OPERATIONAL COMPLEXITY IMPACT ON QUALITY AND PERFORMANCE OF ELECTRICAL AND ELECTRONICS INDUSTRY IN MALAYSIA

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Specially dedicated to

My father, Lee Chin Seng, my mother, Oh Lee Goh

My sisters, Lee Shan Chen, Lee Chaei Chen & families

My Muslim family, Nazriyah Dona Mustafa & the Don Dona family

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~In the name of Allah, the Most Gracious and the Most Merciful~

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ABSTRACT

The contingency view of Quality Management (QM) postulates that QM practices and performance does not always have a direct positive relationship but is contingent upon a third variable that might be moderating it. Despite various QM related publications in the literature, few empirical works were conducted with this view in mind. In this study, operational complexity has been identified as the new moderating variable that is affecting the relationship of QM practices and operational performance. This is based on distinct operational characteristics between original equipment manufacturer (OEM) and contract manufacturer (CM). This survey-based study was conducted in Malaysia's Electrical and Electronics (E & E) manufacturing industry that contributes significantly to the economy and creation of jobs in the country. Data were obtained from 116 companies with a response rate of 17.8%, using company as unit of analysis. Partial Least Square Structural Equation Modelling (PLS-SEM) technique was applied to analyze the data. All three multi-dimension variables of QM practices, operational performance and operational complexity were modelled as second-order variables in PLS-SEM. Measurement model was validated using Confirmatory Factor Analysis (CFA) and proven to be reliable. Results of structural model reveal that operational complexity not only has a positive impact on operational performance but also indicate the higher the operational complexity, the stronger the relationship of QM practices and operational performance. There is no significant difference in the level of operational complexity for OEM and CM. The results also reveal that operational complexity is indeed a significant variable that needs more study. The findings imply that high operational complexity is associated with learning organisation and complexity absorption approach enhances QM implementation in organisational level. Meanwhile, low operational complexity is associated with complexity reduction approach and enhances QM implementation in process level. However, based on Complex Adaptive System (CAS), high operational complexity needs to be managed so as not to reach the threshold of a chaotic stage, which will affect performance. Hence, a web-based IT system has been proposed to manage operational complexity in a local CM that faces an increase in frequency of exchange of information with customers. This study contributes to knowledge in contingency view in QM and extended the application of PLS-SEM in operations management research. It provides insights for managers to cope with increasing operational complexity and to improve performance in the current dynamic business environment.

ABSTRAK

Mengikut pandangan kontingensi dalam pengurusan kualiti, hubungan di antara amalan pengurusan kualiti (QM) dan prestasi tidak semestinya sentiasa bersifat positif. Tetapi, wujud pembolehubah ketiga yang memberi kesan penyederhanaan terhadap hubungan tersebut. Walaupun terdapat banyak penerbitan berkaitan QM dalam kesusasteraan, kajian empirik menggunakan pandangan kontingensi adalah terhad. Maka, kajian ini telah mengenalpasti pembolehubah penyederhanaan baru iaitu kerumitan operasi yang memberi kesan pada hubungan amalan QM dan prestasi operasi. Ia berdasarkan wujudnya perbezaan ciri operasi di antara pengeluar peralatan asli (OEM) dan subkontraktor (CM). Kajian berasaskan soalselidik ini telah dijalankan di industri pengilangan Elektrik dan Elektronik (E & E) di Malaysia yang merupakan penyumbang ekonomi negara yang penting serta mencipta banyak peluang pekerjaan. Data diperolehi daripada 116 syarikat pengilangan dan mencatat kadar sambutan sebanyak 17.8% dengan menggunakan syarikat sebagai unit analisis. Teknik Permodelan Persamaan Berstruktur Kuasa Dua Terkecil Separa (PLS-SEM) telah digunakan untuk menganalisis data. Ketiga-tiga pembolehubah utama, iaitu, amalan QM, prestasi operasi dan kerumitan operasi mempunyai dimensi berbilang dan dimodelkan sebagai pembolehubah tertib kedua dalam PLS-SEM. Model pengukuran telah disahkan melalui Analisis Faktor Pengukuh (CFA). Hasil pengujian model struktur mendedahkan kerumitan operasi bukan sahaja memberi kesan yang positif kepada prestasi operasi tetapi hubungan di antara amalan QM dan prestasi operasi menjadi lebih kukuh sekiranya kerumitan operasi semakin tinggi. Ia turut mendapati tiada perbezaan yang ketara dalam kerumitan operasi di antara OEM dan CM. Keputusan juga mendedahkan bahawa kerumitan operasi merupakan pembolehubah yang penting untuk kajian selanjutnya. Dapatan ini membayangkan bahawa kerumitan operasi yang tinggi ada kaitan dengan pembelajaran organisasi dan pendekatan penyerapan kerumitan akan membantu meningkatkan perlaksanaan QM di peringkat organisasi. Sementara itu, kerumitan operasi yang rendah ada kaitan dengan pendekatan pengurangan kerumitan dan membantu meningkatkan perlaksanaan QM di peringkat proses. Bagaimanapun, mengikut teori Sistem Penyesuaian Kerumitan (CAS), kerumitan operasi yang tinggi perlu diurus supaya kerumitan tidak mencapai tahap hura-hara yang boleh menjejaskan prestasi. Oleh itu, satu sistem teknologi maklumat (IT) berdasarkan web telah dicadangkan untuk mengurus kerumitan operasi di sebuah CM tempatan yang menghadapi kekerapan pertukaran maklumat yang tinggi dengan pelanggan. Pandangan kontingensi dalam QM adalah sumbangan kajian ini kepada pengetahuan. Aplikasi PLS-SEM dalam kajian pengurusan operasi juga merupakan sumbangan kajian. Ia turut membantu para pengurus untuk menghadapi peningkatan kerumitan operasi dan untuk memperbaiki prestasi syarikat dalam keadaan persekitaran perniagaan yang dinamik.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

8D	-	Eight discipline
AFTA	-	Asean free trade area
AVE	-	Average variance extracted
CAS	-	Complex adaptive system
CB-SEM	-	Covariance based SEM
CF	-	Customer focus
CM	-	Contract manufacturer
COMPLI	-	Complicatedness
CR	-	Composite reliability
DV	-	Dependent variable
E & E	-	Electrical and electronics
EFQA	-	European federation quality award
EMS	-	Electronics manufacturing service
ETP	-	Economic transformation programme
FMM	-	Federation of Malaysian manufacturers
GB	-	Gigabyte
GHz	-	Giga hertz
GNI	-	Gross national income
HR	-	Human resource focus
IA	-	Information and analysis
IBM	-	International Business Machines Corporation
IMP	-	Inventory management performance
ISO	-	International standard for organization
IT	-	Information technology
IV	-	Independent variable
LED	-	Light emitting diodes
LS	-	Leadership

LVS	-	Latent variable score
MATRADE	-	Malaysia External Trade Development Corporation
MBNQA	-	Malcolm Baldridge National Quality Award
MIDA	-	Malaysia Investment Development Authority
MITI		Ministry of International Trade and Industry
MPC	-	Malaysia Productivity Center
NA	-	Not applicable
NKEA	-	National key economic area
NSM	-	NationGate Solution (M) Sendirian Berhad
OC	-	Operational complexity
OEM	-	Original equipment manufacturer
OMPCR	-	Operation management practice contingency research
OP	-	Operational performance
OPC	-	Cost (operational performance)
OPD	-	Delivery (operational performance)
OPF	-	Flexibility (operational performance)
OPQ	-	Quality (operational performance)
PCB	-	Printed circuit board
PLS	-	Partial least square
PM	-	Process management
PV	-	Photovoltaic
QA	-	Quality assurance
QAEZ	-	Integrated quality management system
QC	-	Quality control
QM	-	Quality management
QP	-	Quality performance
R & D	-	Research and development
SEM	-	Structural equation modelling
SERVQUAL	-	Service quality
SME	-	Small and medium size enterprise
SP	-	Strategic planning
SPSS	-	Statistical package for social sciences
TQM	-	Total quality management

UNCERT	-	Uncertainty
USB	-	Universal serial bus
VIF	-	Variance inflation factor

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Research

The business world is now hyper-competitive and borderless (Corbett, 2004). Excellence is measured by best in the world instead of best in class and competition is just a mouse-click away (Corbett, 2004). Companies are forced to restructure their processes from the traditional vertical-integrated, self-sufficient structure to specialized and knowledge-driven structure in order to respond to such performance-driven environment (Corbett, 2004). It is practically impossible to have best-in-world expertise in house for every process (Corbett, 2004). Hence, if any external party could run a specific process with a lesser cost, then the external party should run it. This act is called outsourcing. In the manufacturing industry, the party that outsources is known as the original equipment manufacturer (OEM) while the party that provides the service is known as contract manufacturer (CM), electronic manufacturing service (EMS) provider (Mucha, 2008), or simply the subcontractors (Sousa and Voss, 2007). The term contract manufacturer (CM) will be used throughout this writing.

While everyone was jumping on the outsourcing bandwagon in 1980s, quality awareness too emerged as a revolution in the US manufacturing industry due to intense global competition especially from Japan (Evans and Dean, 2003). Japan legendary success in producing products of high quality is attributed to W. Edward Deming and Joseph M. Juran, who introduced statistical quality control to Japan right after World War II (Rafael, 1990; Evans and Dean, 2003). Gryna *et al.* (2007) however, added that the Japanese success came from the commitment from their top management, training for all levels of employees in quality discipline and conducting continuous quality improvement projects. These three elements are part of the total quality management (TQM) concepts, which resulted from the evolution of quality awareness when quality principles are integrated into management system (Evans and Dean, 2003; Gryna *et al.*, 2007). Today, the concept of TQM has extended beyond manufacturing and adopted by service, health care, public sector, finance and education sector (Ooi *et al.*, 2011). In Malaysia, the introduction of QM concept is spearheaded by the foreign OEMs who have setup many facilities through foreign direct investment especially in the electrical and electronics (E & E) manufacturing industry. The industry has been the main contributor to the Malaysian economy since its inception in the 1960s (MATRADE, 2014).

There has been a growing debate in the literature on whether effective Quality Management (QM) practices are universally applicable or context-dependent (Sousa and Voss, 2001; Sousa and Voss, 2008). This is due to reports on failures of QM practices and the relationship between QM practices–performance not being always directly positive (Ebrahimi and Sadeghi, 2013). Some of the causes were lack of management commitment, vision and planning (Macdonald, 1996; Talib *et al.*, 2011), failure of managers to follow the fundamental concepts in implementation (Dale *et al.*, 2000) and lack of employee understanding and involvement (Shaari, 2010). These mixed results in the literature imply that effective QM practices cannot be applied as a 'one size fits all' to all organisations (Sousa and Voss, 2007). There may be moderating variables between them, which are consistent with organisation contingency theory (Zhang *et al.*, 2012). One prominent finding showed that US companies have to implement QM according to their local conditions and not by copying from Japanese companies even though the practices came from the same source (Garvin, 1986). Some of the contextual factors from various QM contingency studies were, organisation uncertainty context (Sitkin *et al.*, 1994; Reed *et al.*, 1996), cultural context (Kull and Wacker, 2010; Rungtusanatham *et al.*, 1998), management strategy context (Sousa, 2003) and operational management context (Sousa and Voss, 2007). All of the studies above found that effective QM practices were contingent to the contextual factors under scrutinizing.

1.2 Problem Statement

The recent spate of recalls due to CMs' poor quality control has triggered the needs to seriously include quality risk in outsourcing decision instead of merely focusing on reducing cost (Gray *et al.*, 2009a; Gray *et al.*, 2009b; Lu *et al.*, 2012). It also generated research in why QM practices could not 'guarantee' quality and improve operational performance. Based on operations perspective, CM and OEM have distinct operation characteristics (Sousa and Voss, 2007). CM seems to have a higher operational complexity compared to OEM due to the nature of its business model. CM has to deal with diverse customers from various industries. They are expected to run low-volume, high-mix types of operations and subject to frequent change in production plan and delivery schedule. Moreover, OEM tends to have influence over internal operations decisions in CM plant (Webster *et al.*, 1997) such as the selection of part suppliers, quality control criteria, process control method and production schedule. This influence creates high level of task uncertainty in the CM environment and the immediate effect is the high intensity of information exchange or communication across all levels of operations between OEM and CM (Galbraith, 1973). Hence, operational complexity could be the contextual variable that is impacting the relationship between QM practices and operational performance. In addition, it is a known fact that effective QM practices are difficult to implement, measure and observe (Macdonald, 1996; Sousa and Voss, 2002). Moreover, it is much more difficult to codify it in contracts with CMs (Gray *et al.*, 2009a).

Therefore, poor performance is due to the ineffective implementation of QM practices impacted by operational complexity. The ineffectiveness is caused by the difficulty in implementation and monitoring which are inherent in QM practices. Therefore this study seeks to investigate whether operational complexity has any impact on QM practices-performance relationships, and whether there is a significant difference in the level of operational complexity between CM and OEM. The problem statement can be conceptualised as in Figure 1.1.

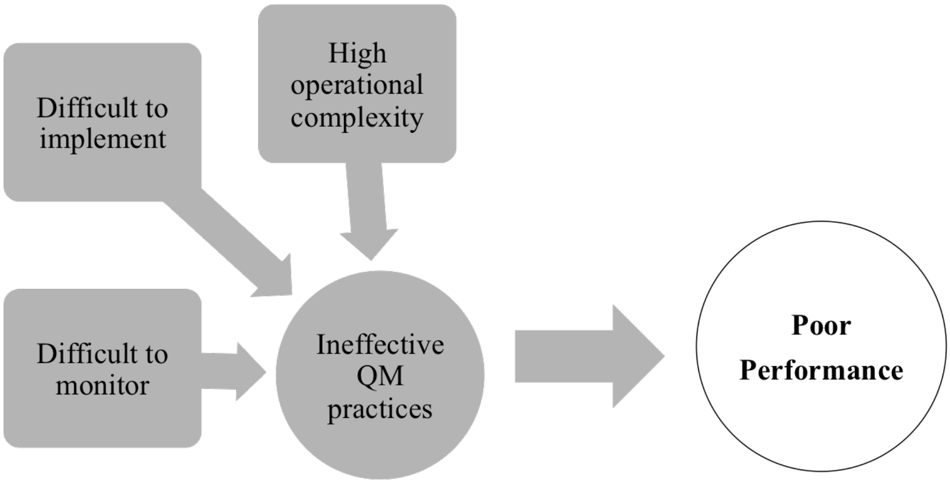

Figure 1.1 Conceptualisation of problem statement

1.3 Research Questions

The following are the research questions guiding this study.

i. Do QM practices contribute to operational performance in Malaysia's E & E manufacturing industry?

ii. Does operational complexity contribute to operational performance in Malaysia's E & E manufacturing industry?

iii. Does operational complexity impact the relationships between QM practices and operational performance in Malaysia's E & E manufacturing industry?

iv. Do CMs and OEMs have different level of operational complexity in Malaysia's E & E manufacturing industry?

1.4 Research Objectives

The following are the objectives for this study.

i. To examine the relationship between QM practices, operational complexity and operational performance in Malaysia's E & E manufacturing industry.

ii. To develop a framework for QM practices, operational complexity, and operational performance relationships.

iii. To compare the operational complexity level between OEMs and CMs in Malaysia's E & E manufacturing industry.
iv. To explore the results of the findings in a local CM and propose a practical solution.

1.5 Research Scope

This research focused on the implementation of QM practices in Malaysia's E & E manufacturing industry, which consists of all sizes of companies from both CMs and OEMs. The respondents are senior executives representing the E & E manufacturing companies operating in Malaysia producing electronics components, electronics consumer products, electronics industrial products and electrical products. The product classification is according to the Malaysian Industrial Development Authority (MIDA). Based on this classification, a list of E & E manufacturers is compiled using the directory provided by Malaysia External Trade Development Corporation (MATRADE) and Federation of Malaysian Manufacturer (FMM). The MATRADE directory (MATRADE, 2013) is assessable online while the FMM directory (FMM, 2011) is purchased from local bookstore. The list consisting 858 manufacturers is used as the population frame representing the E & E manufacturers in Malaysia. Therefore the result of this finding is only generalisable to those manufacturers in the list. Disproportionate stratified random sampling technique is used so that each geographical region in Malaysia is represented. The minimum number of responses is determined for each region before full-scale data collection is conducted.

1.6 Significance of Research

This study hopes to contribute to both knowledge and practice. The results will contribute to the body of knowledge in the field of operation management practice contingency research (OMPCR), a term coined by Sousa and Voss (2008) as part of their efforts to strengthen the conceptual foundation of the field. Through the contingency approach, the focus would be to understand the contextual factors influencing QM practice-performance relationships (Sousa and Voss, 2008). In this study, the contextual factor is operational complexity. This study will reduce the gap in QM related empirical studies in Malaysia in which the majority of the literature focused on direct QM practices-performance relationships. In addition, the study also contributes to the application of partial least square structure equation modelling (PLS-SEM) in operations research. PLS-SEM is an emerging data analysis technique that is gaining popularity for its ability to handle non-normal data, highly complex model and its lesser demand in sample size (Henseler *et al*., 2009; Hair *et al.*, 2011b; Hair *et al.*, 2014a).

The model developed in this study would provide insights to the practitioners on the impact of operational complexity on the performance of their companies. By understanding the relationships between QM practices, operational complexity and operational performance, practitioners would be able to implement effective QM practices and improve the companies' operational performances.

1.7 Structure of Thesis

This thesis is organised into seven chapters. Chapter one provides the background of the study. It also includes the problem statement, research questions, research objectives, scope and significance of the research. Chapter two gives a review of literature on the three main variables identified in this study, mainly, QM practices, operational complexity and operational performance as well as background on the E & E manufacturing industry in Malaysia. Chapter three covers the research methodology. It starts with research paradigm, research design and structure of research method. Then it discusses operationalization of each variable, which leads to the proposed research framework, research hypotheses, research instrument, data collection and finally the data analysis procedures.

Chapter four is the reporting of the results of data analysis. It begins with the data examination, preliminary analysis, demographic profile of the respondents, assessment of measurement model, assessment of structural model and ends with the results of hypotheses test. Chapter five provides the discussions and implications based on the results of hypotheses testing together with expert opinions on the findings of this study. Chapter six is a proposed implementation to manage operational complexity in a local CM. Finally, Chapter seven presents the conclusions and recommendations. It consists of the list of contributions, fulfilment of research objectives, limitations and recommendations for future studies.

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