federation of Malaysian Manufacturer (FMM). Based on the table provided by Krejcie and Morgan (1970), 144 companies need to be selected to represent the overall population which is 236 companies. A set of questionnaire was formulated and designed based on the previous literature in the subject area. Out of 144 questionnaires sent out, 76 firms responded, thus giving a response rate of 52 percent. This response rate was quite reasonable compared to other surveys on environmental technologies adoption, for example 46 percent of 130 samples in Gonzalez and Moran (2005). The sample profile of the survey is shown in Table 1.

Table 1: Sample profile of the respondent

Variables	Item	Frequency	Percentage
Designation	Director	9	12.0
	Manager	30	40.0
	Executive	18	24.0
	Others	18	24.0
Year of designation	Less than 3 years	23	30.7
	3 to 10 years	36	48.0
	Over 10 years	16	21.3
Number of employees	Less than 50	35	46.7
	51 to 150	21	28.0
	More than 150	19	25.3

Validation of Instrument

Validity and reliability of the instrument were conducted by using the original data from main survey. Factor analysis and inter-item consistency reliability or Cronbach's Alpha were obtained to validate the instrument.

Factor Analysis

In order to assess construct validity which means the extent to which a scale is appropriate with operational definition of an abstract variable, factor analysis was used. The analysis was carried out using SPSS data reduction-factor analysis procedure. Separate factor analysis was performed for all measures consisting two or more items. The result were analyzed to check for the items which had low correlation with others, and a low factor loading which provided candidate for a removal in second analysis. The results are outlined in Table 2. All KMO values are above acceptable value of 0.50 (Hair et al., 2006).

Table 2: Final result of factor analysis

Variables	KMO	Factor Loading	% Variance Explained by Component
IV1 Technology performance			
Manufacturing Performance	0.844	0.809, 0.822, 0.887, 0.827, 0.783	68.258
Environmental Performance	0.673	0.830, 0.886, 0.444, 0.753	55.965
IV2 Communication networks			
Membership	0.770	0.767, 0.722, 0.833, 0.781, 0.902	64.507
Capacity	0.750	0.595, 0.754, 0.860, 0.821, 0.594	53.763
IV3 Economic factors			
Cost	0.611	0.646, 0.694, 0.430	58.970
Marketing	0.726	0.899, 0.904, 0.858	78.688
DV Cleaner production strategy adoption	0.760	0.573,0.746,0.766, 0.776, 0.472, 0.536	43.062

Reliability Analysis

An internal consistency analysis was performed separately for the items of each independent variables and dependent variables by using the SPSS reliability procedure. Sekaran (2003) suggested an adequate alpha value is greater than 0.6. As show in Table 3, the alpha values of reliability analysis for this study ranges from 0.676 to 0.879. From the results obtained, all the alpha values are greater than 0.6. Thus it can be concluded that this instrument has internal consistency and is therefore reliable.

Table 3: Reliability analysis result

Variables	Number of items	Mean	Alpha
IV1 Technology performance			
Manufacturing Performance (MPFM)			
Environmental Performance (EPFM)	5	4.708	0.879

Variables	Number of items	Mean	Alpha
	4	4.464	0.676
IV2 Communication networks			
Membership (MBR)			
Capacity (CPCT)	5	4.866	0.860
	5	4.618	0.782
IV3 Economic factors			
Cost saving(CST)			
Improve market share (MKT)			
	3	4.123	0.639
	3	4.522	0.864
DV Cleaner production strategies adoption	6	3.827	0.713

FINDINGS

Table 4 shows some of the basic correlation among the variables. Relative advantage and compatibility are the technology characteristics that have positive significant influence on the adoption of environmental technology. Complexity is not significantly correlated to cleaner production strategy adoption. Environmental performance is significantly correlated with the adoption of the environmental technology. The results show that the implementation of environmental technology is influenced by environmental performance of the technology. Likewise, the correlation between the manufacturing performance and clean production strategies adoption are positive, however they are not statistically significant. Membership and capacity of communication networks are found to have positive relationship with clean production strategies adoption.

Table 4: Pearson Correlation Coefficients of technology characteristics with environmental technologies adoption

Variables	MPFM	EPFM	MBR	CPCT	CST	MKT
DV	0.166	0.409(**)	0.262(*)	0.322(**)	0.111	-0.027

* Correlation is significant at the 0.05 level (1-tailed)
** Correlation is significant at the 0.01 level (1-tailed)

DV	Cleaner production strategies adoption
MPFM	Manufacturing performance
EPFM	Environmental performance
MBR	Membership of communication network
CPCT	Capacity of communication network
CST	Cost
MKT	Market

DISCUSSION

The higher level of environmental technology adoption is the main issue for the achievement of environmental sustainability. Due to existing inherent factors in the process of environmental technology adoption, it is important to understand and assess the possible factors that would influence the environmental technology adoption in organisations as well as food and beverages industry that have significant impact on the environmental pollution. This paper has applied empirical analysis on the influence of technology characteristics on clean production strategy adoption in the Peninsular Malaysia food and beverage industry.

The findings suggest that while manufacturing performance has no impact, environmental performance plays a significant positive role for the technology to be adopted. The explanation for this is perhaps, the firms adopt the environmental technologies to reduce environmental impact of their activity and to comply with current environmental regulation. According to these results, it can be concluded that technology performance contributes to the increment of the environmental technology adoption.

The ability to exploit sources of information effectively may be specific to individual firms, even individual firms within the same industry, and this will in turn influence their decision to adopt new environmental technologies. The finding accord with Mazzanti and Zoboli (2006) and Dupuy (1997) which highlight firm involvement in groups and networking activities as an important factor and close communication networks will allow the identification of needs and availability of technology supply among firms.

The variable ‘cost saving’ seems to have a positive effect on the adoption of cleaner production strategies. Although positive, the impact of this variable on clean technologies adoption is very low. This reveals that the implementation of cleaner production strategies is weakly influence by this factor. The variable ‘access to new market’ on the other hand, has slightly negative influence on cleaner production strategies adoption. There is no significant relationship of market factor with environmental technology adoption. It can be interpreted that products with strong environmental commitment are less oriented in markets. Renning & Ziegler (2005) also obtained the same result in their study and thus environmental technology is not regarded by adopters as an instrument to access new markets (domestic and foreign). These findings are contrary to the assumption that ‘access to new market’ as a motive of adoption of environmental technology by firms.

CONCLUSION

The results that are exhibited in previous section show that increases in implementation of environmental technology are significantly correlated with the technology performance and communication networks. However, there are no significant correlation between environmental technology adoption and economic factors.

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