Faculty of Manufacturing Engineering

AN INTEGRATIVE MODEL OF RESPONSIVENESS AND SUSTAINABILITY REQUIREMENTS FOR AUTOMOTIVE INDUSTRY

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DECLARATION

I declare that this thesis entitled "An Integrative Model of Responsiveness and Sustainability Requirements for Automotive Industry" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

Signature :……..

Supervisor Name :……..

Date :……..

Signature :……..

Co-Supervisor Name :……..

Date :……..

DEDICATION

To my parents

Encik Ahmad & Puan Maizon

and

To my siblings

Junaina, Shuhairi, Hidayah & Taufed

This humble work is a sign of

my love to you!

ABSTRACT

Rapid changes in market demands require manufacturing companies to be responsive and at the same time sustainable in order to compete and survive in their industry. Therefore, the determination of the fundamental elements for responsiveness and sustainability are essential in manufacturing company to remain competitive in the rapid changes market. Up to this date, there is no integrated model of responsiveness and sustainability for manufacturing operations. Thus, the aim of this study is to develop an integrated model between manufacturing responsiveness (MR) and manufacturing sustainability (MS) in the context of manufacturing operations. The fundamental elements of MR and MS has been determine through literature study and the model has been developed based on the concept of Input-Transformation-Output system in manufacturing. The results show that the fundamental elements of MR and MS consist of four elements: (i) Driver, (ii) Enabler, (iii) Measure, and (iv) Impact. Then, the components for MR and MS are determined using literature study and Pareto's 80/20 rule. Next, they were verified using email surveys and face-to-face interviews in automotive-based manufacturing companies for avoiding conflict between the proposed components with the real-context of manufacturing. The same method (literature study and Pareto's 80/20 rule) were used to determine the integrated components. Then, integrated model was developed and validated based on the Measure's components using case study approach. Six automotive manufacturing companies from U.S.A, Germany, and Japan were chosen for validation process. The integrated components of MR and MS has been validated in their relationship and the data are collected from the annual report of the these six automotive manufacturing companies. The results show that all the integrated components have the relation with MR and MS but at the different level which are strong and inconsistent relationship. Thus, this study concludes that the MR and MS have four fundamental elements and sharing their measurable components that have affected their own isolated components.

ABSTRAK

Perubahan yang pesat dalam permintaan pasaran memerlukan syarikat-syarikat pembuatan menjadi responsif dan pada masa yang sama mampan untuk terus bersaing dan bertahan di dalam industri. Oleh itu, penentuan unsur-unsur asas untuk responsif dan kemampanan adalah penting kepada syarikat perkilangan untuk terus kekal kompetitif dalam perubahan pasaran yang pesat. Sehingga kini, tiada lagi model bersepadu responsif dan kemampanan bagi operasi pembuatan. Oleh itu, tujuan kajian ini adalah untuk membangunkan model bersepadu antara responsif pembuatan (MR) dan kemampanan pembuatan (MS) dalam konteks operasi pembuatan. Elemen-elemen asas MR dan MS telah di tentukan melalui kajian literatur dan integrasi model MR dan MS telah dibangunkan berdasarkan konsep sistem Input-Transformasi Output dalam operasi pembuatan. Keputusan kajian menunjukkan bahawa elemen asas MR dan MS terdiri daripada empat elemen, iaitu: (i) Pemacu, (ii) Penggerak, (iii) Pengukur, dan (iv) Kesan. Seterusnya, komponen bagi MR dan MS ditentukan dengan menggunakan kajian literatur dan Peraturan Pareto 80/20. Elemen tersebut telah disahkan menggunakan kaji selidik melalui e-mel dan temu bual bersama lima pakar dari industri automotif di Malaysia. Pengesahan elemen dijalankan melalui Peraturan Pareto 80/20. Model integrasi responsif dan kemampanan dibangunkan menggunakan elemen pengukur dari model MR dan MS. Model integrasi ini telah disahkan menggunakan kajian kes di enam syarikat multinasional dari tiga negara pengeluar utama dalam industry automotif iaitu U.S.A, Jerman, dan Jepun. Kajian kes adalah berdasarkan laporan tahunan syarikat berkenaan untuk lima tahun iaitu 2009 hingga 2013. Keputusan menunjukkan bahawa semua komponen bersepadu mempunyai hubungan dengan MR dan MS tetapi pada tahap yang berbeza iaitu kukuh, tidak konsisten, dan tiada hubungan. Kesimpulannya, MR dan MS yang berkongsi empat komponen pengukur yang juga dikenali sebagai komponen bersepadu (fleksibiliti, penghantaran, kualiti, kos pembuatan) yang memberi kesan kepada prestasi MR dan MS sesebuah syarikat pembuatan

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LIST OF ABBREVIATIONS

BMW	Bayerische Motoren Werke
FCA	Fiat Chrysler Automobiles
MR	Manufacturing Responsiveness
MS	Manufacturing Sustainability
PoC	Percentage of Correlation
STA	Sales Target Achievement

LIST OF PUBLICATIONS

1. Ebrahim, Z., Ahmad, N.A., and Muhamad, M.R. 2014. Understanding Responsiveness in Manufacturing Operations. *Sci. Int. (Lahore)*, 26(5), pp. 1663-1666.
2. Ebrahim, Z., Ahmad, N.A., and Muhamad, M.R. A Model for Manufacturing Sustainability in Manufacturing Operations. Jurnal Teknologi. Status: In review (8384).

CHAPTER 1

INTRODUCTION

1.1 Research Background

In general, a responsive manufacturing company recognises the significance of maintaining and reacting to the customer needs. A 'new breed of customers' demand greater responsiveness to a vigorous set of desires and new competitive situation (Handfield and Nichols, 2002; Bower and Hout, 1988); this phenomenon exposes the local companies to competition from companies worldwide (Monckza and Morgan, 2000; Pagell, 2004). In short, the term Manufacturing Responsiveness (MR) has been associated with how effective a company can react to the needs of the customer while competing in the dynamic markets.

Meanwhile, Manufacturing of sustainability (MS) has arisen through the demand for sustainable economy, environment, and society (Amrina and Yusof, 2011) since it is a critical and timely topic (Linton et al., 2007). In this context, sustainable development is determined as the ability to meet the needs of the present without compromising the ability to meet the needs of the future generations (WCED, 1987). Hence, according to Amrina and Yusof (2011) achieving sustainability in manufacturing activities has been recognised as a acute since shrinking non-renewable resources, stricter regulations related to environment and occupational safety, and expanding consumer demand for environmentally-friendly products.

In addition, Gunasekaran and Spalanzani (2012) suggested that sustainable production operations ought to dependability, cost reduction, responsiveness, flexibility, customisation, and high quality products and services. The result from their study shows that responsiveness actually contributed to the sustainable production operations. It also supported findings of an earlier study on manufacturing responsiveness: a model of Responsive Manufacturing Model founded by Saad and Gindy (2007). In their study, the outputs of responsive manufacturing were accounted for as speed of profitability and growth, response, and customer satisfaction. However, these outputs can only be interpreted into two of three pillars of sustainability concept: (i) Profitability corresponds to sustainable economy, and (ii) Growth, customer satisfaction, and speed of response that correspond to sustainable society. Here, it shows the absence of the third pillar of sustainability, that is sustainable environment. Environmental impacts are accounted for as part of manufacturing performance measures as environmentally sustainable manufacturing practices may be positively related with competitive upshots. Thus, the general description of responsiveness and sustainability can be viewed as the ability of the companies to respond quickly to customer needs with compromised sustainable economy, environment, and society.

1.2 Research Motivation

Responsiveness is a major element which can generate speed in a system (Kritchanchai, 2004). Meanwhile, sustainability is ability of the organisation to improve its economic condition without affecting the natural environment and the social equity for present or future (Feng and Joung, 2009). Up to this date, the integration between MR and MS in the context of manufacturing operations has not yet been developed by any

researcher. In this study, it is believed that the integration between MR and MS will serve as practical methods for manufacturers to assess their manufacturing operation systems.

Over the decades, researchers have articulated and produced numerous models for responsive manufacturing (e.g. Kritchanchai and MacCarthy 1999; Catalan and Kotzab, 2003; Kritchanchai, 2004; Holweg, 2005b; Kurnaz et al., 2005; Reichhart and Holweg, 2007) and sustainable manufacturing (e.g. Bansal and Roth, 2014; Scheumann et al., 2013; Schrettle et al., 2011; Law, 2010; Feng and Joung, 2009). However, all the models were developed as isolated models. These results are inconsistent and ambiguous regarding the enablers of the concepts of MR and MS. Thus, it is crucial to integrate the concept of MR and MS to produce a complete range of outputs of MR and MS such as flexibility, customisation, dependability, responsiveness, high quality products and services, and cost reduction (Gunasekaran and Spalanzani, 2012) as well as economy, sustainable society (Saad and Gindy, 2007) and sustainable environment. In the view of the automotive industry, it encounter greater market pressure to produce high quality products and more quickly, which require a high degree of responsiveness, and the need to sustain the manufacturing operations.

1.3 Research Questions

As the necessity to integrate the concept of MR and MS in the context of manufacturing operations, the following are the research questions:

(i) What are the fundamental elements and components of MR and MS?

(ii) What are the relationships between these fundamental elements and components?

(iii) How can MR and MS be integrated?

1.4 Research Objectives

In this study, the aim is to propose an integrated model for MR and MS in the context of manufacturing operations. Thus, this study embarks on the following objectives:

(i) To determine identify fundamental elements and components of MR and MS in the context of manufacturing operations.

(ii) To develop an integrated model of MR and MS in the context of manufacturing operations and validate the model using case studies related to the automotive industry.

1.5 Research Scope and Limitation

(i) Emphases on responsiveness and sustainability in the context of manufacturing operations, especially in the automotive industry.

(ii) Focus on the measurable components because it can be measured quantitatively for easy to view and understand.

1.6 Research Contributions

The present research delivers significant contributions, particularly in the theoretical and practical perspectives. In theory, this research identifies the relationship between MR and MS in the context of manufacturing operations, specifically automotive manufacturing companies. Through the validation of the proposed model developed, the present study offers some evidences to enhance the understanding of the conceptual model for responsiveness and sustainability, which has been investigated by the previous research. In addition, the proposed integrated model sheds light on the relationships between MR and MS, and it would enhanced understanding of the influences of both MR

and MS on the manufacturing companies. While offering benefits for continuous improvement in manufacturing firms, the principles of the proposed integrated model also can be applied to future studies; the scope of application can be extended to different industries and further development of research on the area of MR and MS.

In practical view, the present research offers significant benefits, especially to the researchers and industrial practitioners. With increased concerns for MR and MS issues, a few pertinent questions arise: what are the fundamental elements for ensuring the company's survival, and can the fundamental elements and components of MR and MS be integrated? Through rigorous processes, the present study has developed and validated an integrated model of MR and MS in the context of manufacturing operations. It is believed that the proposed model could help industrial practitioners in measuring their firm performance in a broader context that includes economic, environmental and social outcomes. Using the proposed model, the industrial practitioners can understand the diverse aspects of MR and MS implementations, and they will be able to identify the strengths and weaknesses in their current practices. Furthermore, the outputs of the study could serve as a source of reference in making decisions and taking further action related to the efforts of promoting environmental protection and social well-being while competing in the dynamic markets.

In summary, the contribution of this study emphasises the theoretical and practical perspectives, which bring benefits to future researchers and industrial practitioners. The proposed integrated model also in fact would benefit not only the body of knowledge, but also other industries which eventually can enhance economic, environmental, and social development of the country.