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THE IMPACT OF SUSTAINABLE MANUFACTURING PRACTICES ON SUSTAINABILITY

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Graphical abstract

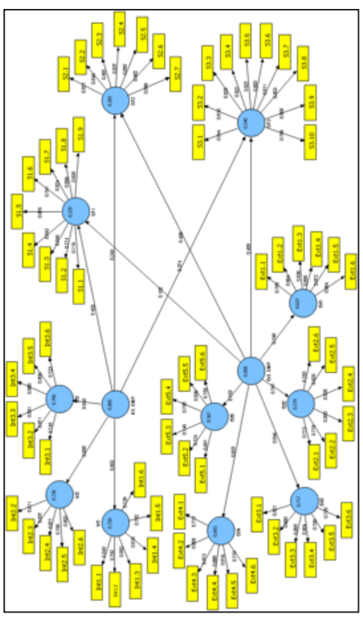

Figure 2 Hypothesized structural and measurement models

Abstract

This study aims to empirically investigate the impact of sustainable manufacturing practices (SMP) on sustainability performance (SP) among manufacturing firms in Malaysia. Drawing from the theoretical lenses of stakeholder theory, the present study advocates the three pillars of sustainability, encompassing economic, environmental, and social sustainability, in measuring firm performance. Using PLS-SEM approach, the survey data collected from 150 firms were analyzed. The findings reveal that both underlying variables of SMP, internal SMP and external SMP, have positive and significant impact on environmental and social sustainability. Surprisingly, while internal SMP proof the significant positive influence on economic sustainability, external SMP failed to do so. Theoretically, the study contributes to the sustainable manufacturing literature by demonstrating the relationship between SMP and sustainability performance (SP). Practically, the study is beneficial for practitioners in understanding the diverse aspects of SMP and SP, identifies the strengths and weaknesses of their current SMP, and provides a guideline in improving their performance.

Keywords: Resource based view, sustainable manufacturing practices, sustainability performance

Abstrak

Kajian ini bertujuan untuk menyiasat secara empirik kesan amalan pembuatan mampan (SMP) terhadap prestasi kemampanan di kalangan firma pembuatan di Malaysia. Berdasarkan kepada teori pihak berkepentingan, kajian ini menyokong tiga tunggak kemampanan, merangkumi kemampanan ekonomi, alam sekitar, dan sosial, dalam mengukur prestasi firma. Dengan menggunakan pendekatan PLS-SEM, data kajian yang dikumpul daripada 150 firma telah dianalisis. Dapatan kajian mendapati kedua-dua komponen yang mengukur SMP, SMP dalaman dan SMP luaran, mempunyai kesan positif dan signifikan terhadap kemampanan alam sekitar dan sosial. Sebaliknya, walaupun SMP dalaman berjaya membuktikan pengaruh positif yang signifikan ke atas kemampanan ekonomi, SMP luaran gagal untuk berbuat demikian. Secara teorinya, kajian ini menyumbang kepada pengembangan ilmu berkaitan dengan pembuatan mampan dengan menunjukkan hubungan antara SMP dan prestasi kemampanan (SP). Secara praktikal, kajian ini adalah bermanfaat kepada pengamal industri dalam memahami pelbagai aspek SMP dan SP, mengenal pasti kekuatan dan kelemahan SMP semasa mereka, dan menyediakan satu garis panduan dalam meningkatkan prestasi mereka.

Kata kunci: Pandangan berasaskan sumber, amalan pembuatan mampan, prestasi kemampanan

1.0 INTRODUCTION

Since the last decades, business environment has been dramatically changed. A great deal of attention has been given to the notion of sustainability due to some controversial issues such as increasing scarcity of natural resources, rapid global environment degradation, and human beings pursuing higher life quality. Conflicts have emerged between the economic outcomes that could induce industrialization, and serious unfavorable effects deriving from destruction of natural resources and severe pollution. For example, while demonstrating impressive industrial development since the 1980's as a result of economic reform, People's Republic of China (PRC), the world's second largest economy with a nominal Gross Domestic Product (GDP) of US$8,229.4 billion in 2012, has been the biggest emitter of carbon dioxide (CO_2) in the world since 2007 with 5.13 tons per capita of CO_2 emission, representing almost 24 per cent of global emissions, in 2009 [1,2]. Surprisingly, Malaysia which took decisive steps to transform their economic orientation, from an economy dependent on agriculture and primary commodities to a manufacturing based, export-driven economy spurred on by high technology, knowledge-based and capital-intensive industries for over years, has released more than 0.85 tons per capita CO_2 emissions of which was recorded by the PRC in 2009 even though the GDP has declined by 1.6 [2,3]. Unfortunately, it is expected that the level of CO_2 and other greenhouse gases such as nitrous oxide, methane and a number of gases that generate from industrial processes is growing [4].

While producing a variety of products for promoting economic development as well as improving social well-being, manufacturing itself is the focal source of natural resources utilization with toxic byproducts and wastes [5,6]. As revealed by United States (US) Environmental Protection Agency (EPA), US has created approximately 12 billion tons of industrial wastes per annum with over one third of them are hazardous [6]. In addition, a number of raw materials and energy resources consumed in manufacturing industries are non-renewable and often, toxic pollution is directly discharged to the atmosphere and waste is disposed of arbitrarily [7]. Generating from human activities such as acquisition of materials, products manufacturing, product use and end-of-life disposal, toxic emissions has given a major risk to human health and the ecosystem. For instance, dipheny polybrominated ethers, widely used as flame-retardants in various consumer products including furniture, electrical appliances, and carpets, have been linked with brain and thyroid problems [8]. Responding to these matters, a question emerges whether continued economic growth as well as expansion of manufacturing activities in the current practices would be sustainable in the long term.

Aiming to achieve economic benefits without dismissing the environmental integrity and social equity that provides the quality of life for all stakeholders in the present and future, it is suggested that manufacturers need to concurrently integrate the three pillars of sustainability pertaining to the economic, environmental, and social aspects into their operational and business activities (which is refer to the Sustainable Manufacturing Practice or SMP)[9,10]. While there are a number of research on Sustainable Manufacturing (SM) strategies, there are still some gaps that need to be further explored. Acknowledging the important of sustainable practices, majority of the discussion in the literature tend to focus on ecological aspects of sustainability while relatively limited consideration given to the social parameter [11,12]. Inconsistent results regarding the significant role of SMP on improving Sustainability Performance (SP) raises an ongoing debate. Some studies have found a positive relationship between SMP and SP [9,13], while others found no relationship at all [10,14]. It seems that there are some limitations of the previous studies which may influence the findings. Since it is context dependent, the research is performed to achieve underlined objective. The statistical connection between SMP and SP needs to be explained. Accordingly, this paper aims to analyze empirically the causal link of SMP on creating better sustainability performance in the wider perspective encompassing economic, environmental, and social dimensions.

In the next section, a review of the related literature is presented followed by an explanation of the research methods in Section 3. The results of the study is presented and further discussed in subsequent section. The paper concludes with implication and recommendation for expending the scope of the study for future research.

2.0 LITERATURE REVIEW

2.1 Sustainability and Sustainable Manufacturing (SM)

While they are progressively discussed in the literature, there is no commonly accepted definition of the concepts of sustainability and SM [6,15]. Historically, the concept of sustainability has emerged in the 1970's when the issue of business ethics was under debate [16,17]. Responding to the global issues of inequality, resource distribution and population impacts, World Commission on Environment and Development proposed a new concept called sustainable development in 1987 which is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs[18]. Although this definition is quite general, it is the most extensively adopted definition to describe sustainability and sustainable development in various contexts.

Previously, some researchers portrayed SM as production methods or technologies that simultaneously focus on improving economic and environmental performance. For instance, Madu defined SM as means for manufacturers to add the most value to their products and services by making the most efficient use of the earth's limited resources, generating the least pollution to the environment, and targeting for environmentally clean production systems [19]. Allwood described SM as developing technologies to transform materials without emission of greenhouse gases, use of non-renewable or toxic materials or generation of waste [20]. Expanding the aims of production activities, US Department of Commerce viewed SM as the creation of manufactured products that use processes that are non-polluting, conserve energy and natural resources, and are economically sound and safe for employees, communities, and consumers [21]. Pursuing economic and environmental improvements as well as promoting and supporting social well-being in the broader perspective, this study defines SM as a firm's intra- and inter-organizational practices that integrate environmental, economic and social aspects into operational and business activities.

2.1 Sustainable Manufacturing Practices (SMP)

Adapting to the changing conditions over years, the evolution of sustainability and SM concepts has given rise to a series of sustainable practices in manufacturing industries, from the application of technology for pollution control and treatment to more integrated systems of production which promote cross functional relationships among the organizational members as well as inter-organizational collaborations [15]. Instead of standalone approaches, the development of SMP also can be explained based on the integration of the three levels, encompassing product, process and system [22]. Changing paradigm from open-loop system (single life cycle) to closed-loop system (multiple life cycles), traditional 3R concept (*reduce, reuse, recycle*) has been transformed to a more sustainable 6R approach (*reduce, reuse, recycle, recover, redesign, remanufacture*) in the product level [22]. Whereas various efforts have been taken in the process level on optimizing technological improvements and process planning for reducing resource consumption, waste generation and occupational hazards as well as improving product life, the context of the system was expanded from organizational itself to a broader supply chain and industrial link [22,23].

Considering various practices for pursuing diverse objectives and goals, SMP can be differentiated into two types based on the orientation of sustainable thinking, namely internal SMP and external SMP. Internal SMP refers to the sustainable practices within a firm's level such as cleaner production, eco-efficiency and employee relation. External SMP focuses on the inter-organizational practices within the value system and beyond the chain of production to improve economic, environmental and social sustainability simultaneously such as supplier relation, customer relation, community relation, industrial relation and close-loop production. The definition of the entire practices is presented in Table 1.

Table 1 Definition of practices

Practice	Definition
Internal SMP:	
Cleaner production	Preventing pollution at source (in the product and the manufacturing processes) rather than remove it after it was created
Eco-efficiency	Producing more products with simultaneously minimizing resource intensity and reducing ecological impact
Employee Relation	Implements a set of plans/ programs to improve employees' well being
External SMP:	
Supplier relation	Monitors and collaborates with suppliers to improve suppliers performance
Customer Relation	Manages customers to improve customers' well being
Community relation	Implements a set of plans/ programs to improve communal performance
Closed-loop production	Closing the material cycle in order to achieve greater sustainable in managing the supply chain
Industrial Relation	Collaborates with neighborhood organizations to improve environmental and social performance

2.3 SMP and Sustainability Performance (SP)

Resource-Based View (RBV) of a firm suggested that appropriate management of unique resources and capabilities would create competitive advantage and thus lead to superior performance [24]. SMP represent competence-based view which deals with a collection of resources within and outside of the organization to develop products and processes for long term sustainability. Such environmental friendly and socially responsible practices would be source of competitive advantage that leads to increase firm performance. As highlighted in stakeholder theory, firms need to serve the interests of diverse stakeholders, defined as individuals or groups who could affect or be affected directly or indirectly by a firm in achieving its goals, either harmed by or benefited from the corporate activities, or whose rights can be violated or have to be respected by the firm [25,26], and deals the relationships with them both in terms of the process and the outcome [27,28,29]. Advocating stakeholder perspective, Elkington [30] proposed Triple Bottom Line (TBL) approach, suggesting that organizational performance should be measured based on the aspects of economic, environment and social. TBL assumed that organizational sustainability only can be achieved when there is a balanced attention to the economic, environmental and social elements of the system [11,31]. A number of studies have acknowledged SMP as sources of economic, environmental, and social sustainability [9,13].

Drawing mainly from the theories of RBV and stakeholder, strengthened by both conceptual and empirical research on sustainability and SM, a theoretical framework addressing the relationships between SMP and SP is developed as depicted in Figure 1.

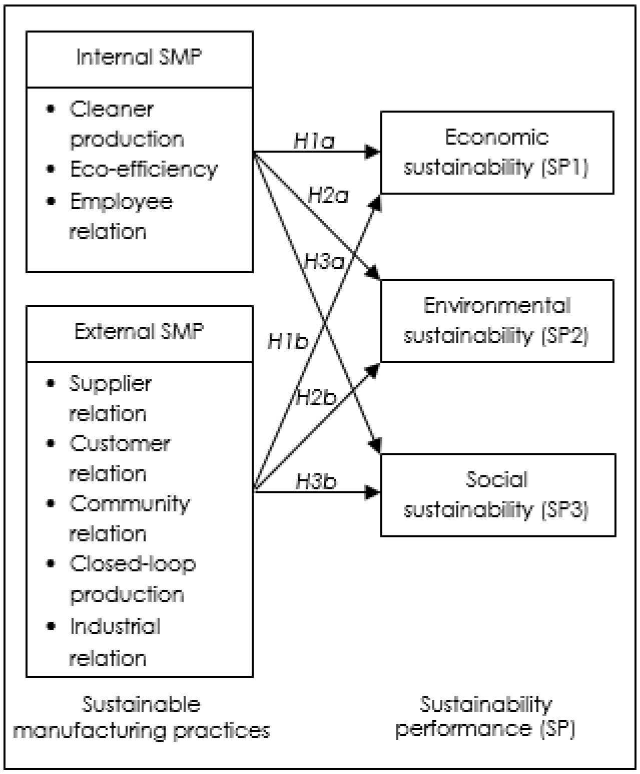

Figure 1 Research framework

2.3.1 SMP and Economic Sustainability (SP1)

The positive relationship between SMP and economic sustainability has been shown in some empirical studies. Through cleaner production and eco-efficiency, internal environmental management would promote economic sustainability by preventing or at least minimizing pollution at source. Creating pollution and waste during manufacturing operations and organizational activities implies the inefficient and ineffective used of resources [32]. While pursuing energy efficiency, water conservation, waste reduction, and other resource efficient practices for improving the viability of ecosystems and reduce ecological impacts, firms are able to improve operational efficiency such as reduced costs and production lead times, and improved quality and productivity [33,34,35,36] as well as generate higher benefits on business at large including increased revenues or profitability, market share and reputation, and better new market opportunities [9,13,37,38]. Corroborating the important of both internal and external SMP, Rao [39] found that greening inbound, production and outbound leads to significant values for better efficiency, quality and productivity as well as cost saving, new market opportunities and increased product price, profit margin, sales and market share. Attempting to eliminate the concept of waste, implementation of closed-loop supply chain strategies for both forward and reverse closed loop initiatives has significant impact on enhanced new product development capabilities, manufacturing capabilities, competencies, operational excellence, market intelligence and competitiveness [40].

Prior studies have listed various economic benefits accrued to firms by engaging with and taking internal and external stakeholders' interest. However, relatively, employee orientation demonstrated greater contribution on corporate financial performance compared to the orientations of other primarily stakeholders such as customers, suppliers, communities and shareholders [41]. In line with the extant empirical results, the following hypotheses are proposed:

H1a Internal SMP have positive and significant impact on economic sustainability.

H1b External SMP have positive and significant impact on economic sustainability.

2.3.2 SMP and Environmental Sustainability (SP2)

While meeting operational and business objectives, SMP would directly lead to increase environmental sustainability. Reflecting by the implementation of proactive environmental strategies and sustainable human resource practices, strong commitment to the social responsibility provides significant benefits to the environment [9,13,33,42,43,44].

Case studies conducted in different industrial sectors support the potential determinant of integrating environmental and social consideration beyond the organizational boundaries to include inter-organizational collaborations on achieving greater environmental sustainability [42,44]. Obvious improvements on environmental performance may attained by firms which had adopted inter-organizational environmental management instead of the optimal strategies independently implemented by the individual firms [42]. Hence, it is proposed that:

H2a Internal SMP have positive and significant impact on environmental sustainability.

H2b External SMP have positive and significant impact on environmental sustainability.

2.3.3 SMP and Social Sustainability (SP3)

In addition to improve economic and environmental performance, SMP have positive effect on social sustainability. Conducted in various countries, a number of studies found that inclusion of social and environmental aspects into technical and organizational activities undertaken by firms would improve social well-being related to employees, customers, suppliers, local communities and society at large. For example, analyzing survey data collected from 212 US manufacturing firms by using Structural Equation Modeling (SEM) approach, Yang [9] provided statistical evidence pertaining positive and significant association of social sustainability with sustainable operations management practices, sustainable customer management practices and corporate social involvement practices. Employing multiple regression analysis to examine empirical data obtained from 105 Malaysian manufacturing firms, Zailani *et al.* [13] found the positive effects of environmental purchasing and sustainable packaging on social sustainability. Gathering data from 711 manufacturing firms operated in 24 different countries (Asian Pacific, European, North American, and South American regions), Hong *et al.* [43] confirmed the positive influence of being environmental friendly on employee satisfaction. Similar result also found on Kim [10] when performing study on 223 small and medium-sized electrical and electronic firms in Korea. Deriving from the past empirical results, the following hypotheses are proposed:

H3a Internal SMP have positive and significant impact on social sustainability.

H3b External SMP have positive and significant impact on social sustainability.

3.0 RESEARCH METHOD

3.1 Measurement Variables

Both exogenous and endogenous latent variables in this study were operationalized based on the combination of scales developed by prior researchers. Nevertheless, a number of self-administered indicator variables were undertaken for some constructs such as Ext5 industrial relation and SP1 social sustainability due to lack of established scales. The indicators were carefully developed based on the conceptual definition that corresponds to the respective constructs. The measure was initially reviewed by a panel of experts consisting of six academic professors and senior lecturers, and two industry professionals to get feedback pertaining to the completeness, clarity, readability and validity of the scales and instructions. Considering the feedback, comments and recommendations from the experts, the measure was refined and further tested by 31 industrial practitioners. Using Cronbach's coefficient alpha, the results proved the internal consistency reliability of all the constructs. Having confirmed the content validity and internal reliability, the measure is ready for the large scale data collection phase.

As mentioned earlier, adapting from the extensive literature review, two exogenous variables being studied namely internal SMP and external SMP, reflect the wider perspective of SMP. Represented by three constructs encompassing Int1 cleaner production, Int2 eco-efficiency and Int3 employee relation, internal SMP measure the extent to which a firm manages its internal operations/relationships to improve sustainability performance while external SMP measure the external operations/relationships through Ext1 supplier relation, Ext2 customer relation, Ext3 community relation, Ext4 closed-loop production, and Ext5 industrial relation, as depicted in Figure 2. Six indicators were used to exhibit the degree of implementation of each construct of SMP in manufacturing firm. For each indicator, respondents were asked to indicate the level of agreement or disagreement with the statements as they thought it is related to current practice in their organization by using a response scale that are anchored by one for *strongly disagree* and five for *strongly agrees*.

Reflected in three dimensions namely economic sustainability, environmental sustainability and social sustainability, twenty-six indicators were developed to access the degree of changes in firm's performance in those three aspects for the last three years. Similar with SMP, respondents were asked to choose a response for each indictor on a five-point scale, given as one for *strongly disagree* to five for *strongly agree*. Operationalizing into nine indicators, economic sustainability measures the extent to which a firm achieves both operational and business success. While seven indicators related to the level of resource usage, pollution emitted and waste generated were used to measure environmental sustainability, social sustainability, reflecting in ten indicators, is intended to capture the changes in social well-being that related to employee, supplier, customer and society at large. A list of indicators for both SMP and SP is provided in Appendix A.

3.2 Data Collection and Sample

Drawing from the directory of Federation of Malaysian Manufacturers [45], a total of 600 manufacturing firms from a diverse range of industries were randomly selected as a sample in the present study. The unit of analysis is individual firm. Complementing with cover letter and self-addressed, stamp-attached envelope, a set of questionnaire was initially mailed to 600 potential respondents. Out of the total questionnaires sent, three were returned as undeliverable, reducing the sampling frame to 597. A month later, a second round of questionnaires was conducted to all non-respondents. Excluding three cases for extreme outliers and five incomplete survey forms, the survey yielded 150 effective responses, representing a response rate of 25.13 per cent. Such response rate is considers acceptable since it is greater than the suggested cut off of 20 per cent [46]. Characteristics of the respondents and responding firms are demonstrated in Table 2.

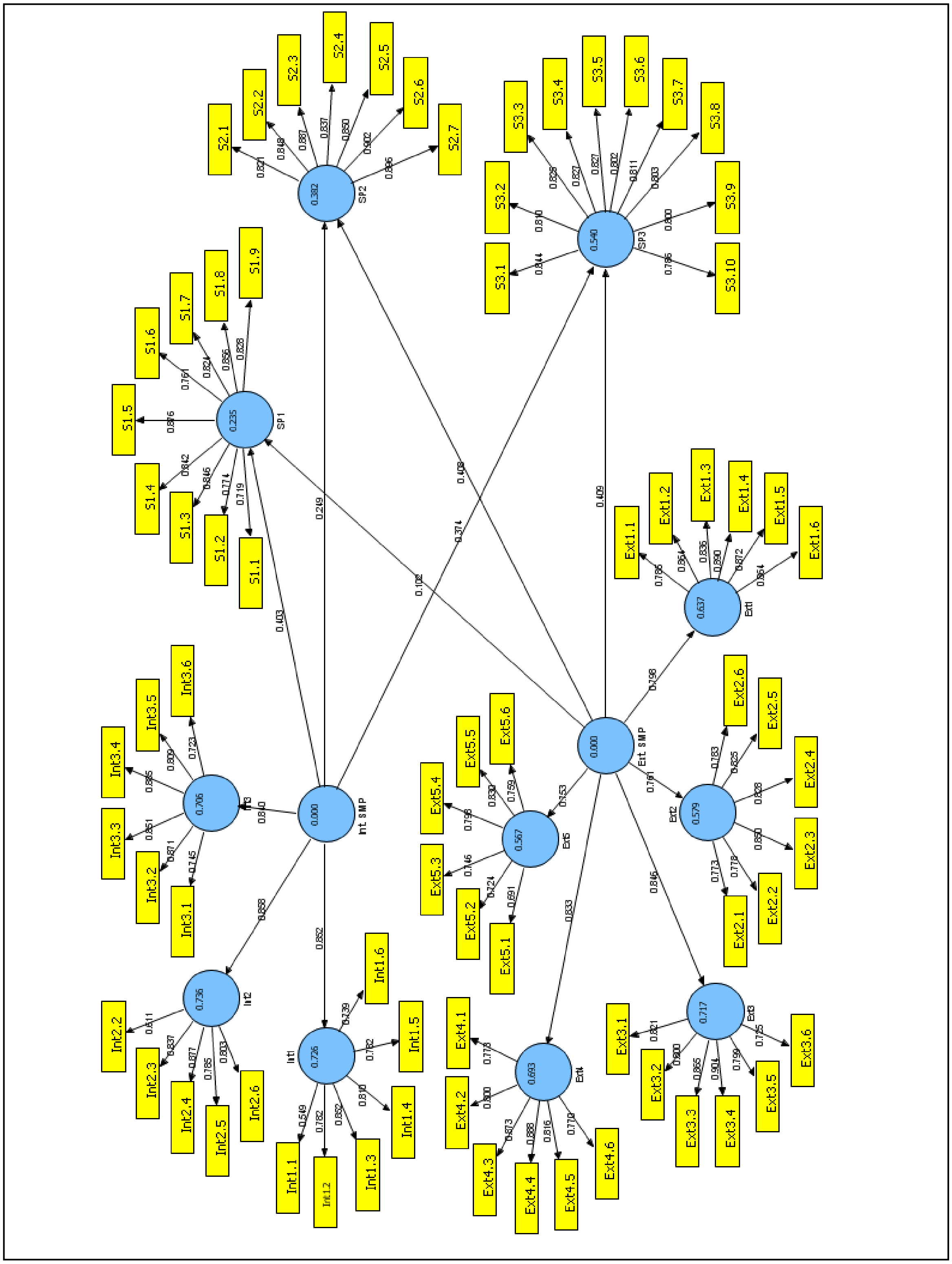

Figure 2 Hypothesized structural and measurement models

Table 2 Profile of respondents and responding firms

Characteristics	Frequency	Percentage
Industry classification:		
Chemical	24	16.0
Electrical and electronics	52	34.7
Food products and beverages	11	7.3
Machinery and equipment	7	4.7
Metals	18	12.0
Textiles and apparel	4	2.7
Transport equipment	29	19.3
Wood based	5	3.3
Firm size:		
Small	18	12.0
Medium	26	17.3
Large	105	70.0
Missing data	1	0.7
Year established:		
Less than 3	4	2.7
3 to 5	6	4.0
6 to 10	9	6.0
11 to 15	16	10.7
16 to 20	23	15.3
More than 20	92	61.3
ISO 9000 certification:		
Yes	103	68.7
No	45	30.0
Missing data	2	1.3
ISO 14000 certification:		
Yes	87	58.0
No	61	40.7
Missing data	2	1.3
Job title/ position:		
CEOs/MD/General Manager	55	36.7
Dept. Head/Assistant Manager	30	20.0
Executive	23	15.3
Engineer	40	26.7
Missing data	2	1.3

Identifying the potential non-response bias, respondent and non-respondent firms were compared on the mean responses of all indicators reflecting SMP and SP as well as in terms of certain characteristics such as industry classification, size, year established, ISO 9000 and ISO 14000 by using independent groups t-test and chi-square test, respectively. The statistical results of both tests reveal no significant differences between those two groups in all variables studied except for the indicator of S2.2 at the 0.05 level, confirming that non-response bias is not a problem in the present study. Since this study relying on self-reported data from single respondent per firm, Harman's single factor test was performed to detect the presence of common method bias. Conducting principal component analysis for all indicators representing both exogenous and endogenous variables, the results show that those indicators account for 74.99 per cent of the total variance, whereas the first factor only explains 36.60 per cent, indicating that there is no general factor in the unrotated factor structure. Accordingly, it is proves that common method bias is not a critical concern in this study which may mislead the interpretations of the findings.

3.3 Statistical Analysis

SEM was employed to test the hypothesized models in the present study. With the ability to test more complex path models involving a larger number of variables simultaneously, the application of SEM in quantitative research has become quiet widespread in recent years [47,48]. Aiming to maximize the explained variance of the three dimensions of sustainability performance, partial least squares SEM (PLS-SEM) approach was conducted to analyze the significant predictors on those three endogenous variables. There were some reasons for choosing PLS-SEM instead of covariance based SEM (CB-SEM). Since the structural equation model in this study is complex, consists of a large number of latent variables and indicator variables, with the focused more on prediction rather than parameter estimation, PLS-SEM is the preferable approach as highlighted by previous researchers [47,48,49].

Following the two-step process on examining PLS-SEM model, the measurement and structural models in this study were assessed separately. At first, the validity and reliability of the measure was analyzed based on specific criteria associated with reflective measurement model specification. Having confirmed the validity and reliability of the measure, the structural model, depicting the causal relationships between SMP and SP, was examined in the second step.

4.0 RESULTS AND CONCLUSION

4.1 Measurement Model Validation

Conducting validation procedure for reflective measurement model as suggested by previous researchers, the measurement models in the present study were tested for unidimensionality, indicator reliability, internal consistency reliability, convergent validity and discriminant validity [47,48,50]. Since PLS-SEM cannot directly measure the unidimensionality, the principal component analysis was employed to test each construct representing SMP and SP, separately. The first run proved to be unsatisfactory since, of the eleven constructs, one was bi-factorial, i.e. Int2 eco-efficiency. The result of that construct was further examined to check for item having low correlation with other items, and a low factor loading that provides candidate for removal in the second run of analysis. Consequently, Int2.1 item was removed from the second run and the result found to be unifactorial. Then, the remaining items were proceed for subsequent analyses in SmartPLS 2.0 M3 [51] and the results are presented in Table 3 through Table 5.

Table 3 Measurement model results [a]

Construct	Loading (1st order)	Loading (2nd order)	CR	AVE
Internal SMP:				
Cleaner production		0.85	0.89	0.58
Int1.1	0.55			
Int1.2	0.78			
Int1.3	0.85			
Int1.4	0.81			
Int1.5	0.78			
Int1.6	0.74			
Eco-efficiency		0.86	0.89	0.62
Int2.2	0.61			
Int2.3	0.84			
Int2.4	0.88			
Int2.5	0.78			
Int2.6	0.80			
Employee relation		0.84	0.92	0.67
Int3.1	0.75			
Int3.2	0.87			
Int3.3	0.85			
Int3.4	0.88			
Int3.5	0.81			
Int3.6	0.72			
External SMP:				
Supplier relation		0.80	0.94	0.73
Ext1.1	0.78			
Ext1.2	0.86			
Ext1.3	0.84			
Ext1.4	0.89			
Ext1.5	0.87			
Ext1.6	0.86			
Customer relation		0.76	0.92	0.65
Ext2.1	0.77			
Ext2.2	0.78			
Ext2.3	0.85			
Ext2.4	0.83			
Ext2.5	0.83			
Ext2.6	0.78			
Community relation		0.85	0.92	0.67
Ext3.1	0.82			
Ext3.2	0.80			
Ext3.3	0.86			
Ext3.4	0.90			
Ext3.5	0.80			
Ext3.6	0.72			
Closed-loop production		0.83	0.93	0.67
Ext4.1	0.77			
Ext4.2	0.80			
Ext4.3	0.87			
Ext4.4	0.89			
Ext4.5	0.82			
Ext4.6	0.77			
Industrial relation	0.69	0.75	0.89	0.58
Ext5.1	0.72			
Ext5.2	0.75			
Ext5.3	0.80			
Ext5.4	0.83			
Ext5.5	0.76			
Ext5.6				
Economic sustainability:			0.95	0.67
S1.1	0.72			
S1.2	0.77			
S1.3	0.85			
S1.4	0.83			
S1.5	0.88			
S1.6	0.77			
S1.7	0.83			
S1.8	0.85			
S1.9	0.83			
Environmental sustainability:			0.95	0.75
S2.1	0.82			
S2.2	0.85			
S2.3	0.89			
S2.4	0.83			
S2.5	0.85			
S2.6	0.90			
S2.7	0.90			
Social sustainability:			0.95	0.66
S3.1	0.85			
S3.2	0.78			
S3.3	0.81			
S3.4	0.83			
S3.5	0.83			
S3.6	0.83			
S3.7	0.80			
S3.8	0.81			
S3.9	0.80			
S3.10	0.80			

Notes: CR = Composite reliability; AVE = Average variance extracted
[a] See Appendix A for indicator or item description

Table 4 Comparison of the AVE and squared correlation between constructs for SMP

	Int1	Int2	Int3	Ext1	Ext2	Ext3	Ext4	Ext5
Int1	**0.58**							
Int2	0.44	**0.62**						
Int3	0.27	0.32	**0.67**					
Ext1	0.20	0.36	0.17	**0.73**				
Ext2	0.45	0.54	0.35	0.23	**0.65**			
Ext3	0.25	0.33	0.24	0.32	0.35	**0.67**		
Ext4	0.21	0.38	0.23	0.31	0.32	0.37	**0.67**	
Ext5	0.09	0.18	0.18	0.30	0.14	0.35	0.34	**0.58**

Notes: Diagonal elements are AVE of each construct; Off-diagonal elements are the squared correlation between constructs

Table 5 Comparison of the AVE and squared correlation between constructs for SP

	SP1	SP2	SP3
SP1	**0.67**		
SP2	0.29	**0.75**	
SP3	0.48	0.40	**0.66**

Notes: Diagonal elements are AVE of each construct; Off-diagonal elements are the squared correlation between constructs

While higher-order factor analysis was conducted to test a second-order measurement models of internal and external SMP, the measurement models of SP were evaluated by using first-order factor analysis. As tabulated in Table 3, all of the indicators have factor loadings greater than 0.5, verifying the indicator reliability of both SMP and SP's measurement models in the present study [52]. The values of Composite Reliability (CR) and Average Variance Extracted (AVE) for the entire constructs are well above the cut-off value of 0.7 and 0.5, respectively, thus confirming the internal consistency reliability and convergent validity of those constructs [47,48,50]. The results generated from the analysis of Fornell-larcker criterion provide good evidence of discriminant validity for all constructs studied since their AVE values are higher than the corresponding inter-construct squared correlations as indicated in Table 4 and Table 5 [47,48,50]. The overall results implied a sufficient degree of validity and reliability of the present measurement models, thus, the validated data set of SMP and SP, consists of 73 indicator variables from 150 cases, is worthy for further statistical analysis to meet the specified objectives in this research.

4.2 Structural Model Assessment

Once the validity and reliability of measurement models are proven, the structural model, depicting the causal relationships between SMP and SP, is assessed based on several criteria such as coefficient of determination (R^2), path coefficients (β) and predictive relevance (Q^2). The results are presented in Table 6.

It is observed that both types of SMP explain 24 per cent of variance (R^2 = 0.24) in economic sustainability. However, conducting resampling bootstrap procedure with 1000 subsamples, internal SMP are the single predictor that positively and significantly improve economic sustainability (β = 0.40, p < 0.01). The analysis fails to confirm the significant impact of external SMP on economic sustainability (β = 0.10, p > 0.05). As a result, *H1a* is supported while *H1b* is not. In contrast, both internal and external SMP have positive and significant impact on environmental sustainability (β = 0.25, p < 0.01; β = 0.40, p < 0.01) and social sustainability (β = 0.37, p < 0.01; β = 0.41, p < 0.01), respectively, thus supporting *H2a*, *H2b*, *H3a* and *H3b*. While predicting 38 per cent of variance (R^2 = 0.38) in environmental sustainability, those sustainable practices explain 54 per cent of variance (R^2 = 0.54) in social sustainability. Relatively, SMP have greatest explanatory power on social sustainability followed by environmental sustainability and the least is on economic sustainability. In overall, the entire set of structural models in the present study has good predictive relevance as indicated by the positive values of Q^2.

Table 6 Structural model results

Hypothesis: Structural path	β [a]	R^2 [b]	Q^2 [c]
H1: SMP→SP1		0.24	0.16
Causal variable:			
Internal SMP - *(H1a)*	0.40**		
External SMP - *(H1b)*	0.10		
H2: SMP→SP2		0.38	0.28
Causal variable:			
Internal SMP - *(H2a)*	0.25*		
External SMP - *(H2b)*	0.40**		
H3: SMP→SP3			0.36
Causal variable:			
Internal SMP - *(H3a)*	0.37**		
External SMP - *(H3b)*	0.41**		

[a] *p < 0.05, **p < 0.01
[b] R^2 values represent the explained variance for the endogenous variables
[c] Q^2 > 0 indicates that the model has predictive relevance, Q^2 < 0 implies that the model is lacking predictive relevance

The assessment of the entire hypothesized models was essential since it offers a strong statistical evidence pertaining to the relationships between SMP and SP. Supporting the findings by some researchers, being environmentally friendly and socially responsible when dealing with internal operations and relations, aim to improve environmental and social sustainability, would lead to better operational [33,34,35,36,40] and business performance [9,13,37,38,39,41]. Although there is no sufficient evidence to support external SMP-economic sustainability link, managing both internal and external operations and relations in sustainable manner would increase environmental sustainability, as implied by the considerable reduction in the level of resources usage, pollution emitted and waste generated, as well as improve social well-being in the aspect of customer, supplier, employee and society at large. These results are consistent with a number of studies, substantiating the important of environmental management and socially responsible practices on creating favorable outcomes with regard to natural environment [9,13,33,42,43,44] and other salient stakeholders such as employee, customer, supplier and local communities [9,10,13,43]. Challenging the findings of previous studies [13,37,38,40], a plausible reason for insignificant relationship between external SMP and economic sustainability is lack of proper strategic planning and implementation. For instance, developing closer relationship with local communities by engaging in community-based projects should be clearly defined in which rather than fulfilling social obligation, the firm should be able to associate the benefits of being socially responsible with actual outcome from an economic perspective. On the other hand, although sharing knowledge, know-how and experience with suppliers in designing sustainable product would improve operational efficiency, direct benefits from these collaborations seem to be in favour of the other party rather than on the firm itself.

5.0 CONCLUSION

The theories of RBV and stakeholder have highlighted the importance of SMP on a firm's sustainability performance. Deriving from those theories together with the other extant literature on sustainability and SM, this study clarifies the link between SMP and SP in a wider perspective, and empirically examines the impacts of both internal and external SMP on economic, environmental, and social sustainability in Malaysian manufacturing firms.

The results of the present study deliver significant implications in both theoretical and practical perspectives. In theoretical view, the study contributes to the body of knowledge by offering empirical evidences pertaining to the association between two types of SMP, namely internal SMP and external SMP, and the three pillars of sustainability, consist of economic, environmental and social sustainability. Adopting PLS-SEM approach, the ability to test those relationships concurrently is valuable for better understanding of the phenomena.

On the other perspective, the findings of the study offer several implications for industrial practitioners. As acknowledge in the literature, pursuing more environmental friendly and socially responsible practices may directly improve environmental and social performance. Ensuring continuous improvement for achieving superior performance, the validated measurement models, generated in this study, may help firms in understanding the contextual elements of both SMP and SP and identify the strengths and weaknesses of their current practices. However, while internal SMP significantly improve economic sustainability, external SMP are not. Instead of acting on well-intentioned impulses or reacting to external pressure, firms are advised to create and grasp economic opportunities derived from being environmental friendly and socially responsible.

Although the result of this study show no empirical support for direct relationship between external SMP and economic sustainability, it is reasonable that these variables could be related indirectly with each other. Future research may highlight the complex relationships between SMP and economic sustainability as well as SMP and the other two dimensions of SP. As the present study analyzes the causal relationships between SMP and SP through survey data, future in-depth qualitative based studies, clarifying on how and why such variables related with each other, would provide further insights into these associations.

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APPENDIX A: SCALE AND INDICATOR

A.1. Internal SMP

Indicate the extent to which you agree with the following statements as they relate to current practice in your organization on a scale from one for *strongly disagree* to five for *strongly agree*.

Dimension 1: Int1 Cleaner production

Int1.1 Substitution of non-environmental friendly materials
Int1.2 Optimization of manufacturing processes to reduce solid waste and emissions
Int1.3 Process design focused on reducing energy and natural resources consumption in operations
Int1.4 Product design focused on reducing energy and materials consumption
Int1.5 Acquisition of clean technology/equipment
Int1.6 Good housekeeping practices

Dimension 2: Int2 Eco-efficiency

Int2.1 Reuse of products/components
Int2.2 Recycling of materials internal to the company
Int2.3 Cross-functional cooperation for environmental improvements
Int2.4 Total quality environmental management is in place
Int2.5 Environmental compliance and auditing programs are in place
Int2.6 The company's efforts in relation to the environmental matters have exceeded the requirements of the relevant regulations

Dimension 3: Employee relation

Int3.1 Guaranteed observation of industry safety regulations
Fair payment of employees
Int3.2 Care for employee's personal development
Int3.3 Supporting work-life balance
Int3.4 Involving employees into making important decisions
Int3.5 Cooperation with unions and labour representatives

Int3.6

A.2. External SMP

Indicate the extent to which you agree with the following statements as they relate to current practice in your organization on a scale from one for *strongly disagree* to five for *strongly agree*.

Dimension 1: Ext1 Supplier relation

Ext1.1 Choice of suppliers by environmental criteria
Ext1.2 Guiding suppliers to set up their own environmental programs
Ext1.3 Bringing together suppliers in the same industry to share their know-how and problems
Ext1.4 Informing suppliers about the benefits of cleaner production and technologies
Ext1.5 Urging suppliers to take environmental actions
Ext1.6 Sending internal auditors to appraise environmental performance of suppliers

Dimension 2: Ext2 Customer relation

Ext2.1 Environmental friendly waste management
Ext2.2 Environmental improvement of packaging
Ext2.3 Eco labeling of products
Ext2.4 Providing credible information about product biography
Integration of customer feedback into business activity
Ext2.5 Prevention of products causing danger for customers

Ext2.6

Dimension 3: Community relation

Ext3.1	Active involvement in the creation of better general conditions in local community
Ext3.2	Cooperation with third party (e.g., public authorities, scientific institutions, NGOs) towards environmental protection
Ext3.3	Continuous dialogue with municipalities to know the most important problems of the local community
Ext3.4	Providing information about corporate social responsibility (CSR) projects and expected benefits
Ext3.5	Encouraging employees to get involved in charitable projects
Ext3.6	Regularly providing donation or sponsorship
Dimension 4: Ext4 Closed-loop production	
Ext4.1	Increase the product's useful life
Ext4.2	Design the product to accommodate multiple future uses/application
Ext4.3	Design the product for easy material recovery
Ext4.4	Ensure that infrastructures for product recovery exist
Ext4.5	Establish recycling procedures
Ext4.6	Establish remanufacturing procedures
Dimension 5: Ext5 Industrial relation	
Ext5.1	Using waste or by-products of other industrial firms as input materials
Ext5.2	Exchange of waste or by-products with other industrial firms
Ext5.3	Share in the management of utilities (e.g., energy, water, waste treatment) with other industrial firms
Ext5.4	Share knowledge (e.g., technological, managerial, environmental) with other industrial firms
Ext5.5	Share ancillary services (e.g., transportation, landscaping, waste collection) with other industrial firms
Ext5.6	Cooperate with local communities towards environmental protection

A.3. Economic sustainability

Indicate the extent to which you agree with the following statements as they relate to both operational and business performance of your organization in the last three years on a scale from one for *strongly disagree* to five for *strongly agree*.

Items	Description
S1.1	Reduced costs
S1.2	Improved product quality
S1.3	Reduced lead times
S1.4	Improved customer service
S1.5	Increased productivity
S1.6	Increased revenues
S1.7	Increased market share
S1.8	Improved reputation
S1.9	Better new market opportunities

A.4. Environmental sustainability

Indicate the extent to which you agree with the following statements as they relate to performance of your organization on reducing the resource usage, pollution emitted and waste generated in the last three years on a scale from one for *strongly disagree* to five for *strongly agree*.

Items	Description
S2.1	Reduced water usage
S2.2	Reduced energy consumption
S2.3	Reduced non-renewable resources usage
S2.4	Reduced hazardous inputs usage
S2.5	Reduced solid waste
S2.6	Reduced waste water emissions
S2.7	Reduced emissions of polluting gases

A.5. Social sustainability

Indicate the extent to which you agree with the following statements as they relate to performance of your organization on creating social welfare with regard to various stakeholders including supplier, employee, customer and local communities in the last three years on a scale from one for *strongly disagree* to five for *strongly agree*.

Items	Description
S3.1	Increased employee satisfaction
S3.2	Better recruitment and staff retention
S3.3	Increased occupational health and safety
S3.4	Improved employee education and skill
S3.5	Improved supplier commitment
S3.6	Increased certified suppliers
S3.7	Increased customer satisfaction
S3.8	Increased public health and safety
S3.9	Reduced local community complaint
S3.10	Improved local community conditions and infrastructure