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The Impact of Sustainable Manufacturing Practices and Innovation Performance on Economic Sustainability

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Abstract

The emergence of the concept of sustainability reflects a decisive change in global thinking, thus forcing firms to reconsider the approach in conducting their business operations. With an aim to boost economic development, firms need to re-establish their corporate strategy by introducing and implementing more integrated sustainable practices. Prior researchers believe that sustainable manufacturing practice (SMP), defined as a firm's intra- and inter organizational practices that integrate environmental, economic and social aspects into operational and business activities, would lead to better firm performance. The research reported in this paper aims to analyze the effect of SMP on economic sustainability (ES) and the mediated effect of SMP on ES through innovation performance (IP). Using survey data collected from 150 Malaysian manufacturers, this paper empirically examines the relationships that exist among SMP (internal and external SMP), IP (product, process, organizational and marketing), and ES. Adopting PLS-SEM technique, the study found that internal SMP has a positive effect on ES and process innovation partially mediates this internal SMP-ES link. Surprisingly, although the relationship between external SMP and ES is not significant, incorporating product and process innovations into this link have changed the significance of the relationship. In general, the results have empirically proven the role of SMP and IP in influencing the economic performance. Thus, it is suggested that instead of acting on well-intentioned impulses or reacting to external pressure, firms should clearly defined and grasp economic opportunities gained from being environmentally friendly and socially responsible.

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1. Introduction

With the growing global concerns on sustainability issues such as scarcity of natural resources, rapid environmental degradation, unequal balance of social equities and intense global competitions, sustainable manufacturing (SM) strategies have drawn attention. The concept of sustainability has considerably influenced the nature of business activities. As human beings constantly pursuing higher life quality, manufacturing firms encounter a pressing challenge on producing more products whilst using less resources as well as less pollution emitted and waste generated [1].

Pursuing more environmentally friendly products and business operations, and being socially responsible would improve operational efficiency [2] and generate competitive advantage [3]. Whereas some researchers found positive and significant impact of sustainable manufacturing practice (SMP) on achieving economic sustainability (ES), there were some other researchers who failed to do so [4,5]. The mixed results might be due to the reason that the contextual elements of SMP and ES have not been well established. Insufficient statistical evidence to support the significant relationship between SMP and ES indicates that there may be a more complex relationship between these two variables. This study aims to analyze the effects of SMP on ES by using empirical data collected from Malaysian manufacturing firms.

The remainder of this paper is organized as follows. Section 2 discusses a relevant literature and develops research hypotheses pertaining to the interrelationships among SMP, IP and ES. The methodological approach applied for the

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empirical analysis is described in Section 3. Results and discussions are given in Section 4 followed by conclusions with theoretical and practical implications in Section 5.

2. Literature review and hypotheses

2.1. Sustainable manufacturing practice (SMP)

Although SM is widely discussed in the literature, there is no generally accepted definition of this concept [6]. In earlier, some scholars viewed SM as production methods or technologies that focus on economic development and environmental protection simultaneously [7,8]. Extending the inclination of translating sustainability into merely being environmental friendly, [9] described 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. Promoting the social well being as well as targeting economic and environmental improvements, this study defines SM as broad notion that developed through the integration of sustainability concepts into the manufacturing system with an aim to achieve sustainability in industrial production.

The evolution of sustainability and SM concepts has given rise to a series of SMP, from the application of technology for the treatment of pollution at the end of the pipe to more integrated systems of production which support the collaboration across functional areas within a firm as well as inter-organizational level such as closed-loop production and industrial symbiosis [6]. Generally, the development of SMP can be seen at the three levels, i.e. product, process and system [10]. At the product level, traditional 3R concept (*reduce, reuse, recycle*) has been transformed to a more sustainable 6R approach (*reduce, reuse, recycle, recover, redesign, remanufacture*), changing paradigm from single life cycle to multiple life cycles [10]. While numerous efforts have been made 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 orientation of the system is evolved from organizational-based to the entire supply chain and beyond the chain of production [10, 11].

Considering the evolution of SM, SMP can be defined as a firm's intra- and inter-organizational practices that integrate environmental, economic and social aspects into operational and business activities. Differentiated based on the orientation of sustainable thinking, there are two types of SMP namely internal SMP and external SMP. While internal SMP focuses on the sustainable practices within a firm, external SMP refers to the inter-organizational practices within the value system and beyond the chain of production to improve economic, environmental and social sustainability simultaneously.

2.2. SMP and economic sustainability(ES)

In resource-based view (RBV) perspective, proper management of unique resources and capabilities would generate competitive advantage and thus lead to superior performance [12]. 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. A number of studies, performed in different countries with using various statistical methods and techniques, found that integration of social and environmental aspects into technical and organizational activities undertaken by firms would increase economic performance [5, 13,14,15].

Zooming into each dimension of SMP, some studies were supported the ability of internal SMP on improving ES. For example, conducting an empirical study on sustainable supply chain among 212 US manufacturing firms, [2] found that sustainable operations management practices would lead to increase operational, market and financial performance. While targeting 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 increase operational efficiency such as cost savings, reduced production lead times, and improved quality and productivity as well as improved revenues or profitability, market share and reputation, and better new market opportunities [5,13,14]. On the other hand, empirical study conducted by [16] demonstrates the greater contribution of employee orientation on corporate financial performance compared to the orientations of other primarily stakeholders such as customers, suppliers, communities and shareholders. This significant result corroborates the findings of previous studies, substantiating positive impact of employee relation on operational and business performance [17,18].

For external SMP, prior studies have listed various economic benefits accrued to firms by engaging with and taking the interest of external stakeholders. For example, measuring corporate social responsibility for competitive success among 67 medium and large firms, [19] found the positive and significant direct effect of social responsibility orientation of firms on competitive success. Employing survey on green supply chain management among some leading companies in Southeast Asia, [20] found that greening inbound, greening production and greening 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. These results, suggesting the positive relationships between external SMP and ES, have been corroborated by some other researchers [5,14,15]. Aiming 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 improving operational excellence and manufacturing capabilities [21]. In line with the extant empirical results, supported by the RBV theory, the following hypotheses are proposed:

- *H1a*. Internal SMP has positive and significant impact on ES.
- *H1b*. External SMP has positive and significant impact on ES.

2.3. SMP, innovation performance (IP) and ES

Environmental conscious and socially responsible practices would be source of competitive advantage that leads to increase firm competitiveness and eventually create superior performance. Part and parcel of SMP is knowledge sharing between firms and diverse internal and external stakeholders, therefore making it possible for firm to improve its innovation performance [22,23] which in turn would lead to firm success.

Ensuring survival and growth in turbulent market environment, firms need to proactively adapt with changes in business environment by renewing their products, processes and organization in a continuous basis [24]. Recognizing innovation as valuable, rare, non-substitutable and unique organizational resources, the ability to successfully implement creative ideas within an organization offers significant benefits for gaining greater ES. The importance of product, process, organizational, and marketing innovations for enhancing firm performance has been widely acknowledged and extensively reported in the current literature [24,25,26].

Although the performance of product, process, organizational and marketing innovations is expected to affect the ES, different types or combinations of different innovation can lead to different findings [27,28]. In that sense, it is expected that all of these innovations are adequately measures the broader concept of IP, which is proposed to mediate the causal relationship between SMP and ES as specifically stated in the following hypotheses:

H2a. IP mediates the relationship between internal SMP and ES.

H2b. IP mediates the relationship between external SMP and ES.

3. Research method

3.1. Data collection and sample

Drawing from the directory of Federation of Malaysian Manufacturers, 600 registered manufacturing firms from diverse industries are randomly selected as sample in this study. Employing a survey-based method, a set of questionnaire has been initially mailed to 600 potential respondents. Out of the total questionnaires sent, 3 are returned as undeliverable, reducing the sampling frame to 597. A second round of survey was conducted to all non-respondents a month later. After discarding 5 incomplete forms and 3 for extreme outliers, in total, the surveys yielded 150 usable responses, representing a 25.13% response rate.

Receiving responses from various manufacturing industries, majority of firms are from four industries, electrical and electronics (34.7%), transport equipment (19.3%), chemical (16.0%) and metals (12.0%), while the remaining 17.3% are from food products and beverages, machinery and equipment, wood based, and textiles and apparel. About 70% of responding firms are large-sized while 18% and 12% are medium and small organizations.

Independent group t-test and chi-square test have been conducted to detect any potential non-response bias in this study. T-test is performed for all measurement items reflecting SMP, ES and IP and the results show no significant differences between early respondents and late respondents (representing non-respondents) in each item tested. Similarly, the chi-square analysis indicates no significant differences between those two groups of respondents in term of industrial classification and firm size. Since this study relying on self-reported data and the responses are accumulated from a single respondent per firm, Harman’s single factor test has been conducted to detect the presence of common method bias. However, the result is not significant, suggesting that the interpretation of the findings of this study would not be confounded by substantial method bias. As a result, a full data set of 150 responses is valid and usable for testing the hypothesized relationships in this study.

3.2. Statistical analysis

With the ability to simultaneously test more complex path models involving a larger number of variables, partial least squares structural equation modeling (PLS-SEM) has been applied to test a series of hypothesized models in this study [27,28]. Following the two step process on assessing PLS-SEM model, the measurement model and structural model are assessed separately.

3.3. Measurement variables

The operationalization of constructs for both exogenous and endogenous latent variables is based on the combination of scales developed by previous researchers. However, because of the lack of established scales, some self-administered indicator variables are undertaken for several constructs such as *Ext5 industrial relation* and *IP3 organizational innovation*. The indicators are carefully developed based on the theoretical definition that corresponds to the respective constructs.

SMP are initially conceptualized based on [6,10], resulting two exogenous latent variables being studied namely internal SMP and external SMP. While internal SMP are measured by three constructs (i.e. *Int1 cleaner production, Int2 eco-efficiency* and *Int3 employee relation*), five constructs have been used to measure external SMP (i.e. *Ext1 supplier relation, Ext2 customer relation, Ext3 community relation, Ext4 closed-loop production,* and *Ext5 industrial relation*). Respondents are asked to indicate the level of agreement or disagreement with 48 indicators of SMP as they thought it is related to current practice in their organization by using a five-point scale, given as one for *strongly disagree* to five for *strongly agree*.

ES measures the extent to which a firm improves operational and business performance in the last three years. Translating into 9 indicators, again, respondent are asked to choose a response for each indicator on a five-point scale, given as one for *strongly disagree* to five for *strongly agree*. Similarly, a five-point response scale, anchored by one for *strongly disagree* and five for *strongly agree*, is used to measure the extent to which a firm successfully performs in product, process, organizational and marketing innovations. In total, 24 indicators have been developed to measure IP.

4. Results and discussion

4.1. Measurement model validation

Following [27,28], the measurement model developed in this study has been tested for unidimensionality, indicator reliability, internal consistency reliability, convergent validity and discriminant validity. Since PLS-SEM cannot directly determine the unidimensionality, the confirmatory factor analysis (CFA) technique in SPSS Statistics 19 is applied to test each construct reflecting SMP, IP and ES, individually. The results found that each set of indicator variables loaded on only one factor except *Int2 eco-efficiency* construct. The result of *Int2* is further analyzed to check for the item that had a low correlation with others and a low factor loading that provides candidate for removal in the second run of analysis. Accordingly, the indicator of *Int2.1* is removed from the second run and the result appears to be unifactorial. The remaining indicators have been tested for further validation analyses in SmartPLS. The results are presented in Table 1.

Table 1. Measurement model results

Construct	Loading (1st order)	Loading (2nd order)	CR	AVE
Internal SMP			0.89	0.72
Cleaner production	0.55 - 0.85	0.85	0.89	0.58
Eco-efficiency	0.61 - 0.88	0.86	0.89	0.62
Employee relation	0.72 - 0.88	0.84	0.92	0.67
External SMP			0.90	0.64
Supplier relation	0.78 - 0.89	0.80	0.94	0.73
Customer relation	0.77 - 0.85	0.76	0.92	0.65
Community relation	0.72 - 0.90	0.85	0.92	0.67
Closed-loop production	0.77 - 0.89	0.84	0.93	0.67
Industrial relation	0.69 - 0.83	0.75	0.89	0.58
Economic sustainability	0.72 - 0.88		0.95	0.67
IP1 Product innovation	0.78 - 0.90		0.93	0.71
IP2 Process innovation	0.82 - 0.89		0.95	0.74
IP3 Organizational innovation	0.83 - 0.90		0.95	0.75
IP4 Marketing innovation	0.79 - 0.88		0.94	0.73

Notes: CR = Composite reliability; AVE = Average variance extracted

All of the factor loadings in both first and second order models are greater than the minimum threshold value of 0.50 [29], thus proving the indicator reliability of each construct in the measurement model. Similarly, all of the values of composite reliability and average variance extracted are well above the minimum required levels of 0.60 and 0.50, respectively [27,28], therefore confirming the internal consistency reliability and convergent validity for each construct. Meanwhile, based on the analysis of Fornell-Lacker criterion, the result confirms the discriminant validity of all constructs since their AVEs are greater than the corresponding inter-construct squared correlations [30].

Having confirmed the validity and reliability of the measurement model, the finalized data set of SMP, IP and ES, consists of 80 indicator variables from 150 cases, is acceptable for further structural model analysis.

4.2. Structural model assessment

In this study, the structural model has been evaluated based on some criteria such as coefficient of determination (R^2), path coefficients (β) and predictive relevance (Q^2). Exceeding the suggested minimum value of 0.1 [31], the R^2 value of 0.50 indicates that the proposed model explains half of the variance of ES, demonstrating the considerable explanatory power of the model. Using a resampling bootstrap procedure with 1000 subsamples, the significance level of path coefficients is determined. As presented in Table 2, the total effect of internal SMP on ES is significant (c = 0.40, p < 0.01), thus supporting *H1a*. The results suggest that the application of pollution prevention methods, clean technologies and sustainable human resource practices are associated with improving operational efficiency as well as increasing financial and market performance.

Table 2. Structural model of internal SMP, IP and ES results

Structural path	β [a]	R^2 [b]	Q^2 [c]
Internal SMP→ES (path *c*)	0.40^{***}	0.50	0.33
Internal SMP→IP (path *a*)			
Outcome variable: IP1 Product	0.10	0.27	0.19
IP2 Process	0.21^{**}	0.31	0.23
IP3 Organizational	0.19^{*}	0.40	0.29
IP4Marketing	0.16^{*}	0.33	0.24
IP→ES (path *b*)		0.50	0.33
Causal variable: IP1 Product	0.37^{***}		
IP2 Process	0.25^{***}		
IP3 Organizational	0.17^{*}		
IP4 Marketing	-0.10		
Internal SMP→ES (path)	0.30^{***}	0.50	0.33

[a] $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$
[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

However, internal SMP has significant effect only on the three hypothesized mediating variables, i.e. process innovation (a = 0.21, p < 0.05), organizational innovation (a = 0.19, p < 0.1) and marketing innovation (a = 0.16, p < 0.1) while, when controlling for internal SMP, product innovation (b = 0.37, p < 0.01), process innovation (b = 0.25, p < 0.01) and organizational innovation (b = 0.17, p < 0.1) have significant effects on ES. The estimated direct effect of internal SMP on ES, controlling for IP, is = 0.30, p < 0.01. The indirect effect (*ab*) of internal SMP on ES through process and organizational innovations are 0.05 and 0.03, respectively. For 95% bootstrapped confidence interval, in contrast with organizational innovation, the indirect effect of internal SMP on ES through process innovation do not include zero and therefore is statistically significant. Since the direct path from internal SMP to ES ( ) is also statistically significant, the effects of internal SMP on ES are only partially mediated by process innovation. Based on the results, *H2a*, postulating the significant mediation effect of IP on the relation between internal SMP and ES, is partially supported. Proving process innovation performance as the significant mediator, the results suggest that successfully improving ways of making products in a continuous basis, resulting from considerable extent of internal SMP implementation, would enhance economic performance.

Unexpected results are found on the interrelationships among external SMP, IP and ES. Referring to Table 3, the total effect of external SMP on ES is not significant (c = 0.10, p > 0.1), thus rejecting *H1b*. The results of this study indicate that inter-organizational collaborations, which aim to improve environmental sustainability and social well being, are not contributing to favorable economic outcomes. Much of the benefits from this external SMP may have gone to the external parties rather than to the firm itself.

Table 3. Structural model of external SMP, IP and ES results

Structural path	β^{a}	$R^{2\,b}$	$Q^{2\,c}$
External SMP→ES (path c)	0.10	0.50	0.33
External SMP→IP (path a)			
Outcome variable: IP1 Product	0.44^{***}	0.27	0.19
IP2 Process	0.38^{***}	0.31	0.23
IP3 Organizational	0.47^{***}	0.40	0.29
IP4 Marketing	0.44^{***}	0.33	0.24
IP→ES (path b)		0.50	0.33
Causal variable: IP1 Product	0.37^{***}		
IP2 Process	0.25^{***}		
IP3 Organizational	0.17^{*}		
IP4 Marketing	-0.10		
External SMP→ES (path)	-0.19^{**}	0.50	0.33

^{a} $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$
^{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

While external SMP have significant effects on all dimensions of IP, i.e. product innovation (a = 0.44, p < 0.01), process innovation (a = 0.38, p < 0.01), organizational innovation (a = 0.47, p < 0.01) and marketing innovation (a = 0.44, p < 0.01), when controlling for external SMP, only three dimensions have significant effects on ES, i.e. product innovation (b = 0.37, p < 0.01), process innovation (b = 0.25, p < 0.01) and organizational innovation (b = 0.17, p < 0.1). The indirect effect of external SMP on ES through product, process and organizational innovations are 0.16, 0.10 and 0.08, respectively. Although the estimated direct effect of external SMP on ES, controlling for IP, is significant, the estimated value is negative (= -0.19, p < 0.05), resulting the possibilities of inconsistent mediation exist. For 95% bootstrapped confidence interval, only the indirect effect of external SMP on ES through product and process innovations do not include zero and therefore are statistically significant. Since the direct path from external SMP to ES ( ) is also statistically significant, the effects of external SMP on ES are only partially mediated by product and process innovations. Thus, *H2b*, postulating the significant mediation effect of IP on the relation between external SMP and ES, is partially supported.

While socially responsible practices offered a favorable long term fiscal advantage, [32] found that such efforts do not have much positive effect on short term financial performance. The cost of complying with environmental regulations or best sustainable practices could be high [33,34]. Several firms believed that the link between financial performance and commitment to sustainability is strong in the long-term [33]. Partitioning the total effects into direct and indirect effects, the results assume that, while engaging with and taking the interests of external stakeholders may directly lead to negative economic results, such efforts would promote greater success on product and process innovations, which ultimately improved ES.

5. Conclusions and implications

The purpose of this study is to analyze the effects of both types of SMP on ES. While the results indicate that internal SMP positively relate to ES, there is no significant relationship between external SMP and ES. However, with the inclusion of IP on those relationships, the results show that internal and external SMP have both direct and indirect effects on ES. Process innovation performance mediates the relationship between internal SMP and ES. While proactively manages internal relations and operations in sustainable manner would directly improved operational and business performance, such efforts promote better performance on applying new production methods and processes that would result in improvements in ES.

Interesting results are found on the interrelationships among external SMP, IP and ES. Partitioning the insignificant total effects into direct and indirect effects, pursuing more environmentally friendly products and business operations as well as being socially responsible by aggressively adopting external SMP may directly lead to negative economic results. However, through greater performance on both product and process innovations, external SMP would indirectly improve ES. For instance, through external SMP which promote external integration and collaboration with various stakeholders such as customers and suppliers, organizationally relevant information, knowledge, and expertise are spread and exchanged among individual members with high speed, accuracy and efficiency. Successful sharing of valuable information among members could be seen in various aspects that support product and process innovations success such as quick response to market changes and technology advancements as well as better understanding of the needs of customers, suppliers, and society at large. While successful introduction of new products provides better new market opportunities and greater profit margin, improvements on the way of making products could reduce cost and lead time as well as improved quality and productivity.

The findings of this study offer several implications in both theoretical and practical perspectives. Theoretically, while the study contributes to the body of knowledge by providing empirical evidences pertaining to the interrelationships among SMP, IP and ES, the ability to test those relationships simultaneously is valuable for better understanding of the phenomena. On the other hand, the results of the study deliver significant implications for industrial practitioners. In general, re-establishing corporate strategy by introducing and implementing more socially responsible and environmental friendly practices may improve economic performance. However, although the importance of external SMP is acknowledged in the literature, external SMP alone may negatively affect economic performance. Therefore, it is suggested that instead of acting on well-intentioned impulses or reacting to external pressure, firms should clearly defined and grasp economic opportunities gained from being environmentally friendly and socially responsible. With impressive performance on both product and process innovations, implementing external SMP may indirectly lead to better performance on reaching ES. Likewise, process innovation mediates the relationship between internal SMP and ES. Thus, based on these statistical evidences, firms should put highly consideration in strengthening their innovation capabilities when adopting sustainable practices, specifically in offerings new products in the markets and creating or improving production processes, for improving economic performance.

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