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Full Length Research Paper

Relationship between management practice and organisation performance under European Union directives such as RoHS: A case-study of the electrical and electronic industry in Taiwan

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The aim of this study is to investigate the effects of the European Union Restriction of Hazardous Substances (RoHS) and Waste Electrical and Electronic Equipment (WEEE) directives set by the European Union on the financial and environmental performances of Taiwan's electrical and electronic companies adopting the green supply chain management. A literature review, in-depth interviews and questionnaires were used as our hypothetical supports. One hundred and fifty-one certified International Organization for Standardization 14001 electrical and electronic companies were randomly selected as the study subjects. Data analyses and hypothesis tests were performed using Statistical Package for the Social Sciences software, and Structural Equation Modelling was used to analyse the pathway model and to test the hypothetical structure in this study. We found that these companies mostly adopted green manufacturing practices and green purchasing practices in order to meet the RoHS and WEEE directives. The results of pathway diagram analysis using structural equation modelling (SEM) also showed that the green supply chain management adopted by the study companies had a positive effect on both their financial ($p < 0.01$) and environmental ($p < 0.01$) performances, and therefore might be used as a reference for Original Equipment Manufacturing and Original Designing and Manufacturing industries in other Asian Pacific countries.

Key words: RoHS, WEEE, green supply chain management, financial performance, environmental performance.

INTRODUCTION

The global environmental concern for conserving environmental resources has put pressure on business management in Taiwan; this concern notwithstanding, the demands of human consumption and convenience have already harmed the environment (Shih, 2003) . Companies have had to face increasing concern over the environment in the past ten years (Sheu et al., 2005), and globalization has forced companies to improve their environmental performance (Zhu and Sarkis, 2006). In addition, the pressure on companies to improve their environmental record has increased not only locally but also globally (Sarkis and Tamarkin, 2005). Green trade barriers, foreign investment, downstream industry, consumers and environmental concerns have obliged factories to begin to think seriously about the implementation of green supply chain management (Zhu and Cote, 2003). The technological development and design of the electrical and electronic industry in Taiwan has gained international approval; many countries have started to build product development centres in Taiwan and have requested the advice of Taiwanese factories regarding Original

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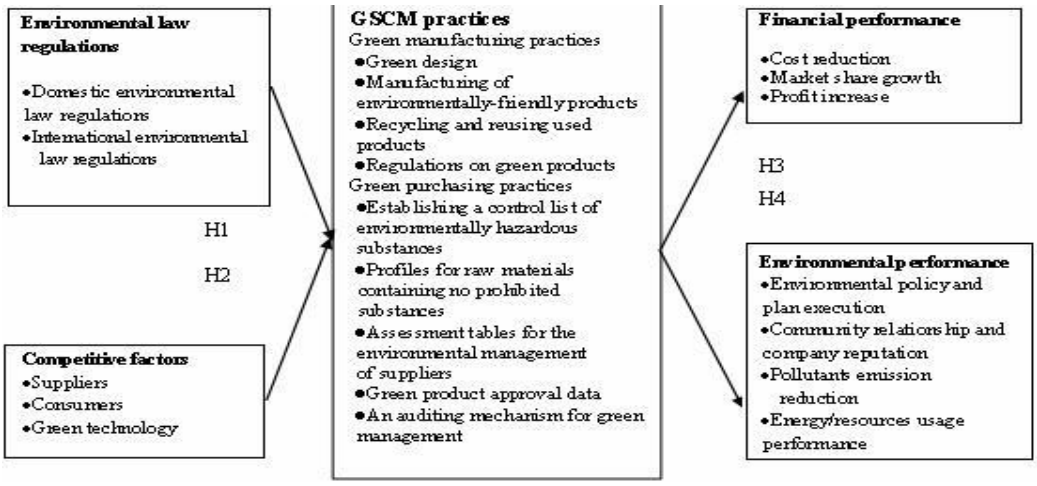

Figure 1. Research structure of adoption of green supply chain management.

Equipment Manufacturing (OEM) and Original Designing and Manufacturing (ODM). According to the International Data Corporation (IDC), ODM in Taiwan has increased significantly in the past few years. In 2004, profit increased by 38% from 2003. Flint Pulskamp, program manager of IDC's Wireless Semiconductors Research, reported that it can be seen from the profits of ODM factories, such as those producing desktops, laptops, motherboards, monitors, etc., that ODM in Taiwan plays an important role in global ODM. The top factories are almost always Taiwanese factories (IDC, 2006). Meike Escherich, principal research analyst of Gartner Research, warned that an increasing number of countries are imposing environmental regulations, and that there will be more new laws passed in the future. Therefore, more concern has to be raised related to the manufacturing of electrical and electronic products. Research is needed to enable manufacturers to ensure that their products fulfil "green" environmental regulations (Gartner, 2006).

Several factors (e.g. the relevant fees for joining EU, the increasing costs of materials and management operation, and the cost caused by new design, etc.) have made the WEEE (Waste Electrical and Electronic Equipment), RoHS (Restriction of Hazardous Substances) and EuP (energy-using products) directives implemented by the EU affect the electrical and electronic products exported from Taiwan to Europe, which are worth 220 billion Taiwan Dollars (about 6.67 billion U.S. Dollars) (Liu, 2007). In addition, other directives such as the Eco-design of End Use Equipment (EuE) and Integrated Product Policy (IPP) directives cannot be ignored if the products are to be exported to Europe. Therefore, the related manufacturers have to integrate green management and strategy into their product design and production according to the related directives. The introduction of the concept of green supply chain management is therefore an important strategy of the electrical and electronic industry in Taiwan. Other Asian Pacific countries such as Japan, China and Korea have already implemented the related environmental regulations (Gartner, 2006). Emerging Industrial countries such as Thailand, Vietnam, India, Malaysia, Indonesia and the Philippines are also facing similar environmental pressure as their manpower is beginning to supply products and assembly services to the global market. As Taiwan has an influential role in manufacturing computer products and ODM, it is therefore important to investigate the experience of green supply chain management in companies in Taiwan, so as to set an example to other Asian Pacific countries according to the RoHS and WEEE directives.

GSCM (Green supply chain management) includes a wide range of management strategies, including internal environmental management, external green supply chain management, investment recovery and ecological or environmental practice design (Zhu and Sarkis, 2004). This study verifies the adoption of green chain supply management by Taiwanese electrical and electronic companies that are mainly based on OEM and ODM production in response to green regulations such as the RoHS and WEEE directives.

Therefore the aims of this study are:

i. To investigate the major external factors affecting the adoption of green supply chain management by electrical and electronic companies in Taiwan.
ii. To investigate which green supply chain management these companies implement according to green issues.
iii. To testify as to the relationship between green supply chain management and the environmental and financial performance of these companies.

MATERIALS AND METHODS

Figure 1 shows the research structure of the adoption of GSCM practices in this study, in which the relationships between environmental law regulations, competitive factors, GSCM practices, environmental performance and financial performance are surveyed. A

Table 1. Company information (TSEC, 2007).

Company name	Capital	Products
ACER	240.55 billion Taiwan Dollars (approx. 7.3 billion U.S. Dollars)	Personal computer
ASUS	370 billion Taiwan Dollars (approx. 11.2 billion U.S. Dollars)	Computer, communication, consumer electronic, mother board
MSI	94.92 billion Taiwan Dollars (approx. 2.9 billion U.S. Dollars)	Notebook, consumer electronics
TATUNG	442.98 billion Taiwan Dollars (approx. 13.4 billion U.S. Dollars)	Home appliances, industrial appliances, digital audio products
TMSC	2642.04 billion Taiwan Dollars (approx. 80.0 billion U.S. Dollars)	Wafer, IC packaging and testing, mask making, grain
UMC	1895.22 billion Taiwan Dollars (approx. 57.4 billion U.S. Dollars)	Wafer, chip

statistical model for testing hypotheses relating these variables are developed through this research.

The green supply chain management situation in Taiwan

Six representative leading companies adopting GSCM in Taiwan are introduced as follows and their major characteristics are summarized in Table 1 (TSEC, 2007). The green supply chain management of Taiwan Semiconductor Manufacturing Company (TSMC) includes environmental accounting, life cycle assessment, green purchasing and reduction of greenhouse gas emission. At the same time, it has strict control over its raw material supplier to make sure that there are no EU- prohibited materials in the E & E products (TSMC, 2005). United Microelectronics Company (UMC) has established a control list of environmentally hazardous substances and profiles for raw materials containing no prohibited substances, as well as having developed an environmental management table to evaluate the environmental protection performance of its supp-liers. The company has also included suppliers' environmental information into its e-management of suppliers and provides the necessary training to relevant personnel to enhance their awareness of environmental protection (UMC, 2004). For ACER Inc. (ACER), their green supply chain management includes four main categories: green product regulations, green product approval data, evaluation management mechanisms and green purchasing systems (ACER, 2005). ASUSTek Computer Inc. (ASUS) not only satisfies consumer demand, but also actively provides information and services to its suppliers if they encounter any problems. They also provide ASUS e-Green login and assessment, first confirming the supplier's ability by components confirmation mechanisms, and then making sure the suppliers are using green management by using green factors and elimination mechanisms. They also insist on conserving natural resources and maintaining green design, purchasing, manufacturing, sales and services (ASUS, 2005).

In order to maintain participation in the European market, Tatung Company (TATUNG) meets the demands of RoHS and consumers' green purchasing by developing its green supply chain management. They request upstream suppliers to provide guarantees, examination reports and hazardous substance reports; they also re-examine their suppliers in order to strengthen their supply chain to provide up-to-standard products to meet the demand of consumers' green purchasing and of the EU's RoHS directive (Tatung, 2005). Micro-Star International Company (MSI) has high standards in meeting environmental and health and safety directives. Their product development is moving in the direction of green design, sustainable improvement processes, reduction in pollutants emission in working environment and facilities, resource/energy usage and health and safety risks, etc. (MSI, 2006). From the studies of Zhu and Sarkis (2006), Li et al. (2006) and Walton et al. (1998), and also the experiences of the E & E companies in Taiwan, general green supply chain management can be divided into two areas: green manufacturing practices and green purchasing practices. Green manufacturing practices include green design, manufacturing of environmentally-friendly products, recycling and reuse of used products, and regulations on green products. Green purchasing practices include establishing a control list of environmentally hazardous substances, profiles for raw materials containing no prohibited substances, assessment tables for the environmental management of suppliers, green product approval data, and an auditing mechanism for green management. Madu et al. (2002) stated that green manufacturing is a way of product manufacturing from cradle-to-grave. Nihei (2001) defined green purchasing as minimizing the environmental burden when purchasing products, for example, a recycled product which has priority can be defined as a green purchase.

Research hypothesis

External factors that affect the implementation of green supply chain management

Zhu and Sarkis (2006) showed the effect on sales, suppliers, competitors and internal factors of the implementation of green supply chain management in Chinese companies. The pressure of environmental protection comes not only from laws, but also from other areas such as consumers, shareholders, customers and environmental groups (Hall, 2000). Regulations, laws and competition have urged groups to be conscious of the natural environment (Sarkis, 1998). From the literature review and professional advice, this study chose to divide the external factors of green supply chain management into environmental law regulations and competitive factors.

Environmental law regulations

The Institutional theory explains that external pressure will affect organisational structural properties (Meyer et al., 1987). McCrea (1993) stated that the power of the law is an important stakeholder. Whether or not industrial products fulfil environmental regulations can affect the environmental protection strategy of a company. Government law and policy induces sustainable development prin-

principles globally, which affects international trade agreements (Brent and Visser, 2005). Environmental policy directly affects manufacturing, service practices and pollutants emission (Hutchinson, 1996). From the reviews of Brent and Visser (2005), Seuring (2004) and Hutchinson (1996) and professional advice, this study divided environmental law regulations into domestic and international law regulations.

Domestic environmental law regulations

Domestic environmental law regulations force companies to adopt related strategies or practice in order to increase the environmental performance of the companies. Companies are therefore facing the increasing cost of recycling products, environmental regulations and recycled product handling (Prahinski and Kocabasoglu, 2006). Zhu and Sarkis (2006) found that domestic regulations and industry environmental regulations are two major sources of pressure in companies. Today, companies cannot ignore environmental issues. Increasing environmental rules and public pressure force the companies to include environmental issues in their executing plan (Walton et al., 1998) . An increase in public environmental knowledge, governmental regulations and policies requirements has made the companies diverge from traditional thinking and adopt green manufacturing or environmental management system strategies (Hui et al., 2001). Environmental regulations and public pressure have affected companies' standard confirmation to the environmental improvement (EIC, 2005). Government environmental regulations have become the major driving force in increasing company compliance in environmental protection (Handfield et al., 1997).

International environmental law regulations

Environmental issues have increasingly affected trade, especially in importing countries. In developed countries, strict regulations have caused an increase in manufacturing cost; therefore their products cannot compete with those from environmentally-developing countries. Thus, the fact that developed countries requested that all imported products fulfil their environmental standards eventually led to trade barriers. Environmental regulation is the most common pressure upon Chinese companies, and the environmental standards of the importing countries are another source of pressure (Zhu and Sarkis, 2006). Environmental regulations, governmental pressure and international standardization (e.g., ISO 14000) etc. changed customer demand and companies' understanding of the environmental impact. Companies therefore started to develop an environmental strategy in their facilities so as to maintain uniformity in their services and supply partners (Sarkis and Sroufe, 2005). Further government intervention promoting greater environmental regulation appears inevitable. Global, national and local environmental legislation is already taking hold (Rodrigue et al., 2001). Many companies and governments have been affected by international environment agreements such as the Kyoto Protocol, Global Changing Climate Protocol and Montreal Protocol (EIC, 2005). Following on from the above references, the first hypothesis of this study is:

Hypothesis 1

Environmental law regulations have positive causes and effects on the adoption of green supply chain management by companies.

Competitive factors

Porter (1995) thought that the five competitive factors that affect companies are potential intruders, suppliers, industry competitors, customers and substitutes. Zahra and Neubaum (1998) stated that the so-called competition factors are rampant within the industry and over-competition will lower the profits. Lau (2002) verified that competition factors such as high product quality, low production cost, good supplier relationships, creative products/design and advanced product technology are the important factors for improving competitiveness. Following on from the above references, this study divided competitive factors into supplier, customers and green technology.

Suppliers

The supplier plays an important role in the whole chain, and good suppliers directly affect the product quality, cost and reputation of the company. The supplier becomes the major factor in the whole supply chain performance, and a bad quality supplier can affect the performance of the whole supply chain (Sarkar and Mohapatra, 2006). Today, many companies put pressure on their suppliers and demand them to execute environmental management systems so as to pass the ISO 14001 standard (Zutshi and Sohal, 2004). The market direction of the supplier affects the reliability of the manufacturer (Zhao and Tamer, 2006), and the supplier has an obvious effect on the product quality to a certain extent (Forza and Filippini, 1998). The relationship between supplier and manufacturer is crucial in developing a sustainable competitive advantage (Cannon and Homburg, 2001). Managers and consultants believe that a good relationship with the supplier determines the competitive advantage of the factory (Sheth and Sharma, 1997). The environmental performance of the supplier is now thought to be a key decisive factor in many companies (Clark, 1999).

Consumers

The demand of consumers has now become the most important external pressure affecting the environmental performance of companies (Doonan et al., 2005). Sometimes, the pressure of a big company can exceed that of legal environmental standards (Hall, 2000). Lamming and Hampson (1996) pointed out that 75% of consumers in the US can be affected by the environmental reputation of a company. About 80% of consumers are willing to pay more for environmentally- friendly products. In order to obtain a more sustainable strategy, the environmental properties of products and services must fulfil consumer demands (Zhu and Sarkis, 2006). Organisations now face increasing environmental regulations, and eco-consumers obtain more and more negative information about the activity and product pollution of the companies (Larsson et al., 1996) . The increasing number of consumers who are concerned about the environment has led many marketing managers to restrict their purchasing strategy to goods related to environmental protection (Follows and Jobber, 2000).

Green technology

Green technology, or environmental technology, refers to technology that minimized hazards to the environment through sustainable design of products and processes that save energy and reduces reliance on non-replaceable raw materials. Green technology includes: pollution prevention technology, pollution control technology and pollution management systems (Klassen and Whybark, 1999). Shrivastava (1995) defined environmental technology as a manufac-

turing facility, method and process, product design or transport system that can save energy and natural resources. This technology can lower the environmental burden on humans and protect the environment. By developing green technology, companies can maintain their environmental advantage (Porter and Linde, 1995). The specific function of green technology has a direct effect on the environment. It emphasises saving energy by reducing use of fossil fuels. On the other hand, there is an emission law regulation to limit solid waste, sewage and gas (Weatherall, 1990). Following on from the above references, the second hypothesis of this study is:

Hypothesis 2

Competitive factors have a positive effect on the adoption of green supply chain management.

Organisation performance

Daft (1995) defined performance as the evaluation of achievement of the company target. Walton et al. (1998) stated that green supply chain management can generate environmental and company profit, and Russo and Fouts (1997) suggested that there is a positive effect on environmental performance and financial performance. A green supply chain can improve environmental performance (reduce waste emission and improve the environment) and competitiveness (improve product quality, increase efficiency and productivity, and reduce the cost) and further affect financial performance (new marketing opportunities, increase product price, marginal returns, contribution to market and sales) (Purba, 2002). This study investigates, from the financial performance and environmental performance perspectives, the organisation performance of Taiwanese electrical and electronic factories when adopting green supply chain management.

Financial performance

Financial performance refers to meeting company economical targets such as sales growth, profit margin, earnings per share (EPS) and EPS after tax (Venkatraman and Ramanujam, 1986). Environmental protection can be of some benefit to financial performance. Green supply chain management can reduce purchasing cost and energy consumption, reduce emission of pollutants and processing cost and reduce accident penalties (Zhu and Sarkis, 2004). Sustainable methods lead to a reduction in internal costs and the development of new markets; they also develop the reusable properties of the waste (Tsoulfas and Pappis, 2006). Environmental manufacturing has a positive effect on financial performance (e.g., profit growth, sales growth, market share growth) (Fuentes-Fuentes et al., 2004). Environmental supply chain management not only increases environmental profit but also company profit (Lippmann, 1999). Good environmental performance not only has a positive effect on good financial performance but also on environmental exposure (Al-Tuwaijri et al. 2004). This study divided organisation financial performance into cost reduction, market share growth and profit increase.

Hypothesis 3

Adoption of green supply chain management has a positive effect on organisation financial performance.

Environmental performance

Sharma and Vredenburg (1998) defined environmental performance as the natural environmental impact of companies that perform business management. Environmental performance indicators are divided into operating performance and management performance. The operating performance index refers to material cost, energy management, pollutant emission, and organisation physical environment assessment. The management performance index refers to the supply of effective administrative information and the contribution of environmental management to the whole organisation (Papadopoulos and Giama, 2007) . Green supply chain management not only aids environmental performance but also ensures that the company itself and the suppliers follow environmental requirements. The effective management of suppliers can lower cost, increase recycling of waste and reduce pollutants production, which in turn can prevent penalties and further reduce related disposal and operating costs (Sarkis, 2003). Sustainable methods can reduce pollutants production, increase the recycling and reuse of materials, and also increase effectiveness in energy, water and by-products usage (Tsoulfas and Pappis, 2006). In the supply chain, if the company can co-operate with its major supplier, the environmental performance of the company will therefore increase (disposal of solid waste, air and sewage emission) (Vachon and Klassen, 2006). By compiling the above references and professional advice, this study divided environmental performance into environmental policy and plan execution, community relationship and company reputation, pollutants emission reduction and energy/resources usage performance, etc. Therefore the fourth hypothesis of this study is:

Hypothesis 4

Adoption of green supply chain management has a positive effect on an organisation's environmental performance.

Samples and analytical methods

The questionnaire objects of this study were in the top 1000 companies list elected in the manufacturing section of Common Wealth magazine in 2004. The selected companies passed ISO 14001 standardisation before the end of December, 2004. We focused on information and electronics, telecoms, optoelectronics, semiconductors, electronic products and accessories companies as our major questionnaire survey objects. We sent out 500 questionnaires in total; eighteen were rejectted, twenty were invalid. There were in total 150 valid questionnaires received, that is, valid questionnaires accounted for 30% of the total questionnaires. The major reason for choosing these companies was the announcement of the EU WEEE, RoHS and EuP directives, which affect the export of electrical and electronic products by Taiwan. This study used SPSS11.0 and LISREL 8.7 to analyse and test the hypotheses.

Research tools and variables

The questionnaire used in this study, entitled 'Adoption of green supply chain management practice and organisational performance', was referenced to Sarkis (1998), Sarkis (2001), Purba (2002), Zhu and Cote (2003), Zhu and Sarkis (2004), Brent and Visser (2005), the environmental performance assessment of the ISO environmental management system, and advice from electrical and electronic experts and scholars in Taiwan. Following the concept model of this study, we used related categories in this study as the research variables. The operational definitions of the research variables are shown in Table 2.

Exogenous variables

There are two external variables in this study: environmental law regulations and competitive factors. The environmental law regula-

Table 2. Operational definitions of various categories in this study.

Various categories	Operational definition	References
Adoption of green supply chain management	The company adopts methods such as green manufacturing practice and green purchasing, and improves the product and its process, co-operation between the company and its suppliers in order to increase the environmental performance of suppliers and customers.	Sarkis (2001), Zhu and Cote (2003), Zhu and Sarkis (2004)
Environmental law regulations	Environmental regulations and policy and international law regulation pressure increasing the environmental awareness of the organisation.	Sarkis (1998), Brent and Visser (2005)
Competitive factors	Factors leading competition within the industry	Porter (1985), Lau (2002)
Financial performance	Evaluation of financial target achievement	Venkatraman and Ramanujam (1986), Daft (1995)
Environmental performance	Evaluation of environmental target achievement	Daft (1995), Sharma and Vredenburg (1998)

tions external variable results from the reaction of two observed variables: domestic environmental law regulations and international environmental law regulations. On the other hand, the competitive external variable results from the reaction of the three observed variables of suppliers, consumers and green technology.

Endogenous variables

The endogenous variables in this study were divided into two types: intervening variables and outcome variables.

Intervening variables

The only intervening variable is green supply chain management practice. This intervening variable is the result of the reaction of two observed variables: green manufacturing practice and green purchasing practice.

Outcome variables

There are two outcome variables: financial performance and environmental performance. Financial performance is the result of the reaction of three observed variables: cost reduction, market share growth and profit increase. Environmental performance results from the reaction of environmental policy and plan execution, community relationship and increase of company reputation, reduction in pollutants emission and energy/resources usage performances.

Composite variables

The questions in this study followed the seven-point Likert Scale: strongly agree – 7, agree – 6, somewhat agree – 5, no comment – 4, somewhat disagree – 3, disagree – 2 and strongly disagree – 1. The marks for the group variables were given by the sum of the marks for each question divided by the number of questions.

RESULTS

General information analysis

The general information analysis of each of the research objects in this study is shown in Table 3. This includes gender, age, education and position in the company. The research objects in this study were mainly male (88%), aged from 41 – 50 (40.7%). The lowest education level was diploma (35.3%); education includes postgraduate level (64.7%); and positions such as environmental- and health-related department chief, deputy chief and officers were the major objects (55.3%).

Choice of estimation methods

In SEM, maximum likelihood estimation is greatly affected by variables distribution. Kline (1998) stated that if the absolute value of skewness of the variables is larger than 3, this is extreme skewness. If the absolute value of the coefficient of kurtosis is larger than 10, this is abnormal; if it is larger than 20, then this is regarded as extreme kurtosis. From Table 4, it can be seen that the skewness values in this study range from -1.51 to 0.00 with an absolute value of smaller than 3. Kurtosis ranges from -1.20 to 2.69 with an absolute value of less than 10. These results show that the skewness and kurtosis of the observed variables are not large, and therefore we used maximum likelihood estimation in this study.

Offending estimates

There should be no negative error variation or large standard deviation, and the coefficient of standardisation should not be > 0.95 in the general model (Bagozzi and Yi, 1988). Table 5 shows that the standard error of each parameter is significantly positive (the *t*-values of the significance test are all > 1.96). The coefficient of standardisation ranges from 0.76 – 0.95, meaning that there is no offending estimate.

Reliability test

From Table 6, it can be seen that the R^2 value of fourteen

Table 4. Average value, standard deviation and coefficient of state submit of observed variables.

Dimensions	Average	Standard deviation	Skewness	State submit
Environmental law regulations				
Domestic environmental law regulations (X1)	6.19	0.57	-1.19	0.75
International environmental law regulations (X2)	6.16	0.67	-0.21	-1.20
Competitive factors				
Suppliers (X3)	5.41	0.61	-0.34	0.30
Consumers (X4)	5.24	0.67	-0.12	-0.91
Green technology (X5)	5.73	0.68	-0.96	0.01
GSCM practices				
Green manufacturing practices (Y1)	5.69	0.84	0.00	-0.85
Green purchasing practices (Y2)	5.08	0.67	-0.03	-1.12
Financial performance				
Cost reduction (Y3)	5.69	0.90	-0.55	-0.57
Market share growth (Y4)	5.33	0.73	-0.09	-0.36
Increase in profit (Y5)	5.30	0.80	-0.15	-0.15
Environmental performance				
Environmental policy and plan execution (Y6)	5.90	0.64	-0.68	-0.13
Community relationship and company reputation (Y7)	5.82	0.73	-1.51	2.69
Pollution emission reduction (Y8)	5.88	0.68	-1.12	1.32
Energy/resources usage performance (Y9)	5.89	0.63	-0.82	0.18

observed variables ranges from 0.57 to 0.90, which falls within the suggested confidence $R^2 > 0.45$ (Bentler and Wu, 1993). The construct reliability of five potential variables ranges from 0.75 to 0.94, which fulfils the criteria that the suggestion value is equal to or larger than 0.5 (Hair et al., 1998).

Validity test

Convergent validity

The loading factor ( ) of observed variables shown in Table 5 ranges from 0.76 to 0.95, which is significant and higher than the threshold of 0.45. This indicates that the observed variables can reflect all the potential variables in the structure. The average variations of potential variables (Table 6) are 0.60, 0.72, 0.82, 0.85 and 0.80, which are all larger than the 0.5 threshold (Bentler and Wu, 1993). This indicates that the five potential variables were affected by the observed variables rather than by measuring error.

Discriminate validity

From Table 7, the potential variables are seen to be significant. This indicates that there is a difference between potential variable settings in the 1.00 model and all potential variables free estimation models. This result shows that such potential variables can be differentiated and supported by discriminate validity.

Test for overall model fit

From the view of SEM, the adoption of the whole model index is assessed by at least the following three measures:

Absolute fit measures

(i) Goodness of Fit Index (GFI): It is suggested that when GFI is larger than 0.9, then this is a good fitness. The theoretical model value is 0.89, which is close to the value for good fitness.
(ii) Root Mean Square Residual (RMR): When RMR is smaller than or equal to 0.05, there is good fitness. The value in this study is 0.04, implying there is a good fitness.
(iii) Root Mean Square Error of Approximation (RMSEA): When RMR is smaller than or equal to 0.05 there is good fitness. A value of 0.05 to 0.08 for RMSEA is regarded as good fitness; the value in this study is 0.08, which is therefore in the good fitness category.

Incremental fit measures

(i) Non-Normed Fit Index (NNFI): when the NNFI value is > 0.9 it is regarded as accepted. The value in this study is 0.93, indicating acceptance.
(ii) Comparative Fit Index (CFI): A CFI value of > 0.9 is regarded as accepted. The value in this study is 0.94, which means it is accepted.

Table 5. Model parameters estimated values.

Parameters	Non-standard parameters value	Standard error	*t* value	Standardised parameters
1	1.00	-	-	0.76
2	1.23	0.23	5.36	0.80
3	1.00	-	-	0.90
4	1.01	0.08	12.30	0.83
5	1.01	0.08	11.86	0.81
6	1.00	-	-	0.89
7	0.78	0.07	11.14	0.91
8	1.00	-	-	0.89
9	0.88	0.04	18.39	0.95
10	0.93	0.05	17.55	0.93
11	1.00	-	-	0.90
12	1.05	0.07	14.08	0.83
13	1.08	0.06	17.63	0.91
14	1.04	0.05	19.18	0.94
1	0.70	0.18	3.81	0.40
2	0.42	0.13	3.37	0.30
1	0.33	0.09	3.62	0.31
2	0.23	0.06	3.60	0.31
1	0.14	0.04	3.92	0.43
2	0.17	0.05	3.19	0.37
3	0.07	0.02	3.87	0.18
4	0.14	0.02	6.03	0.31
5	0.17	0.03	6.54	0.35
1	0.12	0.05	2.56	0.20
2	0.09	0.03	3.25	0.16
3	0.17	0.03	3.76	0.21
4	0.05	0.01	3.95	0.10
5	0.09	0.02	5.33	0.14
6	0.08	0.01	6.64	0.19
7	0.17	0.02	7.66	0.32
8	0.88	0.01	6.26	0.17
9	0.04	0.01	4.77	0.11

Note: *t* value: 1.96 (*p < 0.05), *t* value: 2.58 (**p < 0.01).

Parsimonious fit measures

(i) Parsimony Normed Fit Index (PNFI): Scholars suggest that PNFI should be larger than 0.5 as the accepted level. This study value is 0.72, which is accepted.

(ii) Parsimony Goodness of Fit Index (PGFI): Normally a PGFI value of 0.5 is set as the acceptance level. The value in this study is 0.6, which is accepted.

(iii) Normed Chi-Square ($^2/df_m$): When the model value is less than 3, this means a good fit. The model value in this study is 2.13, which is of good fitness.

The fitness threshold in the whole model is based on the observed information and theoretical model fitness. Mentioned above it can be seen that the whole fitness of this theory model can be accepted.

Pathway relationship test

Figure 2 shows the standard pathway diagram; its results are summarised in Table 5. All the hypothesised results are shown in Table 8. From Table 8, it can be seen that the research hypothesis result is significant.

DISCUSSION

Conclusions

In developing countries, many companies are under external pressure to improve their environmental performance (Sumiani et al., 2007). Globalization results in both pressure on and a drive for Chinese enterprises to improve their environmental performance. As a developing country, China has to balance economic and environmental performance. Green supply chain management (GSCM) is emerging as an important approach for Chinese enterprises to improve performance (Zhu and Sarkis, 2004). Whether companies can increase their financial performance and environmental performance in some developing countries such as Thailand, Vietnam, India, Malaysia, Indonesia and the Philippines is a major concern. The aim of this study, using the electrical and electronic companies in Taiwan as an example, is to investigate the pressure or force when adopting green supply chain management, and whether adoption has an effect on financial and environmental performance. From the questionnaires and interviews from domestic electrical and electronic entrepreneurs whose companies passed the ISO14001 standard before the end of December 2004, we obtained 150 valid samples. The results are as follows:

External major factors

The adoption of green supply chain management practice has a positive effect on environmental law regulations, including domestic and international regulations. It also has positive effects on competitive factors such as suppliers, consumers and green technology. Similar to the previous findings of studies such as those of Seuring (2004), Gottberg et al. (2006), Porter and Linde (1995) and Lau (2002), this study found that factors such as environmental law regulations and competition can force or lead to the adoption of green supply chain management. The regression coefficient of the effect of environmental law regulations on the adoption of green supply chain management is 0.4, which is slightly larger than that of the competitive factor (0.3). This result indicates

Table 6. Construct reliability and average variation.

Dimensions	R^2	Construct reliability	Average variation
Environmental law regulations		0.75	0.60
Domestic environmental law regulations	0.57		
International environmental law regulations	0.63		
Competitive factors		0.88	0.72
Suppliers	0.82		
Customers	0.69		
Green technology	0.65		
GSCM practices		0.90	0.82
Green manufacturing practices	0.84		
Green purchasing practices	0.80		
Financial performance		0.94	0.85
Cost reduction	0.79		
Market share growth	0.90		
Increase in profit	0.86		
Environmental performance		0.94	0.80
Environmental policy and plan execution	0.81		
Community relationship and company reputation	0.68		
Pollution emission reduction	0.83		
Energy/resources usage performance	0.89		

Table 7. Discriminate validity.

Potential variables	(1)	(2)	(1)	(2)	(3)
Environmental law regulations (1)	1.000				
Competitive factors (2)	0.296**	1.000			
Green supply chain management practices (1)	0.399**	0.396**	1.000		
Financial performance (2)	0.370**	0.366**	0.578**	1.000	
Environmental performance (3)	0.431**	0.271**	0.265**	0.172*	1.000

Note: *p < 0.05, **p < 0.01

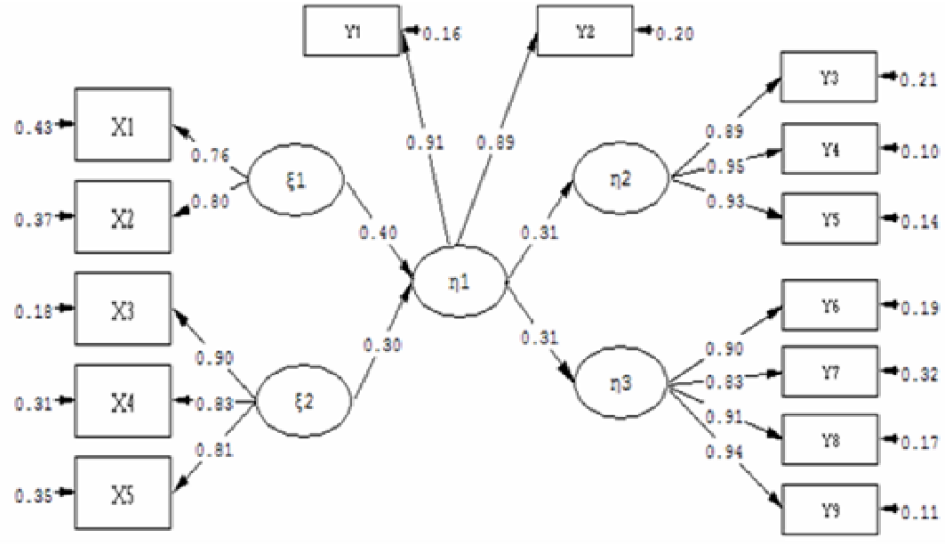

Figure 2. Green supply chain management practice adoption standardised pathway diagram.

Table 8. Test analysis results.

Pathway hypothesis	Structure coefficient	Standard deviation	*t* value	Conclusion
H1: Environmental law regulations Green supply chain management practices	0.40	0.18	3.81**	Accept
H2: Competitive factors Green supply chain management practices	0.30	0.13	3.37**	Accept
H3: Green supply chain management practices Financial performance	0.31	0.09	3.62**	Accept
H4: Green supply chain management practices Organisation environmental performance	0.31	0.06	3.60**	Accept

Note: **p < 0.01

that the major force or pressure on companies to adopt green supply chain management comes from environmental law regulations, both domestic and international.

Organisation financial performance

In the sub-dimension of financial performance, the adoption of green supply chain management has a positive effect on cost reduction, market share growth and profit increase. This result disagreed with the Walley and Whitehead (1995) study, which stated that companies, in order to fulfil environmental regulations, have to use environmental facilities that will increase cost and lower profits and therefore become a burden on the company. This study, however, further confirmed the points of view of Purba (2002) and Sarkis (2001), which emphasised the improvement of financial performance when adopting green supply chain management.

Organisational environmental performance

In the course of organisational environmental performance, the adoption of green supply chain management has a positive effect on environmental policy and plan execution, community relationship, increase in company reputation, reduction in pollutants emission and energy/ resource usage performance. This result confirmed the views of Purba (2002) and Sarkis (2001), which emphasised the improvement of organisational environmental performance following the adoption of green supply chain management.

Suggestions

Due to the time limit, this study cannot analyse and investigate different industries. Therefore, there may be differences with reference to other industries. On the other hand, the increase in global and international environmental awareness and the rise of the green consuming concept have led the public to increase their social responsibility. Therefore, when a company adopts green supply chain management, they should not only concentrate on the environmental and financial performance, but also on sustainable performance. Therefore, this study suggests that investigators also focus on this area.

Study contributions

(i) In the face of global environmental regulations such as the EU RoHS and WEEE directives, the OEM and ODM companies that produce PC-related products cannot avoid the green wave and the underlying green supply chain management. ODM companies in Taiwan play an important role in the global ODM market. The adoption of green manufacturing practices (green design, manufacturing of environmentally-friendly products, recycling and re-use of used commodities, and regulations on green products) and green purchasing practices (establishing a control list of environmentally hazardous substances, profiles for raw materials containing no prohibited substances, assessment tables for the environmental management of suppliers, green product approval data, and an auditing mechanism for green management) can improve environmental and financial performance. This study can be used as a reference for ODM and OEM companies in other Asian Pacific countries.

(ii) The traditional production of a company is mainly focused on the profit of the company and ignores supplier co-operation, upstream industry and downstream customers during the production cycle. This study found that the company has to seek co-operation with its upstream suppliers in terms of green-related production technology. They also need to understand the problems encountered by the suppliers in providing the information and services required. The company also needs to consider the downstream customers as a reference for manufacturing in order to gain profit in the whole green supply chain.

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