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Clean Production Strategies Adoption: A Survey on Food and Beverage Manufacturing Sector

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Abstract

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. This paper provides an analysis of factors influencing the adoption of clean production strategies among food and beverage firms in Peninsular Malaysia. The main purpose is to determine the relationships of three non-regulatory factors with clean production strategies adoption. Three sets of interrelated factors leading to the widespread adoption of these technologies considered are: technology characteristics, technology performances and communication networks. This paper begins with an introduction and literature review, followed by the hypotheses statements. Pearson Correlation analysis was applied to examine these hypotheses. A sample of 76 Malaysian food and beverage firms was used for investigation, with one respondent for each firm. The results of the analysis indicated that technology characteristics, technology performances and communication networks are significantly influence the adoption of clean production strategies.

Keywords: Environmental technology; technology adoption; food and beverages industry.

Introduction

According to Blackman (2005), 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. 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, 2004; Bernauer et al., 2006; Saint-Jean, 2006). Once regulatory requirements are met, additional environmental improvements are often seen as non-essential to the functioning of the organization. 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.

Technology adoption is the set of practices and factors related to organizations selecting, deploying, and sustaining the use of the technology (Troshani and Doolin, 2005). 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

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presented. The paper concludes with a discussion of the significance and implications of the results.

Literature Review

The literature survey found 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, 2004; 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) characteristics of the environmental technology; (2) communication networks; (3) technology performance. 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 et al., 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., 2007; 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

The government has identified the processed food industry 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).

However, 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 et al., 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

The field of environmental technologies is characterised by a high degree of diversity and heterogeneity. In general, the term is used to subsume technologies and applications that are supposed to help reduce the negative impact of industrial activities and services, of private and public users on the environment (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. This term includes devices and systems used in environmental programs to duplicate environmental conditions to control, prevent, treat, or remediate waste in process discharges.

According to Borup (2003), in dealing with pollution and environmental problems, the development of environmental technologies started with 'end of pipe' solutions, then, first cleaning technologies and later integrated solutions and cleaner production technologies appeared. Environmental technologies are characterized into three general categories: pollution control technologies, pollution prevention technologies and management systems (Klessen and Whybark, 1999).

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 et al. 2007; among others). There is lack of study on the aspects of the worth of the technology that lead to technology adoption.

Technology Characteristics

According to Tornazky and Klien (1982), as many as thirty distinct characteristics have been found to significantly affect adoption. However, some are more consistent than others in their relationship to technology adoption. These characteristics include the relative advantage the technology offers compared to the costs involved in adopting it, its complexity and compatibility with adopting organization, and how observable the results of the innovation are (Russell and Hoag, 2004). In this study three characteristics of the environmental technology are focused, they are relative advantage, compatibility and complexity.

The adoption of a new technology usually requires the implementation of complementary technologies, changes in existing production process or the organization of the firm and additional training of the workforce on the new technology. Therefore, when there is an 'installed base', the costs of switching to a new technology might be high, as the new technology might be incompatible with the existing system (Gonzalez & Moran, 2005). Process inflexibilities and ways to overcome them are an issue in some sectors. Technology adopted are expected to generate competitive advantage via practical benefits including increased levels of quality and service, efficiency, reliability, and etc. (Taylor and Murphy, 2004). Development and adoption of technology that can be easily incorporated into existing production processes are more attractive to many firms.

On the other hand perceived set up and on-going cost, technical difficulties and technology complexity are likely to make innovations unattractive, adversely affecting their adoption (Taylor and Murphy, 2004; Weber 2005). Innovation which are simple to use and do not require long installation times will have faster diffusion rates than those which are more complex (Dupuy, 1997). Thus, the hypotheses addressed as follows:

H_1 Characteristics of technology have significant influence on cleaner production strategy adoption.

$H_{1.1}$ Technology relative advantages have positively significant influence on the adoption of cleaner production strategies.
$H_{1.2}$ Technology compatibility has positively significant influent on the adoption of cleaner production strategies.
$H_{1.3}$ Technology complexity has negatively significant influent on the adoption of cleaner production strategies.

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 (1998), Sartorius and Zundel (2004), 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_2 Manufacturing performance and environmental performance have significant influence on cleaner production strategy adoption.
$H_{2.1}$ Manufacturing performance has positively significant influence on the adoption of cleaner production strategy adoption.
$H_{2.2}$ 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_3 Membership and capacity of communication network have significant influence on cleaner production strategy adoption.

$H_{3.1}$ Membership of communication networks has positively significant influence on the adoption of cleaner production strategy.

$H_{3.2}$ Capacity of communication networks has positively significant influence on the adoption of cleaner production strategy.

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
	Manager	30	40
	Executive	18	24
	Others	18	24
Year of designation	Less than 3 years	23	30.7
	3 to 10 years	36	48
	Over 10 years	16	21.3
Number of employees	Less than 50	35	46.7
	51 to 150	21	28
	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
IV1Technology Characteristics			
Relative advantages (RA)	0.731	0.804, 0.857, 0.522, 0.802	57.434
Compatibility (CPTB)	0.741	0.836, 0.885, 0.761, 0.867	70.301
Complexity (CPLX)	0.723	0.710, 0.736, 0.756, 0.624, 0.790. 0.633	50.555
IV2 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
IV3 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
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 Characteristics			
Relative advantages (RA)	4	4.885	0.741
Compatibility (CPTB)	4	4.724	0.853
Complexity (CPLX)	6	2.746	0.802
IV2 Technology performance			
Manufacturing Performance (MPFM)	5	4.708	0.879
Environmental Performance (EPFM)	4	4.464	0.676
IV2 Communication networks			
Membership (MBR)	5	4.866	0.860
Capacity (CPCT)	5	4.618	0.782
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	RA	CPTB	CPLX	MPFM	EPFM	MBR	CPCT
DV	0.407(**)	0.354(**)	-0.158	0.166	0.409(**)	0.262(*)	0.322(**)

* 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

RA Relative advantages

CPTB Compatibility

CPLX Complexity

MPFM Manufacturing Performances

EPFM Environmental Performances

MBR Membership of Communication Networks

CPCT Capacity of Communication Networks

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 indicate that the characteristics of the environmental technology influence the environmental technology adoption. The results of the study shows that the benefits gained from the implementation (relative advantage) are among the reasons why companies adopt the environmental technology. The adoption of environmental technology may help to improve the environmental image of the firm and this will help to improve relationship with regulators and financial institutions.

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 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.

Conclusion

The results that are exhibited in previous section show that, on the whole, increases in implementation of environmental technology are significantly correlated with the characteristics of the technology, technology performance and communication networks.

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