ENHANCING FLEXIBLE MARKETING POSTPONEMENT STRATEGY AND CUSTOMER RELATED PERFORMANCE: THE ROLE OF NEW TECHNOLOGY AND INNOVATION

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ABSTRACT

This paper examines the importance of incorporating new technology and innovation in supply chain management (SCM) processes in Malaysian companies. The study measures senior production or SCM managers’ perceptions regarding new technology and innovation in supply chain management processes and level of performances in their companies. The paper specifically investigates relationship between new technological and innovation in SCM, Marketing postponement flexibility and customer related performance (CRP) and these associations were analyzed through statistical methods such as Pearson’s correlation, cluster analysis and Structural Equation Modelling (SEM). The findings suggest that new technology and innovation in SCM processes, and its adoptions have significant correlations with Marketing postponement flexibility and customer related performance. In addition, the SEM result demonstrates that new technology and innovation in SCM proxies namely ‘technology and innovation in product and process design’, ‘technology and innovation in new product development’ and ‘technology and innovation in production line process’ appear to be of primary importance and exhibit significant impact on Marketing postponement flexibility and customer-related performance. Findings of the study provide striking demonstrations of the power and importance of new technology and innovation in enhancing performances of companies. The result indicates that companies should emphasize greater attention to the product and process design as well as new product development aspects of the
new technology and innovation in SCM and marketing as well as a greater degree of management support for technological enhancement initiatives.

**Key words:** Supply chain management (SCM), New technology and innovation, Marketing postponement flexibility, Customer related performance and Structural equation modeling (SEM).

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1. INTRODUCTION

The process of making, distributing and marketing products and services to customers is becoming the most effective and efficient way for businesses to stay relevant and is central to the practice of supply chain management (SCM). As global competition increases, manufacturing companies should be more involved in how their suppliers and customers operate their businesses. They need to focus on processes that have significant impact on performances. Incorporating new technology and innovation is one of the important elements in SCM. SCM with new technology and innovation orientation involves a new way of approach and includes the integration of vision, culture, and strategy to provide the customers with high technological and quality products at competitive prices (Davis & Heineke, 2005). Increasing global competition and the rising costs of natural resources today as well as customers’ demands for higher product quality, greater product selection, and better customer service have created new challenges for manufacturing companies. The new global business scenario have led many Malaysian manufacturing companies to adopt high technological processes, minimize wastage and defects, enhance product quality to sustain or improve overall firm performance. The main objectives of this paper are:

- To empirically assess the importance of each new technology and innovation variable on performance.
- To empirically determine whether new technology and innovation has significant impact on postponement flexibility.
- To empirically discover whether new technology and innovation has significant impact on customer related performance.
- To empirically test whether there is a direct effect of postponement flexibility on customer related performance.
- To empirically highlight new technological and innovation variables most emphasized by high financial performance companies.

This paper explores the possibility of adopting new technology and innovation in SCM processes as the basis for enhancing marketing postponement flexibility (POSTPONE) and customer related performance (CRP) in Malaysian manufacturing companies. First, this paper proceeds with a brief explanation on the new technology and innovation in SCM principles and literature review; second, it highlights the conceptual framework which includes the explanation of the conceptual model and hypotheses. Third, it discusses the methodology adopted, and the tests conducted to obtain reliable and valid measures of variables. Fourth, it highlights the preliminary statistical analyses which include correlations between new technology and
innovation in SCM, postponement flexibility and customer related performance, classification of companies using cluster analysis and rankings of new technology and innovation variables using Friedman rank test. Fifth, it presents the result of structural equation modelling (SEM). Finally, the overall results are then discussed and implications highlighted.

2. LITERATURE REVIEW

2.1 New Technology and Innovation in Supply Chain Management

SCM involves integration, co-ordination and collaboration across organizations and throughout the supply chain. According to Ganeshan and Harrison (1999), a supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers. Supply chain management (SCM) is “the management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole” (Christopher, 1998). SCM comprises of functions like distribution planning, demand forecasting, purchasing, requirement planning, production planning, warehousing, material handling, inventory, packaging, order processing, and transportation etc. All these functions are considered as building blocks of SCM in today's business environment.

Supply chain management seeks to enhance performance by closely integrating and coordinating the internal functions within a company and effectively linking them with the external operations of suppliers and customers. Firms must achieve a relatively high degree of integration before implementing SCM which involves integration, coordination and collaboration across organizations and throughout the supply chain.

Today’s era of global competition has created increasing challenges for manufacturing companies. Manufacturing companies that do not keep up with new technology and innovation would lose out to competitors. Nowadays, manufacturing companies do not only compete on prices but also on who would first introduce new technological, creative, innovative and high quality products to enable them to be market leaders and ultimately gain higher profits. Supply Chain management has the potential to assist the organization in achieving both cost and a value advantage (Christopher, 1998 & Lambert, 1998). Many researchers claim that supply chain management can result in better supply chain performance (Christopher, 1998 and Christiansee & Kumar, 2000), but very few empirical studies have been carried to investigate the impact of new technology and innovation in SCM on postponement flexibility and customer related performance. There are a number of processes for incorporating new technology and innovation investigated in this study namely ‘technology and innovation in product and process design’, ‘technology and innovation in new product development’ and ‘technology and innovation in production line processes’.

New technology and innovation in this study includes new technology and innovation in SCM system, designs and processes. New technology and innovation refers to the application of the latest scientific or engineering discoveries to the design of operations and production processes. New technology and innovation can also mean that information technology and automation have been integrated into the processes. The term automation refers to the integration of a range of advanced
information and engineering discoveries into operations processes. Automation projects are basically initiated to achieve improved quality, faster production and increased flexibility. There is a variety of new technologies used in manufacturing. Types of manufacturing automation may include machine attachment, numerically control machine, robots, automated quality control inspection, automatic identification systems and automated process control. On the other hand automated production systems may comprise of automated flow lines, automated assembly systems, flexible manufacturing systems, automated storage and retrieval systems. Lastly software systems for automation may include several computer -based systems such as computer aided design (CAD) or computer aided manufacturing (CAM), computer integrated manufacturing (CIM) and enterprise resource planning (ERP) (Gaither & Frazier, 2002).

New technology and innovation can create cost-effective, flexible and agile supply chain management. New technology and innovation can be effectively leveraged in supply chain management (SCM) in the context of the Malaysian manufacturing environment in order to achieve operational excellence, high technological processes, business growth, better informative decision making and new opportunities. With global purchasing, high-quality and high-technology products are the factors that drive purchases. Many of the improvements in supply chain performance would not have been possible without similar improvements in the new technology and innovations as well as information systems that are the backbone of most well-run supply chains. In addition, new technology and innovations are changing the way supply chains perform. Internet, intranet and other electronic communications can synchronize a firm’s supply chain with those of its supply chain members in producing, merchandising and transporting products more efficiently. Product design collaboration using new technological decision support systems manages design across the lifecycle of a product, from introduction to service support to obsolescence, by having suppliers become part of the design process. This helps cut design and production times, improves product quality, and achieves faster time-to-market (Gaither & Frazier, 2002).

2.2. Marketing Postponement Concept

Postponement involves the process of delaying marketing final product configuration until the actual order requirement is specified by the customer. Keeping products in semi-finished would allow more flexibility and customization in completing the final products and also enables a company to respond more quickly to market demand. Postponement is an approach to marketing, designing and developing standard, configurable products that can be differentiated quickly and inexpensively once actual customer demand is known. Basically, postponement simply means adding variety after receiving a customer order rather than in anticipation of orders (Ballou, 1999; Iacocca Institute, 1991).

To manage inventory effectively in this environment, companies must anticipate demand changes. However, global market demand is difficult to forecast in times of economic uncertainty. It is even more challenging when you add the competitive pressures of globalization, shorter product cycles, mass customization, and outsourcing. Although holding finished products as inventory can buffered the impact of uncertainties and can accommodate the market needs but finished products lose value quickly and risk obsolescence or inventory write-offs. Further complicating the demand challenge is the fact that customer demand for product specification is
increasing, and companies must produce several versions of each model (Ballou, 1999; Lampel and Mintzbert, 1996; Van Hoek, 2000)).

Producing value added products that fulfill customers’ requirements at the exact place and time, enable companies to maximise their profits through fully understanding real customer requirements. However, many companies are exploring ways toward this in response to constantly changing demands. This allows a manufacturer to achieve the marketing benefits of customisation while reaping the cost benefits of standardised production in anticipation of future customer orders (Lampel and Mintzbert, 1996). With a high degree of conformance to the customers’ ultimate requirements, postponement has been identified as an important approach for contributing to the attainment of agility and customer orientation, through its contribution to the:

- customisation of products and services;
- use of customer order information through the supply chain; and
- cross functional efforts (Van Hoek, 2000).

Many manufacturers and retailers today are turning to postponement, or a delayed differentiation strategy, to strike the right inventory balance at all points in the product lifecycle. By holding inventory in a less-finished state or postponing final product assembly until actual customer demand is known, companies can respond more quickly to market opportunities and offer greater customization options. However, adopting a postponement strategy typically requires a fundamental redesign of manufacturing processes. Postponement also calls for a high degree of collaboration and visibility across the supply chain. In all cases, however, postponement is used as a way to reduce risk and inventories while still providing high product variety and acceptable response times (Van Hoek, 2001; Iacocca Institute, 1991).

3. THE CONCEPTUAL FRAMEWORK

3.1. The Conceptual Model

This section explores the linkages between new technology and innovation, postponement flexibility and customer related performance constructs and variables within the context of the Malaysian manufacturing industry. The proposed model, as depicted in Figure 1, is based on three main constructs—(i) Technology and innovation (TECH); (ii) Postponement flexibility (POSTPONE); and (iii) Customer related performance (CRP).

Essentially, new technology and innovation variables represent a manager’s assessment of the overall level of new technology and innovation in SCM. Three dimensions of new technology and innovation in SCM processes adapted from several sources (Davis & Heineke 2005, Mekong capital.com, 2004) were considered to relate to distinctive features of new technology and innovation in SCM processes and are therefore incorporated in the conceptual model as shown in Figure 1. The new technology and innovation dimensions include: ‘Technology and innovation in new product development’ (T7NPDEV), ‘Technology and innovation in product and process design’ (T7PPDSGN), and ‘Technology and innovation in production line process’ (T7PPROC).

In order to capture the multi-dimensional nature of performance measures, postponement flexibility is manifested by ‘Flexibility in developing different versions or product’ (PVERSION), ‘Flexibility in meeting changing customers needs’
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(PCNEEDS), ‘Flexibility in modifying demand function’ (PMDD) and ‘Flexibility in
catering for current trend of demand from customers’ (PCTREND). On the other
hand, customer related performance is operationalised by scales namely ‘Fill
customers’ orders on time’ (CORDER), ‘Meet customers’ short order-to-delivery
cycle time’ (CCYCLE) and ‘Fast respond to customers needs’ (CFASTRES).

Figure 1 The Conceptual Framework Linking New technology and innovation in SCM,
Marketing Postponement Flexibility and Customer Related Performance

3.2. Hypotheses

New technology and innovation variables have important influence on production and
customer results such as marketing postponement flexibility and customer related
performance. A structural equation model is used in this study to analyze the
structural effect of new technology and innovation in SCM processes on these
performance results. The first hypothesis states that implementing effective new
technology and innovation processes can enhance marketing postponement flexibility.
The second hypothesis proposes that implementing new technology and innovation
processes improves customer related performance. In addition, this study tries to test
(The third hypothesis) whether there is a direct effect of marketing postponement
flexibility on customer related performance within the context of Malaysian
manufacturing companies. Therefore, the following main hypotheses are investigated:

\[ H_1: \text{New technology and innovation has a positive structural effect on}
\]
postponement flexibility.

\[ H_2: \text{New technology and innovation has a positive structural effect on customer}
\]
related performance.

\[ H_3: \text{Marketing Postponement Flexibility has a positive structural effect on}
\]
customer related performance.
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In investigating the structural effect of new technology and innovation on those performance results, it is also pertinent to determine the structural loadings of each new technology and innovation variable. Therefore, this study also attempts to test the following hypotheses:

\( H_{1A} \): ‘New technology and innovation in new product development’ has positive structural loading on new technology and innovation in SCM.

\( H_{1B} \): ‘New technology and innovation in product and process design’ has a positive structural loading on new technology and innovation in SCM.

\( H_{1C} \): ‘New technology and innovation in production line processes’ has a positive structural loading on new technology and innovation in SCM.

More importantly, this study aims to test the overall SEM model fit based on the main null hypothesis:

\( H_0 \): The overall hypothesized model has a good fit.

For structural modeling, accepting this hypothesis indicates that the model presented, adequately reproduce the observed covariance matrix (Bollen, 1989; Joreskog, 1989; Mueller, 1996) and suggests that the data fit the proposed SEM model. Therefore, later in the test of goodness of fit for the structural equation modeling, the probability that is expected should not be significant (probability value > 0.05) to support the overall null hypothesis which suggests that the overall hypothesized model has a good fit.

4. RESEARCH METHODOLOGY

The main intention of this study is to comprehend how new technology and innovation in SCM processes influence performances of the companies. The units of analysis chosen for this study are Malaysian manufacturing companies and each company is being represented by either production or SCM manager. The sampling frame was derived from the Federation of Malaysian Manufacturing Companies Directory (FMM). Two hundred useable responses were analyzed using the SPSS package from a targeted 300 hundred companies. The primary purpose of the research was to measure production manager’s or SCM manager’s perception of new technology and innovation initiatives and to gain insight into the benefits of adopting new technology and innovation in the manufacturing industry. The goal is to understand and determine critical variables of new technology and innovation in SCM that would be able to better enhance marketing postponement flexibility and customer related performance. Face to face interviews with these managers were conducted for checking the information accuracy, validating the outcome of analysis and developing an understanding of practical aspects of new technology and innovation in SCM.

The instrument used in this study was a structured survey questionnaire, which was designed to assess the companies in term of the described dimensions. The instrument developed consists of two major parts. The first part comprises several constructs measuring new technology and innovation in SCM, and the second part comprises several performance measurements. To enable respondents to indicate their answers, seven–point interval scales were used for the questionnaire regarding the level of SCM practices including the element of new technology and innovation in the companies. The respondents were asked to indicate the current practice of the new technology and innovation in SCM processes based on the scale of 1 (very low degree
of current practice) to 7 (very high degree of current practice). A total of three determinants of new technology and innovation variables, which have been widely referred, were extracted. Due to confidentiality matters and standardization of measurements, the performance measures namely marketing postponement flexibility and customer related performance also used a seven-point interval scale, representing a range of agreement on statements whether over the past three years these performances are high relative to competitors after implementing new technology and innovation in SCM processes. Before creating the final scales, the data were checked for normality and outliers.

5. INDEPENDENT AND DEPENDENT CONSTRUCTS’ MEASUREMENT: FACTOR ANALYSES, VALIDITY AND RELIABILITY

As the initial data analysis, new technology and innovation and marketing postponement flexibility as well as customer related performance (CRP) variables or proxies were subjected to factor analyses, validity and reliability tests. These tests were computed to select and assess the final items of the constructs that would be utilized for statistical and hypotheses testing. Exploratory factor analysis (EFA) was conducted to investigate whether the factors derived from the exploratory factor analysis fit the constructs described theoretically in the literature review (Table 1). The result from the exploratory factor analysis (Table 2) indicates that the KMO (Kaiser-Meyer-Olkin) measure is 0.874 with significant chi-square value (Barlett’s Test of Sphericity = 1675.063). The value of KMO in this analysis surpasses the threshold value of 0.50 as recommended by Hair et. al (1998). All constructs exhibit high factor loadings and fall into the designated factors. This result provides evidence to support the theoretical conceptualization of the three constructs.

The confirmatory factor analysis (CFA) or a measurement model using AMOS 5 was employed for examining construct validity of each scale by assessing how well the individual item measured the scale (Ahire, Golhar and Walter 1996). Specifically, the confirmatory factor analysis was used to detect the unidimensionality of each construct. Unidimensionality is evidence that a single trait or construct underlie a set of measures (Hair et al. 1988). The goodness of fit index (GFI) and comparative fit index (CFI) of the three constructs computed from the confirmatory factor analysis (CFA) exceeded the 0.90 criterion suggested by Hair et al. (1998), hence, establishing the construct validity (see Table 2). CFA showed all the items were loaded highly on their corresponding constructs, which supported the independence of the constructs and provided strong empirical evidence of their validity.

Since data for this study was generated using multi-scaled responses, it was deemed necessary to test for reliability (Frohlich & Westbrook, 2001). The reliability analysis was conducted by calculating the Cronbach’s alpha for the main constructs. Items that did not significantly contribute to the reliability were eliminated for parsimony purpose. The result shows that the Cronbach’s alpha measures for the three main constructs exceeds the threshold point of 0.70 suggested by Nunnally (1978).
Enhancing Flexible Marketing Postponement Strategy and Customer Related Performance: The Role of New Technology and Innovation

Table 1 Descriptive Statistics and Factor Analysis

<table>
<thead>
<tr>
<th>New technology and innovation (TECH):</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Exploratory Factor Analysis –EFA (Varimax Rotation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Factor Loadings1 (POSTPONE)</td>
</tr>
<tr>
<td>Technology and innovation in new product development (T7NPDEV)</td>
<td>5.2400</td>
<td>1.35335</td>
<td>.305</td>
</tr>
<tr>
<td>Technology and innovation in product and process design (T7PPDSGN)</td>
<td>5.1950</td>
<td>1.41314</td>
<td>.275</td>
</tr>
<tr>
<td>Technology and innovation in production line process (T7PPROC)</td>
<td>5.0700</td>
<td>1.38372</td>
<td>.274</td>
</tr>
<tr>
<td>Postponement Flexibility:(POSTPONE)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexibility in developing different versions of product (PVERSION)</td>
<td>5.2200</td>
<td>1.25278</td>
<td>.801</td>
</tr>
<tr>
<td>Flexibility in meeting customer changing needs (PCNEEDS)</td>
<td>5.3900</td>
<td>1.17251</td>
<td>.830</td>
</tr>
<tr>
<td>Flexibility in modifying demand function (PMDD)</td>
<td>5.2700</td>
<td>1.18496</td>
<td>.855</td>
</tr>
<tr>
<td>Flexibility in catering for current trend of demand (PCTREND)</td>
<td>5.3000</td>
<td>1.11635</td>
<td>.828</td>
</tr>
<tr>
<td>Customer related performance (CRP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fill customers’ orders on time (CORDER)</td>
<td>5.1900</td>
<td>1.13150</td>
<td>.173</td>
</tr>
<tr>
<td>Meet customers’ short order-to-delivery cycle time (CCYCLE)</td>
<td>5.1600</td>
<td>1.14935</td>
<td>.188</td>
</tr>
<tr>
<td>Fast respond to customer needs (CFASTRES)</td>
<td>5.3000</td>
<td>1.04665</td>
<td>.179</td>
</tr>
</tbody>
</table>

Alpha coefficients for new technology and innovation, postponement flexibility and customer related performance ranged between 0.898 and 0.943 after the alpha maximization process were carried out (Table 2). As a result, 10 items were retained for the three constructs.

Table 2 Statistical Results

<table>
<thead>
<tr>
<th>CONSTRUCT</th>
<th>Exploratory Factor Analysis –EFA (Varimax Rotation)</th>
<th>Confirmatory Factor Analysis (CFA)</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eigenvalue</td>
<td>% of Variance Explained</td>
<td>Cumulative Variance Explained</td>
</tr>
<tr>
<td>Technology and innovation</td>
<td>3.088</td>
<td>30.876</td>
<td>30.876</td>
</tr>
<tr>
<td>Postponement Flexibility</td>
<td>2.670</td>
<td>26.696</td>
<td>57.572</td>
</tr>
<tr>
<td>Customer related performance</td>
<td>2.635</td>
<td>26.351</td>
<td>83.923</td>
</tr>
</tbody>
</table>
Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization (KMO= 0.874, Bartlett's Test of Sphericity (chi-sq)= 1675.063**) 

6. PRELIMINARY RESULTS 

6.1 Pearson’s Correlations between Technology and Innovation, Marketing Postponement Flexibility and Customer Related Performance 

Table 3 exhibits Pearson’s correlations between new technology and innovation, marketing postponement flexibility as well as customer related performance. A single measurement was obtained for marketing postponement flexibility by averaging determinants namely ‘Flexibility in developing different versions of product’, ‘Flexibility in meeting customer changing needs’, ‘Flexibility in modifying demand function’ and ‘Flexibility in catering for current trend of demand’. The same method applies whereby a customer related performance (CRP) indicator was derived by compounding determinants specifically ‘Fill customers’ orders on time’, ‘Meet customers’ short order-to-delivery cycle time’ and ‘Fast respond to customer needs’ into a single measurement. The result suggests that marketing postponement flexibility indicator has high correlations with ‘Technology and innovation in new product development’ (r = 0.566) followed by ‘Technology and innovation in product and process design’ (r = 0.544) and lastly ‘Technology and innovation in production line process’ (r = 0.532).

Table 3 Pearson’s Correlation between Technology and Innovation, Postponement Flexibility and Customer Related Performance

<table>
<thead>
<tr>
<th>Technology and Innovation in SCM (TECH)</th>
<th>Postpone ment Flexibility</th>
<th>Customer Related Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Technology and innovation in new product development (T7NPDEV)</td>
<td>.566( **)</td>
<td>.529( **)</td>
</tr>
<tr>
<td>2 Technology and innovation in product and process design (T7PPDSGN)</td>
<td>.544( **)</td>
<td>.518( **)</td>
</tr>
<tr>
<td>3 Technology and innovation in production line process (T7PPROC)</td>
<td>.532( **)</td>
<td>.484( **)</td>
</tr>
</tbody>
</table>

The findings suggest that to support the implementations of marketing postponement concept and enhance marketing postponement flexibility, a manufacturing company should invest its resources in incorporating new technology and innovation in production line process, new product development as well as product and design process to accentuate the abilities to respond faster to customer changing needs. Customer related performance indicator has high correlations with all new technology and innovation variables especially with ‘Technology and innovation in new product development’ (r = 0.529). Hence, the result suggests that technology and innovation in new product development, as well as in product and process design are very crucial in an attempt to enhance customer related performance.

6.2 The Cluster Analysis and Friedman’s Rank Test 

At this point, it is also pertinent to investigate what are the crucial new technology and innovation processes that are most emphasized by high financial performance
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companies so as to provide a guideline to other upcoming manufacturing companies. To achieve this purpose, it is necessary that this study explores on the segmentation or classification of manufacturing companies by computing the cluster analysis. Three cluster analyses were conducted to further explore on the segmentation of manufacturing companies in this study. Since financial performance is a very important bottom-line outcome, therefore the first company classification is based on financial performance clustering. The result from cluster analysis statistically segmented these manufacturing companies into two clusters based on financial performance measurement namely “High Financial performance companies” and “Low financial performance companies”. Table 4 highlights further information about these clusters. From the result, we can also suggest that higher level of new technology and innovation implementations are more pertinent in “High financial performance companies”, in comparison to “Low financial performance companies”. The finding highlights that “High financial performance companies” set high priority on technological aspect of production such as ‘Technology and innovation in product and process design’, ‘Technology and innovation in product development’ and ‘Technology and innovation in production line processes’. The rationale for these three emphasis are obvious, since to respond faster to customers changing needs, to gain a bigger market share and to penetrate new market, a manufacturing company needs to produce high quality and new technological products in order to become the market leader and reap better profits.

Table 4 Rankings of Technology and Innovation in SCM Based on Financial Performance Using Friedman’s Test

<table>
<thead>
<tr>
<th>New technology and innovation in SCM</th>
<th>High financial performance companies (n = 142, chi-square = 6.705, significant =0.035, overall cluster’s mean = 5.451)</th>
<th>Low financial performance companies (n=58, chi-square = 2.886, significant =0.236, overall cluster’s mean = 4.477)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friedman’s Test Rank Mean Std Dev</td>
<td>Friedman’s Test Rank Mean Std Dev</td>
<td>Friedman’s Test Rank Mean Std Dev</td>
</tr>
<tr>
<td>Technology and innovation in new product development (T7NPDEV) 2.07 1 5.521 1.219</td>
<td>2.06 1 4.552 1.429</td>
<td>2.04 2 5.479 1.264</td>
</tr>
<tr>
<td>Technology and innovation in product and process design (T7PPDSGN) 2.04 2 5.479 1.264</td>
<td>2.05 2 4.500 1.525</td>
<td>1.89 3 5.352 1.262</td>
</tr>
<tr>
<td>Technology and innovation in production line process (T7PPROC) 1.89 3 5.352 1.262</td>
<td>1.89 3 4.379 1.437</td>
<td>1.89 3 4.379 1.437</td>
</tr>
</tbody>
</table>

The second cluster analysis categorizes these manufacturing companies into one of two groups:

1. “Excellent” marketing postponement flexibility achievers.
2. “Low” marketing postponement flexibility achievers.

The result suggests that in order to emulate “excellent” marketing postponement flexibility achievers, a manufacturing company should emphasize on “Technology and innovation in new product development”, “Technology and innovation in product and process design” and “Technology and innovation in production line process” (see Table 5). The advancement of technology in manufacturing processes would support
the postponement in marketing, producing the final product and enable companies to enhance the process of product customization.

**Table 5** Rankings of New technology and innovation Variables Based on Marketing Postponement Flexibility Using Friedman’s Test

<table>
<thead>
<tr>
<th>New technology and innovation in SCM</th>
<th>Excellent marketing postponement flexibility achievers (n =137, chi-square = 9.547, significant=0.008, overall cluster’s mean = 5.564)</th>
<th>Low marketing postponement flexibility achievers (n=63, chi-square = 1.689, significant=0.430, overall cluster’s mean = 4.307)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friedman’s Test</td>
<td>Rank</td>
<td>Mean</td>
</tr>
<tr>
<td>Technology and innovation in new product development (T7NPDEV)</td>
<td>2.09</td>
<td>1</td>
</tr>
<tr>
<td>Technology and innovation in product and process design (T7PPDSGN)</td>
<td>2.03</td>
<td>2</td>
</tr>
<tr>
<td>Technology and innovation in production line process (T7PPROC)</td>
<td>1.88</td>
<td>3</td>
</tr>
</tbody>
</table>

**Table 6** Rankings of Technology and Innovation Variables Based on Customer Related Performance Using Friedman’s Test

<table>
<thead>
<tr>
<th>Technology and innovation in SCM</th>
<th>High customer related performers (n=134, chi-square = 5.485, significant=0.064, overall cluster’s mean = 5.520)</th>
<th>Low customer related performers (n=66, chi-square = 24.263, significant=0.119, overall cluster’s mean = 4.454)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friedman’s Test</td>
<td>Rank</td>
<td>Mean</td>
</tr>
<tr>
<td>Technology and innovation in new product development (T7NPDEV)</td>
<td>2.07</td>
<td>1</td>
</tr>
<tr>
<td>Technology and innovation in product and process design (T7PPDSGN)</td>
<td>2.03</td>
<td>2</td>
</tr>
<tr>
<td>Technology and innovation in production line process (T7PPROC)</td>
<td>1.90</td>
<td>3</td>
</tr>
</tbody>
</table>

Since customer related performance is also a very importance bottom-line outcome, therefore the last classification is based on customer related performance clustering. This last cluster analysis segregates the manufacturing companies into one of two groups:
Table 6 highlights further information about the cluster. From the result, we can also infer that the higher level of new technology and innovation variables are more pertinent among “High” customer related performers than “Low” customer related performers. “High” customer related performers” set high priorities on “Technology and innovation in new product development”, “Technology and innovation in product and process design” and “Technology and innovation in production line processes”.

Overall, we can conclude that high performance companies set high priorities on technology and innovation in new product development. Product and production designs are continuously developed and modified to adapt to changing market conditions and changing production technology and to allow for manufacturing improvements.

7.0. STRUCTURAL EQUATION MODELING

Given the confirmatory nature of this study, the statistical analysis technique called structural equation modelling (SEM) was utilized. A SEM model was employed to investigate simultaneous linkages that allow a researcher to determine the relative strength of relationships between variables. The linkages between new technology and innovation (TECH), postponement flexibility (POSTPONE), and customer-related performance (CRP), are depicted in the model shown in Figure 2. The SEM model was evaluated to check if the specified items provided adequate fit. To support the assumption regarding the fitness of the SEM model with the empirical data, the acceptance of the null hypothesis of the overall model is expected. Hence, in this test of goodness of fit for the structural equation modeling, the resulting probability should be higher than 0.05 to support the overall null hypothesis of the model.

Table 7 Results of the Overall Model Fit

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Model Values</th>
<th>Recommended values for good fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi square</td>
<td>37.801</td>
<td></td>
</tr>
<tr>
<td>Probability Level</td>
<td>0.221</td>
<td>≥ 0.05</td>
</tr>
<tr>
<td>Degree of Freedom</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>$\chi^2$/df</td>
<td>1.181</td>
<td>≤ 3.00</td>
</tr>
<tr>
<td>Bollen (1989) Incremental Fit Index (IFI)</td>
<td>0.997</td>
<td>≥ 0.90</td>
</tr>
<tr>
<td>Tucker &amp; Lewis (1973) TLI</td>
<td>0.995</td>
<td>≥ 0.90</td>
</tr>
<tr>
<td>Bentler (1988) comparative fit model (CFI)</td>
<td>0.997</td>
<td>≥ 0.90</td>
</tr>
<tr>
<td>Normed fit index (NFI)</td>
<td>0.978</td>
<td>≥ 0.90</td>
</tr>
<tr>
<td>Goodness of fit index (GFI)</td>
<td>0.965</td>
<td>≥ 0.90</td>
</tr>
</tbody>
</table>

*Chau (1997)

The findings of the SEM model indicate that the resulting Chi-square value is 37.801 with 32 degrees of freedom and p-value of 0.221 (Figure 2). The result supports the null hypothesis that the SEM model has a good fit ($H_0$). The p-value is considerably substantial (p-value > 0.05), in supporting the proposition that the overall model fits the data. Furthermore, other statistical structural indices such as Bentler comparative
fit model (CFI = 0.997), Bollen Incremental Fit Index (IFI = 0.997) and Tucker and Lewis Index (TLI = 0.995) further suggest that the model has a satisfactory fit (Table 7). Since the probability value and structural modeling indices are well above the recommended level, the model is considered to be a reasonable representation of the data (Hair et al., 1998; Za’faran Hassan and Arawati Agus 2010, Za’faran Hassan, Ramachandran, K. K., & Norlida Kamaluddin, 2013).

The direct structural effect of new technology and innovation on marketing postponement flexibility (structural effect = 0.620) is considered high given the complex causal linkages, suggesting the importance of ‘Technology and innovation in new product development’ followed by ‘Technology and innovation in product and process design’ and lastly ‘Technology and innovation in production line process’ in supporting postponement flexibility in Malaysian manufacturing industry. Therefore, we have enough evidence to accept the proposition that new technology and innovation in SCM has a positive and significant structural effect on postponement flexibility ($H_1$ is supported). Establishing the causal linkages between input and bottom-line outcomes is difficult in most complex system. Surprisingly, the direct structural effect of technology and innovation on customer related performance is quite high and significant (structural effect = 0.451) ($H_2$ is supported). However, the direct structural effect of postponement flexibility on customer related performance (structural effect = 0.200) is relatively low but still significant and able to support the third hypothesis ($H_3$ direct effect is supported). These findings suggest that new technology and innovation is able to enhance postponement flexibility and customer related performance directly.

![Figure 2](image)

**Figure 2** The Structural Linkage between New technology and innovation, Postponement Flexibility and Customer Related Performance

Looking at the structural loadings of each new technology and innovation determinants (Table 8) on the main construct, we can see that new technology and innovation in product and process design (structural loading = 0.958) has the highest contribution towards new technology and innovation implementation. This is followed by new technology and innovation in new product development (structural loading = 0.933) and lastly new technology and innovation in production line process
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(structural loading = 0.874). All of these indicators have significant probability values (critical values ≥ 2.00), giving statistical evidence that the contributions of these variables towards overall new technology and innovation construct are significant and positive ($H_{1A}$, $H_{1B}$ and $H_{1C}$ are supported). The examination of residuals also reveals that variances among variables are perfectly explained by the respective constructs.

**Table 8** Structural and Measurement Results of the SEM Model

<table>
<thead>
<tr>
<th>(i) Constructs and indicators</th>
<th>Std. Loadings</th>
<th>Std. Errors</th>
<th>Critical Ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. New technology and innovation :</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology and innovation in new product development (T7NPDEV)</td>
<td>.933</td>
<td>.052</td>
<td>20.036</td>
<td>0.000</td>
</tr>
<tr>
<td>Technology and innovation in product and process design (T7PPDSGN)</td>
<td>.958</td>
<td>.053</td>
<td>21.046</td>
<td>0.000</td>
</tr>
<tr>
<td>Technology and innovation in production line process (T7PPROC)</td>
<td>.874</td>
<td>.042</td>
<td>21.045</td>
<td>0.000</td>
</tr>
<tr>
<td>b. Postponement Flexibility:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexibility in developing different versions of product (PVERSION)</td>
<td>.780</td>
<td>.073</td>
<td>13.133</td>
<td>0.000</td>
</tr>
<tr>
<td>Flexibility in meeting customer changing needs (PCNEEDS)</td>
<td>.864</td>
<td>.072</td>
<td>14.348</td>
<td>0.000</td>
</tr>
<tr>
<td>Flexibility in modifying demand function (PMDD)</td>
<td>.826</td>
<td>.080</td>
<td>12.456</td>
<td>0.000</td>
</tr>
<tr>
<td>Flexibility in catering for current trend of demand (PCTREND)</td>
<td>.856</td>
<td>.062</td>
<td>15.156</td>
<td>0.000</td>
</tr>
<tr>
<td>c. Customer related performance:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fill customers’ orders on time (CORDER)</td>
<td>.891</td>
<td>.053</td>
<td>18.225</td>
<td>0.000</td>
</tr>
<tr>
<td>Meet customers’ short order-to-delivery cycle time (CCYCLE)</td>
<td>.900</td>
<td>.059</td>
<td>18.528</td>
<td>0.000</td>
</tr>
<tr>
<td>Fast respond to customer needs (CFASTRES)</td>
<td>.899</td>
<td>.049</td>
<td>18.528</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Thus, a manufacturing company can improve its marketing postponement flexibility and customer related performance by integrating and adopting new technology and innovation in SCM processes. The result highlights the unique contribution of new technology and innovation on postponement flexibility and customer related performance and supports the notion that the structural model has a satisfactory fit. We can obviously suggest that new technology and innovation can help manufacturing companies enhance postponement flexibility and ultimately improve customer related performance of manufacturing industry in Malaysia.

**8. CONCLUSION AND IMPLICATIONS**

To meet the increasing demands of high-quality and technological goods from sophisticated local and overseas markets, manufacturing companies must continuously improve their efforts in technological and quality operations. New
technology and innovation in SCM provides a vision that focuses everyone in an organization on product, production and quality improvements. The pursuit of these improvements is not only requested by the market but also driven by the need to survive. The importance of critical variables of technology and innovation is highlighted by utilizing SEM.

The associations and effects of the three technological and innovation variables are also evaluated using Pearson’s correlations and cluster analyses, in addition to structural equation modeling (SEM). The results of the study assist in the understandings of how technology and innovation determinants influence marketing postponement flexibility and customer related performance. The findings and evidences derived from the statistical analysis lead to several main conclusions suggested as follows:

1. Technology and innovation in SCM has significant correlations with marketing postponement flexibility.
2. ‘Technology and innovation in new product development process’, ‘Technology and innovation in product and process design’ as well as ‘Technology and innovation in production line process’ have positive and direct effects on postponement flexibility.
3. Postponement flexibility (especially Flexibility in developing different versions of product, Flexibility in meeting customer changing needs, Flexibility in modifying demand function and Flexibility in catering for current trend of demand) have positive and direct effects on customer related performance (specifically Fill customers’ orders on time, Meet customers’ short order-to-delivery cycle time and Fast respond to customer needs).
4. ‘High financial performance companies’ possess higher levels of ‘Technology and innovation in new product development process’, ‘Technology and innovation in product and process design’ as well as ‘Technology and innovation in production line process’ than ‘low financial performance companies’.

In short, the findings of this study suggest that new technology and innovation would be able to support and accommodate the postponement process as well as increase the level of production and marketing flexibility. It would make the task of keeping the product in semi-finished forms less complex and able to accelerate the process of transforming the products into the final outputs according to customers’ specifications. New technology and innovation would no doubt increase the marketing postponement flexibility in catering the changing customers’ needs. This subsequently would lead to better product customization and ultimately increase the abilities to fill customers’ orders on time, meet customers’ short order-to-delivery cycle time and respond faster to customer needs. Achievement of these benefits requires changes in the way companies design and develop products and production line processes using new technological tools. Though expensive at the initial stage of adoption, the outcomes can be substantial. Using the latest design technology, the manufacturing companies may save huge amounts of time and money in bringing new products to market faster. Many companies today are on the forefront of installing technological system and processes such as assembly lines using robots and automated, computer-driven machines (Gaither & Frazier, 2002).

The conclusion emerging from this study is that new technology and innovation in supply chain management processes would ultimately result in positive gains. The results validate some of the key linkages and support beliefs and evidences by researchers regarding the relationships between new technology and innovation in SCM, marketing postponement flexibility and customer related performance. It is also
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important to note that this study attempts to enrich the literature review and make a contribution in supply chain management-related studies. This study to some extent helps in resolving controversy about the magnitude and measurements of performance gains from adopting new technology and innovation in SCM. By strengthening new technology and innovation processes, improved performance will likely to occur. This result provides evidence that improving internal practices will positively impact the most important bottom-line performance measures.

The study will be of particular interest to practicing production managers or top level managers as it suggests what new technology and innovations factors that should be emphasized or prioritized to stimulate performances. The result indicates that manufacturing companies should emphasize greater attention to the new product development aspects of the new technology and innovation in SCM processes and a greater degree of management support for new technology and innovation enhancement initiatives.

REFERENCES


