An exploration of relationships between environmental practice and manufacturing performance using the PLS path modeling

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Abstract: - Many manufacturers turn to highlight the concept to improve product development, quality goals, waste reduction, energy conservation, and to enhance manufacturing performance. Environmental practices involve complex components ranging from planning the product/process design, top management support, production practice to organizational design. Only few works concern about the relationship between environmental practice and manufacturing performance. However, there is lacking of a model to facilitate the comprehensive relationships between environmental practice components and manufacturing performance. In this study, the conceptual framework is proposed and tested between an environmental practices and the manufacturing performance. This empirical assessment collects 616 respondents from Taiwanese high-tech manufacturing firms and modelizing used partial least squares path.

Keywords: - environmental practice; manufacturing performance; PLS path modeling

1. Introduction

An increasing trend awareness of environmental impact as a result of economic activity has leading to greater political and social demands on manufacturing firm level to reduce their environmental impact [1]. Zilahy [2] and Stone [3][4] emphasizes the importance of social factors in the implementation of lower environmental impact projects and point out a number of inadequacies in the change of management processes for environmental practices impact on manufacturing firm level such as on-going improvement, leadership, support, achievement, communication involvement and program design. Many manufacturers have embraced this concept to improve product development, quality goals, eliminate waste and to enhance manufacturing performance. Lower the environmental impacts are enabled firms to benefit from its strengths to support environmental issues [5][6][7][8]. Apparently, the ability of an environmental practice is closely associated with completion of manufacturing firms. A substantial body of research has focused on the technology basis [9][10]. The limited understanding of environmental practice model has hampered the development of a widely accepted framework that would characterize and categorize environmental activities in manufacturing practices.

Previous studies on environmental management strategy has based on finding out competitive advantage or linking with their present total quality management program to argue that environmental practices may improve on their operational performance. For instance, Tseng et al. [8] indicate the positive relationships between cleaner production principles, continuous improvement and operational performance. Galdeano-Gomez et al. [11] results indicate a positive relationship between firm investment in environmental practices and productivity improvement, also showing the presence of positive environmental spillovers. Most of prior studies are unable to prove the key internal supportive factors are coordinated to each other and there is none further study to present a comprehensive framework to approach environmental practices. Furthermore, the linkage of a comprehensive model between environmental practices and manufacturing performance has not been thoroughly examined.

However, environmental practices is an overall strategic organizational approach to planning product/process design, top management support, production practices, organizational design for environmental practice and therefore affect on the manufacturing performance [12]. An important input from business executives and managers is knowledge of essential components of environmental practices and profound impact of those components on manufacturing performance. This way, emphasis is placed on those components that add value to the organization. In such intensive competitive environment, it is important to devote the firm's limited resources to creating value and to improving manufacturing performance and efficiency. The following research question is explored in this study:

- What are the components of environment practices?
- What effect do the critical components of environmental practices have on manufacturing performance?

To solve the stated research problem, partial least squares (PLS) path modeling is utilized in this study. When dealing with structural equation models, two important points should be analyzed in more depth. When building questionnaires for modeling studies many variables may be of interest but have to be abandoned because they are not continuous or Likert scale like variables. Another issue is the model building strategy; when many variables are involved, expert knowledge can be too weak to build a robust and well suited model. Furthermore when variables are of mixed type the usual approach can lead to poor results. This study thus presents an adapted version of PLS path modeling for different types of data (ordinal or nominal) called partial maximum likelihood, it is especially advantageous in the case of nominal or binary variables [13][14]. This study is based on statistical testing to build the structural model using the first component of the principal components analysis on each block of the model [14].

The paper proposes to examine the relationship between environmental practices and manufacturing performance using PLS. Therefore this paper makes two academicals contributions. First, it develops the theoretical basis for linking environmental practices to manufacturing performance. The theoretical development considers that the integration of the inadequacy key points such as organizational design (OD) for environmental practices; management driving force (MDF); environmental practices for manufacturing (EPM) ; life cycle assessment (LCA) for product/process design; and three Rs (TRs); of environmental practices into a framework. The second contribution consists in testing empirically the impact environmental practices on diverse dimensions of manufacturing performance. The rest of the paper consists five sections, after this introduction, the remainder of this study is structured as follows: section 2 discusses the research background; section 3 describes research method, section 4 the empirical approach to electronic industry in Taiwan. Finally, implications and conclusions are drawn in section 5.

2. Literature Review

The major benefits of environmental practices are general to research critical points, which pertain to environmentally aware consumers who are producing less waste by practicing; the “Three R’s” reduce, reuse, and recycle [15][16]. To achieve environmental practices, it is necessary to study the flow of energy and materials of each industrial firm. Under this approach, these flows are followed from their initial sources, through the environmental practices for manufacturing (input-transfer-output), to the consumer and to their ultimate disposal [17][18][19].

The ultimate disposal, the consumers are buying products that are less toxic or contain less packaging, using reusable containers and other reusable items, maintaining and repairing products, participating in recycling programs, and buying products made from recycled materials, produced with reduced emissions and materials consumption per unit of manufacturing or service output. The environmental practices discipline brings together the manufacturing performance, production, resource consumption and environmental damage aspects of an operation in a unique way. The environmental competencies are particularly valuable to the organization. Levitt [20] suggests that the goal of businesses is to “create and maintain customers.” In recent years, a study forecasts that for various reasons, and with relative clarity regarding the subject, companies have to implement a new trend - customer relationship management - as a factor that will allow them to survive in new market conditions such as environmental requirements, favoring the relationship with their customers [21][22].Close working relationships foster and deepen trust and cooperation and enable exchange business partners to address operational issues, among other things, early in the production process [23]. Establishing close relationships with a limited number of suppliers, when properly and selectively used, has been directly linked to customer focus and manufacturing performance [24].

The cooperative relationships with suppliers are importance to its purchasing function, and the recognition that a company needs to optimize its entire environmental practical plan, and their purchasing strategies should be aligned in support of the firm’s environmental practices [25][26]. The strategic purchasing contributes to effective environmental practices when it fosters a long-term strategic orientation between the firm and its supplier selection.

While top management support has generally been identified as a success key parameter, the nature of this impact needs to be analyzed in further detail in order to enhance our understanding of the phenomenon and draw useful implications for environmental practice researches and practices [27][28]. The environmental practices investment, strong top management commitment can lead to superior conversion effectiveness and improves manufacturing performance. Environmental practices may create sustained competitive advantage directly if the top management support is able to exploit unique environmental practices. There are few researches emphasizing top management that is significance to environmental practices literature [29][2][3][4]. One of the major functions of top management executives is to influence the setting of organizational values and develop suitable management styles to ensure that the environmental practices is on track.

Sharing information with suppliers through electronic data interchange is also a critical component of environmental practice [30][31][32]. IT also enhances environmental practices efficiency by providing real-time information regarding product availability, inventory level, shipment status, and production requirements to all suppliers. Yao et al. [33] presents electronically-enabled supply chains that offer the potential for reduced costs and higher sales. The study concludes with three major findings. First, top management support and external influences are both important determinants. Second, perceived benefits to customers, perceived benefits to suppliers, and perceived internally focused benefits are all found to positively influence the use of electronically-enabled system. Third, distributors or reverse logistics information is more likely to perceive greater customer benefits from the use of electronically-enabled system than are manufacturers and retailers. The indicators of this construct are revealed to denote the presence of electronic transactions, supplier management and manufacturing performance in various forms of environmental practices [34].

Moreover, life cycle assessment (LCA) considers the entire life cycle of the product design from extracting and processing raw materials, manufacturing, transportation and distribution to use, reuse, maintenance, recycling and final disposal [35]. LCA is a process used to analyze and assess the environmental impacts of a product, process or activity over its whole life cycle. In assessing environmental impacts of waste management, LCA helps expand the perspective beyond the waste management system [36][37][38]. The significance of this is illustrated primarily by the indirect environmental impacts caused by surrounding systems, such as energy and material production, which often override the direct impacts of the waste management system itself [39][40]. LCA integrates the four stages with regard to the framework of product and process design.Business environmental practices has evolved with influences from reactive and proactive activities and policies set forth by organization [41][42][43][44][45][46]. The environmental practices required top management leadership and commitment, promotes the participation of employees, and strategic plan with customer focus in company-wide implementation. Organizing is regarded as an important instrument for development regarded as an important instrument for developing better and environmentally compatible products at lower costs. Dale and Lascelles [47] specific on the variety of starting points and motivations for continuous improvement, it is impossible to identify a unique environmental implementation plan detailed clarifying the order in which particular system and technologies should be used [48][49]. Environmental technologies is even used as a green slogan associated to products or processes which are supposedly environmentally friendly, for example by avoiding the use of specific toxic chemicals. It should promote the link between firms, dealing with final products and waste recycling/reusing in a cooperative attempt to improve environmental efficiency. This kind of improvement can be achieved through direct transfer of advanced technology. However, Bunney and Dale [50] emphases that they should be selectively used according to the different stages of quality management in an organization [51].

The assessment of Henderson [52] can make comprehensive, systematic and regular views of an organization's activities that ultimately result in planned improvement actions. The assessment process helps organizations identify their strengths and shortcoming and best practices. With the common organizational direction and an increased consistency of purpose, moreover, it can provide organizations with opportunities to build greater unity in pursuit of initiatives that effect improvement [53]. In other words, assessments are a means that help analyze organizations' status quo in implementing the environmental practices and in achieving their strategic objectives. Many researchers and practitioners believe that few well-defined assessment and feedback system can help develop specific measure to system and technologies toward manufacturing policies excellence. The feedback loops takes place both at the level of a social process and the level of commitment development and an expanding number of stakeholders as well as at the level optimizing cleaner production approaches [54][2].

Training is another issue that provides employees with the knowledge and skills to meet their overall environmental activities and personal objectives. If carried out consistently and reinforced in the workplace through updated skills and environmental protection education needed, training can form a solid base for continuous improvement [55]. Training and people are defined as those factors characteristic to a particular enterprise, which influence the level of implementation of preventive environmental options. These factors are critical for environmental practices since these two advocates a total commitment to customer satisfaction through continuous improvement and environmental policy in all aspects of the business [56]. Kirkwood [57] and Camisón [58] advocate that the actions for adoption of training and people towards environmental protection and total quality can be arranged into technological aspects and intangible aspects. The technological aspect involves production tools and techniques, while the intangible aspect is concerned with behavioral rules, management style, organizational and communication structures. The change should be planned and carried out in a consistent and incremental manner.

Cox and Blackstone [59] stated that "To be most effective, the manufacturing should act in support of the overall strategic directions of the business and provide for its performance". A common success theme of operations strategy is picked up the manufacturers' choices of emphasis among key capabilities. The literatures suggest four manufacturing performance: cost, quality, delivery, and flexibility to be attended [60][61][62]. Manufacturing performance guided the choice and development of competitive priorities and specifies how the operations function provides a firm with its strategy in the future marketplace or tactical goal of the operational functions [63][64].

Previous discussion within the context of environmental related issues have focused on forming an overview of manufacturing performance to be obtained through management driving force (MDF), life cycle assessment (LCA) (product/ process design), three Rs (TRs), environmental practices for manufacturing (EPM) and organizational design (OD) in order to lower the environmental damage and improve manufacturing performance of the firms operation.

These critical components will be briefly defined in the next sections. As we noted before, one of primary focuses of this study is to test the associate of the critical components of environment practices to each other and their influences on manufacturing performance in uncertainty. Such relationships in uncertainty are therefore examined through the use of PLS approach. Taiwan high tech manufacturing firms are selected for the purpose of this study.

3. Research Method

This section details the steps in operationalizing environmental practices components from previous literature review. Following Churchill's [65] paradigm for construct development and measurement, this study first conceptualize the construct of environmental practices model and then operationalize it by developing 30 item measurements to evaluate the different facets of environmental practices components with regard to Taiwanese high-tech manufacturers. Thereby the survey instrument, usually, many social science problems which are nominal, ordinal, and possible actions, the PLS is the suitable modeling method in this study.

3.1 Research variable and constructs

The previous discussions within the context of environmental practices have focused on some critical lacking components. The literature review and the inputs from industry and academia are integrated to compose the conceptual framework which illustrates a summary of possible relationships linked by arrows. This conceptual framework (see Fig. 1) consists of five components in terms of environmental practices affecting manufacturing performances, including: OD for environmental practices; MDF; EPM; LCA and TRs. In the case of manufacturing firms in Taiwan, EPM and TRs are viewed as the major spirit of firms for environmental practices involved in a reverse logistics process. This conceptual framework for environmental practices and manufacturing performances also emphasizes on OD, MDF and LCA to support and smoothly run the whole manufacturing in terms of environmental practices in order to make better manufacturing performances. The research constructs and variables are described as follows:

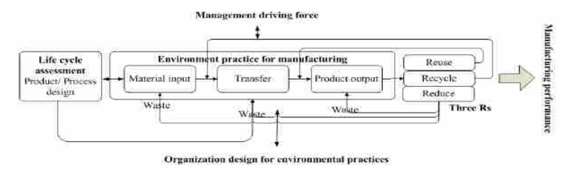

Figure 1. The conceptual framework

OD: according to Tseng et al. [66], organizational design is defined as the characteristic to a particular enterprise which influences the level of implementation of preventive environmental options. Organizational design is regarded as an important instrument for development is regarded as an important instrument for developing better and environmentally compatible products at lower costs. Organizational design include the size and situation of the company, its industrial sector, the available infrastructure (including the type and state of the equipment used and other characteristics of its infrastructural environment) especially, education and training is of consideration that provides employees with the knowledge and skills to meet their overall work and personal objective [54][55][56]. The pollution prevention has proven to be a valuable concept, because prime focus on material flows and the emphasis on minimization of environmental effects. It leads to improvements in efficiency and reductions in waste and emissions.

MDF: this construct uses Tseng et al. [8] and Tseng et al. [66] studies for measuring the leadership, customer focus, continuous improvement and strategic plan are interacted with environmental practices, the management commitment is also significant in the company organizing level. Strategic planning functions as a vehicle to integrate quality requirements with business activities of an organization so that environmental policy is reflected in its corporate vision, mission and strategy statements. Information technology can enhances environmental practices efficiency by providing real-time information regarding to all management and production information [41][42][43][44][45].

EPM: the construct is referred from [67]. The Production processes need to use energy and resources efficiently in order to eliminate toxic raw materials, and to reduce both the amount and toxicity of all emissions and wastes before they leave the production process, thus, production technology improvement or the adoption of new environmental technology help to increase environmental protection. For products themselves means reducing the products' environmental impact throughout their entire life cycle, from raw material extraction to ultimate disposal. The process analysis, monitoring and improvement is helping the organizations evaluate the achievements of predicted results and monitor continuous improvement efforts moving to the right direction. However, the firms should develop their total quality management philosophy, environmental policy, procedures and objectives, simultaneously [41][49].

LCA: LCA is a process to analyze and assess the environmental impacts of a product, process or activity over its whole life cycle. It has been successfully utilized in the field of solid waste management to assess environmental impacts. LCA is a methodology considering the entire life cycle of products and services-from cradle to grave (from raw material acquisition through production, use, and disposal).It is thus a holistic assessment methodology of products and services. LCA has been proven to be a valuable tool to document the environmental considerations that need to be part of decision making towards sustainability [67]. LCA considered the entire life cycle of the product: extracting and processing raw materials; manufacturing, transportation and distribution; use, re-use, maintenance; recycling and final disposal [35].

TRs: recycling is just one way to reduce wastes. To be really effective, this study has to incorporate the 3Rs Reduce, Reuse, and Recycle into our daily production routine. Reducing the amount of waste production produce is by far the most effective way to battle the flow of garbage into the landfill. Source reduction actually prevents the generation of waste in the first place, so it is the most preferred method of waste management and goes a long way toward protecting the environment. Reusing products, when possible, is even better than recycling because the item does not need to be reprocessed before it can be used again. Recycling turns materials that would otherwise become waste into valuable resources. In addition, it generates a host of environmental, financial, and social benefits. Materials like glass, metal, plastics, and paper are collected, separated and sent to facilities that can process them into new materials or products [67].

MP: MP was investigated using the suggestions originally from Hayes and Wheelwright [61]. The components are as following: Low-price products are typically commodity products, of which customers cannot distinguish the products of one firm from those of another in terms of functionality and styling [68]. Product quality is a critical competitive capability for satisfying customer requirements. Delivery emphases on customer service as indicated by either delivery reliability or delivery speed. Delivery speed is critical to react quickly to customer orders [69]. It is also ability to deliver products quicker than competitors is critical [70]. Flexibility is a complex and multi-dimensional capability that requires a company-wide effort to increase a firm's responsiveness and reduce waste and delays [71][72].

3.2 Research hypotheses

As noted earlier, environmental practices takes the form of joint planning and decision making regarding environmental issues, which is consistent with examples and cases presented in the prior literatures [73][74][75]. A general form of practices, not necessarily associated with the environmental aspects of operations management, is found to be positively linked to the selection of pollution prevention technologies, which usually generate benefits in terms of cost and quality [76][77]. The manufacturing performance generated by environmental practices is twofold. First, environmental practices include knowledge integration and cooperation between organizations, which are recognized as OD and LCA that might generate manufacturing performance [78][79]. As such, manufacturing organizations adopting environmental practical activities with their downstream and upstream can be developed a proper OD [80], which can be expected to translate not only into improved environmental performance, but also into three Rs concept. The cases evidence supports the linkage to improved productivity [73], while limited surveys have revealed improved product quality and manufacturing performance. Second, environmental practices is directly associated with a proactive manufacturing management orientation [81].

Therefore, this study examines four widely accepted manufacturing performance indicators: cost, quality, delivery, and flexibility. This study aims to explore relationships between environmental practices and manufacturing performance. Based on the literatures, the conceptual framework presented in Fig. 1, research hypotheses are developed for the exploration of relationships between such constructs (latent variables): OD, MDF, LCA, EPM, TRs, and MP. The series of hypotheses are developed and tested in this paper.

The first of hypothesis relates to the interrelationships between environmental practices components (environmental practices for manufacturing; Management driving force; Life cycle assessment; and Organizational design). Dale and Lascelles [47], Miettinen and Hama1ainen [35], Palmer and Griffith [32], Cousins [26], Ragatz et al. [23], Christiaanse and Kumar [34], Sousa [22], Kirkwood [57], Giannetti et al. [17], Zilahy [2], Stone [3][4], Eriksson et al. [40], Tseng et al. [66], have consistently argued that environmental practices are more than just making some routine practices. There are many components that must be combined to form a complete practical model. Based on the literature, this research generates the following hypothesis:

H1: All environmental practices components are (OD, MDF, LCA, EPM, and TRs) positively supported to each other.

Furthermore, environmental practices has to be involved in top down operation decisions, therefore, once manufacturing performance to be prioritized, it becomes the basis for making operational decision as the goal of operational function in marketplace [24][59][64]. And understanding of the dynamics of environmental practices has the greatest effect on manufacturing performance [82]. The second hypothesis is as follows:

H2: All environmental practices components are (OD, MDF, LCA, EPM, and TRs) positively influenced the manufacturing performance.

3 Measuring item and instrument

Prior to data collection, the survey instrument was pre-tested for content validity in two stages. In the first stage, six experienced researchers were asked to review the questionnaire for the ambiguity, clarity and appropriateness of measuring items used to measure each construct. Based on the obtained feedback, the instrument was modified to enhance clarity and appropriateness of the measures purporting to tap the constructs. In the second stage, the survey instrument was mailed to five management executives affiliated with electronic manufacturing firms. These executives were asked to review the questionnaire for structure, readability, ambiguity and completeness. The final survey instrument incorporated feedback received from these executives, which enhanced the comprehensibility of the instruments. This process yielded a survey instrument that was judged to exhibit high content validity. Then, this survey instrument was distributed to the target respondents. Related constructs and measuring items are as shown in Appendix.

4. Empirical Analysis

4.1 Sample and survey

Samples for the study were collected from 690 Taiwanese high-tech companies. Using simple random sampling method (α=0.05), questionnaires, along with a cover letter and pre-paid reply envelope were mailed to 690 subject companies. Various efforts were employed, i.e. telephone follow-up and personal communication, to encourage respondents to complete and return the questionnaires. A total of 676 responses were obtained during the four month period following the distribution of the questionnaires. Discounting the number of invalid questionnaires, 616 valid questionnaires with an effective return rate of approximately 91% that meeting an acceptable response rate.

For this study, this paper adopts the favorable software named “Smart PLS” [83] to perform data analyses with the PLS path modeling. The PLS path modeling and the covariance structure analysis known as LISREL (Linear Structural Relations) or SEM (Structural Equation Models) are two main approaches to modeling relationships between latent variables [84][85]. Unlike the LISREL with a homogeneity assumption of the observed population, the PLS path modeling is more suitable to be applied in real world applications. In particular, it is better to employ the PLS path odeling when models are complex [86][87]. Using the PLS path modeling requires a minimum sample size of 30 [88]. This study with a sample size of 616 meets this requirement.

The PLS handles two models meanwhile: (1) a measurement model called the outer model relating the MVs (Manifest Variables) to their own LVs (Latent Variables) and (2) a structural model called the inner model relating some endogenous LVs to other LVs. The measurement model is tested by the reliability and validity analyses, and the structural model is tested by path coefficients between constructs in the model [89]. In this study, the MVs in each outer model are such as: EPM 1 through EPM 4 for EPM; TR1 through TR6 for TRs, MDF1 through MDF5 for MDF, LCA1 through LCA4 for LCA, OD 1 through OD4 for OD, and MP1 through MP7 for MP. Moreover, there are six LVs in the inner model including OD, MDF, LCA, EPM, TRs, and MP. The following sections are the testing of hypotheses in this study.

4.2 Convergent reliability and validity

According to [90], it is acceptable that the CR (Composite Reliability) value is higher than 0.7 while the AVE (Average Variance Extracted) value is higher than 0.5. As shown in Table 1, the values of CR are all higher than 0.7 and the values of AVE are all higher than 0.5. This means the study reach satisfied convergent reliability and validity.

Table 1 Convergent reliability and validity

	AVE	Composite Reliability	R Square	Cronbachs Alpha	Communality	Redundancy
EPM	0.682	0.810	0.108	0.538	0.682	0.072
LCA	0.722	0.838	0.115	0.614	0.722	0.084
MDF	0.723	0.839	0.181	0.619	0.723	0.130
MP	0.565	0.794	0.248	0.613	0.565	0.140
OD	0.506	0.803		0.676	0.506	
TRs	0.540	0.772	0.435	0.600	0.540	0.176

4.3 Path coefficients and predictive ability

Regarding the best contributors to constructs in this model, see Fig. 2, for EPM is the EPM 2 (Support with Benchmarking and Monitoring all over the time) of 0.878, for TRs is the TR3 (Recyclable materials) of 0.919, for MDF is the MDF2 (Gathering customer information and needs regularly) of 0.879, for LCA is the LCA3 (Emphasis upstream raw materials in environmental LCA concept) of 0.885, for OD is the OD4 (Training and people, Lower frequency of environmental accident) of 0.778, and for MP is the MP5 (increase goods delivery on time rate) of 0.818. Table 2 merely shows that item loadings are significant.

Table 4 merely shows that path coefficients are significant between constructs in the model. Especially, the path coefficient "EPM → TRs" with 0.499 has the greatest positive direct effect, followed by "OD → MP" with 0.498. As for the R^2 value of endogenous constructs (see Table 1 or Fig. 2), the "TRs" has the best ability to explain 43.5% in this model. On the whole, the combination of OD, MDF, LCA, EPM, and TRs has the predictive ability for 24.9% of the "MP".

Table 2 Item loadings

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
EPM 2 <- EPM	0.675	0.663	0.074	0.074	9.149
EPM 4 <- EPM	0.530	0.534	0.077	0.077	6.851
LCA 3 <- LCA	0.602	0.606	0.075	0.075	7.984
LCA 4 <- LCA	0.575	0.569	0.076	0.076	7.549
MDF 2 <- MDF	0.639	0.624	0.117	0.117	5.450
MDF 4 <- MDF	0.535	0.538	0.095	0.095	5.649
MP 1 <- MP	0.363	0.372	0.127	0.127	2.857
MP 4 <- MP	0.473	0.461	0.119	0.119	3.966
MP 5 <- MP	0.485	0.467	0.101	0.101	4.778
OD 1 <- OD	0.314	0.303	0.085	0.085	3.677
OD 2 <- OD	0.325	0.327	0.069	0.069	4.726
OD 3 <- OD	0.317	0.309	0.077	0.077	4.119
OD 4 <- OD	0.440	0.461	0.090	0.090	4.882
TRs 3 <- TRs	0.703	0.701	0.075	0.075	9.416
TRs 5 <- TRs	0.298	0.295	0.065	0.065	4.560
TRs 6 <- TRs	0.273	0.266	0.079	0.079	3.445

Table 4 Path coefficients

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
EPM -> TRs	0.499	0.495	0.079	0.079	6.343
LCA -> TRs	0.253	0.267	0.080	0.080	3.161
OD -> EPM	0.329	0.336	0.085	0.085	3.888
OD -> LCA	0.340	0.362	0.098	0.098	3.469
OD -> MDF	0.426	0.442	0.076	0.076	5.614
OD -> MP	0.498	0.477	0.110	0.110	4.542

Although the predictive ability of 24.9% was not so high, the analysis results using PLS path modeling confirmed certain relations between environmental practices and the manufacturing performance. Thus, the research hypothesis H1 (All OD, MDF, LCA, EPM, and TRs positively support each other) is supported by the data, while the research hypothesis H2 (All OD, MDF, LCA, EPM, and TRs positively influence the manufacturing performance) is not supported. The study results indicated that only OD has positive influence on MP.

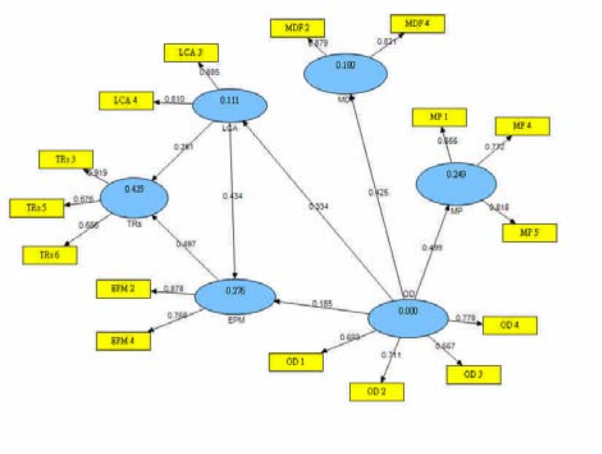

Figure 2 Relations between constructs

5. Discussions and Conclusions

5.1 Discussions

Empirically, the results are also consistent with a recent study that linked firm's environmental activities to environmental performance and enhance competitiveness. For example, Rao [91] found a significant and positive relationship between the degree of dissemination of environmental knowledge by downstream organizations and these organizations' environmental performance. Another study found a positive link between green supply chain practices (including a mix of practices and monitoring activities) and both environmental and economic performance [92]. Furthermore, considering that environmental performance, as one component of operational performance, ultimately has repercussions for financial performance [93], the results here also enrich our understanding of how different aspects of environmental practices affect operational performance.

This study focused on the impact of environmental practices on manufacturing performance. An environmental practice was defined as the interaction between organizations components pertaining to joint environmental planning and shared environmental know-how or knowledge. As such, any monitoring or control elements usually include in manufacturing process. This way, environmental practices was predominantly linked to superior delivery and cost reduction performance. Hence, upstream environmental practices are essentially linked to manufacturing process-based performance in the form waste treatment fees and reliable deliveries. In contrast, downstream practices were associated with product based performance in the form of conformance to specifications and durability. The studied industry is to assure the quality of inputs from upstream used in the production process. Therefore, environmental practices with upstream can easily be predisposed to integrate product-based quality and environmental issues explaining the results of this paper that the quality is not in the model. On the other hand, downstream wants quality inputs because defective or sub-par inputs will ultimately be reflected in their own product quality and in other performance dimensions such as cost and delivery. Most likely, OD, being a form of proactive key factor environmental practices to manufacturing performance, it links with MDF, LCA and EPM, and also play as critical factor linked to manufacturing performance. The dichotomy observed regarding the impact of upstream and downstream practices on different manufacturing performance variables is important for future research in the supply chain field. First, many studies in recent years combined upstream and downstream activities in one unified construct [92][94]. While conceptually correct, this approach can hide some important research contributions as suggested by the results of this paper. One important organizational characteristic, the capacity of an OD to absorb knowledge transfers, could have furthered our understanding of the practices–performance relationship but was outside the scope of this paper. In fact, greater absorptive capacity helps organizations to cultivate and transform knowledge acquired in the environmental practices more effectively. Hence, it can be expected that an OD capacity will moderate the practices–performance relationship. Finally, the results provide support to the proposition that an organization with proactive environmental management will develop innovative solutions to environmental challenges, which in turn leads to improvement in other facets of the organization's operations [95].

Practically, manufacturers should strive to improve on multiple constructs of environmental practices model to arrive at the full realization of benefits, which may improve environmental image and thus, possibly, economic benefits. The contribution of this research is to build up the theoretical model of environmental practices towards sustainable organization and the researchers and practitioners are paying increasing attention to the phenomenon of social responsibility. This study takes a step in that direction by clarifying, organizing and integrating terms and concepts relevant to both of economics and ecological aspects in the firm's processes and conducting an empirical investigation of this causality. Despite the fact that this study is the first largest and comprehensive in the empirical study, it does suffer from limitations, and these give rise to a number of suggestions for the future study.

5.2 Theoretical implications

While it is important to consider these findings against the backdrop of earlier empirical work, assessing theoretical implications ultimately lays the groundwork for systematic improvements in environmental practice and future research.

Environmental practices are a complex con-current encountering situation. This study presents numerous interactions within organizational designs and to manufacturing performance. For the environmental practices requires organizations' strategic objective, training to all employees and to manufacturing performance. More specifically, two direct outcomes of environmental practices are the development of well organizing organization and the development of the capabilities to integrate internal coordination [96]. Such an environmental practices lead to a competitive advantage [66][80]. Environmental practices can initiate or prompt the development of capabilities for integration of internal and external know-how and technologies. These tacit capabilities, as it expands and deepens, can build more competitive advantage that is difficult to replicate, leading in turn to a competitive advantage consistent with its internal components. This internal control proposes that organizations operate within a organization of interdependent relationships developed and fostered through strategic-level components interaction. The primary emphasis of the research related to the relational view focuses on internal components activities pertaining to manufacturing performance. For example, information sharing and integration improve manufacturing efficiency through lower costs and better delivery performance [96]. Similarly, a product/ process LCA design was positively linked to strategic-level integration [97]. All of these internal components are primarily associated with what could be viewed as "core" operations or products. However, the research conducted within the relational paradigm is rather silent on historically non-core manufacturing activities such as those related to the natural environment. However, environmental issues increasingly cannot be managed in isolation from manufacturing activities; in fact, manufacturing is linked to environment related practical management within plants [76][98]. Thus, not only must upstream and downstream relationships evolve and mature through time [99], but as these relationships develop, environmental practices can also form one component. One theoretical framework under which the boundaries of the relational paradigm might be enlarged is to consider environmental practices components within the broader context of sustainable development [100]. Together, this study's results have direct implications for practice. Environmental practices with upstream and downstream contributed to a relatively broad range of competitive benefits. Practices with suppliers on environmental issues was linked to five study components and manufacturing performance—cost and delivery. In contrast, the quality performance is insignificant in manufacturing's primary strategic thrust, due to the highly automated manufacturing design, the quality problem is well handled by the management team, and therefore they didn't emphasis on manufacturing performance.

5.3 Limitations

While studying a single industry, it allows for greater control over contextual and operational factors. However, it is not without its drawbacks. First, using a single industry in the electronic manufacturing allowed greater specificity in detailing and surveying the types of integration components underway, but potentially limits external generalizability. Future research would benefit from expanding this investigation across multiple industries approaches. This study is unable to test and account for the cross sectional study, for the lags between the existence of practices and performance, for the lack of follow through on the progress of particular firms in our study; all of which is a limitation of all such studies.

A second limitation of the design of this study is the fact that it used only one respondent, which might potentially create grounds for bias. Second, any potential bias introduced by the single respondent cannot be explicitly ruled out; however, earlier research suggests no major concerns [101], and careful targeting of a knowledgeable respondent can assist in overcoming potential problems with common method variance [102].

5.4 Future study

There exists a wide scope for future research on the instrumentation issues of this environmental practices model implementation. The validation of this scale is an ongoing process. And, validity is established only over a series of studies that further refine and test the measurement constructs across manufacturers and countries. Development of valid and reliable measurement items will only be accomplished through the use and refinement of the measurement scale in subsequent studies. These measurements can evolve and progress into many new areas supporting the construction and confirmation of theories. However, the authors were suggesting that this environmental practices model might apply to the respondents for multi-attribute utility analysis [96] for the utility functions of all constructs in future study. The bias computation can be resolved by the fuzzy set theory. However, the computation is quite complicated needed to be computed step by steps. Although the internal validity of our research variables is acceptable, the research is of a purely single industrial snapshot, the future study might include cross industries study.

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Appendix Constructs and measuring items

EPM 1	Be relevant and meaningful in terms of environmental protection
EPM 2	Support with Benchmarking and Monitoring all over the time
EPM 3	Production Process should be clearly defined, measurable, transparent and verifiable
EPM 4	Recognize relevant issues related to upstream and downstream of company's activities
TRs 1	Reuse (Water reduction)
TRs 2	Reuse (Solid waste management)
TRs 3	Recycle (Recyclable materials from production)
TRs 4	Recycle (Recyclable water, papers from operations)
TRs 5	Reduce (Air emissions)
TRs 6	Reduce (Waste prevention from operation site)
MDF 1	Customer focus (Cooperate with Green labeling, cleaner production)
MDF 2	Customer focus (Gathering customer information and needs regularly)
MDF 3	Strategic purchasing (ISO 14000, Green labeling products)
MDF 4	Top management support (All environmental objectives)
MDF 5	Information technology (Waste prevention)
LCA 1	Involve product design in environmental LCA concept
LCA 2	Involve process design in environmental LCA concept
LCA 3	Emphasis upstream raw materials in environmental LCA concept
LCA 4	Apply in environmental LCA concept in downstream of your industry
OD 1	Organizing (A team for environmental objective)
OD 2	System and technologies (Decrease consumption for hazardous and toxic materials)
OD 3	Assessment and feedback (For further improvement in organizational design)
OD 4	Training and people (Lower frequency of environmental accident)

MP 1	Cost reduction (energy consumption, decrease fine of environmental accident etc.)
MP 2	Cost reduction (material purchasing)
MP 3	Quality improvement (Lower scrap rate)
MP 4	Delivery (Decrease waste treatment fee)
MP 5	Delivery (increase goods delivery on time rate)
MP 6	Flexibility improvement (Capacity utilization)
MP 7	Flexibility improvement (increase product line)