

## **THE RELATIONSHIP BETWEEN INTERNAL AND EXTERNAL MANUFACTURING COMPLEXITY**

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### **Abstract**

This paper discussed about the behavior of manufacturing complexity in Malaysian industry. In order to make it more specific, manufacturing complexity is divided into internal and external. Cross references related article used to classify the elements of each category to form a questionnaire survey. The main objective of the survey is to analyze the relation between internal and external manufacturing complexity beside additional information on manufacturing complexity from Malaysian perspective. A survey was conducted among various manufacturing firm across Malaysia with 51 respondents that represent their firm. The survey was distributed using e-mail, postage mail and by hand. The result shows that most respondents were unsure about manufacturing complexity while increase sales and revenues and action of competitor ranked first in each category in mean score. Lastly, it is proven that internal and external manufacturing complexities have a close and significant correlation especially in coping with rapid improvement of technology and trending. This result is beneficial to manufacturer worldwide to take appropriate action in managing manufacturing complexity.

**KEYWORDS:** *manufacturing complexity, internal, external, survey, correlation analysis*

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## **HUBUNGAN ANTARA PEMBUATAN KOMPLEKS DALAMAN DAN LUARAN**

### **Abstrak**

Kajian ini membincangkan mengenai tingkah laku kerumitan perkilangan dalam industri Malaysia. Untuk menjadikannya lebih spesifik, kompleks pembuatan dibahagikan kepada dalaman dan luaran. Artikel berkaitan silang rujukan digunakan untuk mengklasifikasikan unsur-unsur setiap kategori untuk membuat tinjauan soal selidik. Objektif utama kaji selidik ini adalah untuk menganalisis hubungan antara kerumitan perkilangan dalaman dan luaran selain maklumat tambahan tentang kompleks perkilangan dari perspektif Malaysia. Kaji selidik telah dijalankan di kalangan pelbagai firma pengilangan di seluruh Malaysia dengan 51 responden yang mewakili firma mereka. Tinjauan ini diedarkan menggunakan e-mel, surat-menyurat dan serahan tangan. Keputusannya menunjukkan bahawa kebanyakan responden tidak pasti tentang kompleks pembuatan meningkatkan jualan dan hasil serta tindakan pesaing berada di peringkat pertama dalam setiap kategori dalam skor min. Akhir sekali, terbukti bahawa kerumitan pengilangan dalaman dan luaran mempunyai korelasi yang rapat dan signifikan terutamanya dalam menghadapi peningkatan dan kepesatan teknologi. Hasil kajian ini memberi manfaat kepada pengeluar di seluruh dunia untuk mengambil tindakan sewajarnya dalam menguruskan kerumitan pembuatan.

**KATA KUNCI:** *kompleks pembuatan, dalaman, luaran, kajian, analisis korelasi*

### **INTRODUCTION**

In today's globalization era, technology and facilities related with manufacturing sector are rapidly improving. The improvement surely focused in improving any related performance in manufacturing such as cycle time, quality and cost. Even though there are various improvement in manufacturing environment, manufacturing firms still struggling with manufacturing complexity (MC) challenges (Mahmood et al., 2015). In fact, manufacturing firms currently are facing a dramatic increment of complexity compared to the previous situation (Düsseldorf, 2012). Mahmood et al. (2014) mentioned that MC occurred in all areas in manufacturing practice and spreading across firm.

As the technology improving, MC also keep expanding relatively. This is the reason to study the elements related and manage MC in appropriate way. Complexity is defined as relation among various elements or parts in a system

which one element may has relation or connection with many other elements (Poulis and Jackson, 2005; Milling et al., 2006; Windt et al., 2008; Heylighen, 2011; Park and Okudan, 2015). This shows that bigger company with bigger system will experienced greater MC. For example, global manufacturer with customers from various country need to comply with different specification based on customer requirements. In order to manage MC, manufacturing firms need to well understand MC itself.

There are various researchers have defined and classified MC in different ways. Until now, the term MC has no generally admitted definition and classification. According to Mahler and Bahulkar (2009); Größler et al. (2006); Blecker et al. (2004); Jost (2004); Götzfried (2013), MC can be classified into two namely external MC and internal MC. This classification will guide manufacturing firms to understand MC and consequently manage MC well (Blecker et al., 2004). Figure 1 shows the basic relationship between internal MC and external MC. Both internal and external MC are related with each other where some significance amount of internal MC impacted on external MC. Same goes to the other side.

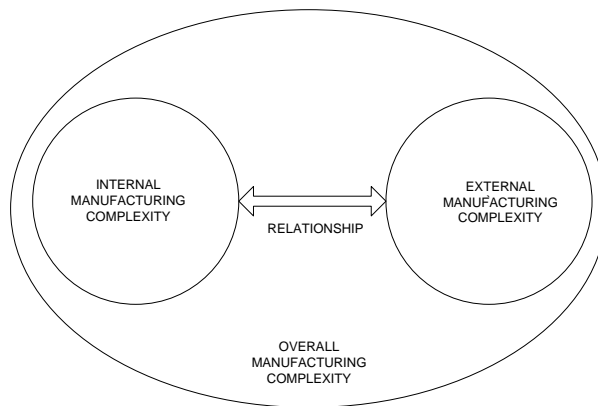


Figure 1: Basic Relationship between Internal and External MC

Internal MC consists of elements that are manageable by the organization but still internal MC caused by elements of external MC (Arteta and Giachetti, 2004; Mahler and Bahulkar, 2009). On the other hand, external MC consists of elements that within outside boundary and not in organization's charge. External MC creates an environment where organizations need to cope with it whereas internal MC comes (Milling et al., 2006). This classification makes managing MC more easier because organizations knew the limit where only certain area they can control and the rest are considered uncertain. Samy et al. (2015) agreed that uncertainty is the major source of external MC where it includes demand and supply variation. Isik (2011) has come out with a model where internal MC is manufacturers' responsibility while external MC comes from suppliers and

customers. This cycle will be existed as long as the business runs. That is the importance of this research to determine the exact relationship between internal MC and external MC particularly in Malaysian industry.

## **RESEARCH METHOD**

Firstly, cross references research articles from 1999 to 2015 regarding MC are made in order to understand better and determine the related elements of internal MC and external MC. This method used in order to systematically review literature from various researchers in the related field (Yusup et al., 2015a). From that, there are 30 elements in internal MC while 22 elements in external MC. The questionnaire was constructed consisting of several demographic questions followed by these internal and external MC elements. According to (Yusup et al., 2015b), questionnaire is suitable to be used to gather original data from large sample with minimal costs and without researchers influence. The questionnaire uses five Likert's scale (1=strongly disagree, 2=disagree, 3= neutral, 4=agree, 5= strongly agree). The questionnaire was distributed to the representative of manufacturing firms in Malaysia using three mediums which are e-mail, postage mail and by hand. From the total of 200 distributed questionnaires, there are 51 responses collected. The data was analyzed using SPSS software. Analyses included in this research are descriptive analysis, calculation of mean score and Spearman rho correlation test.

## **RESULT AND DISCUSSION**

In this chapter, the elements of questionnaire represent by abbreviation that is enclosed in appendix which perception on MC by B1 until B5, internal MC elements by I1 until I30 and external MC elements by E1 until E22. The first section in the questionnaire is demographic. Demographic data is important to know the respondents' basic background where different background has different environment thus reflected human perception. SME Corp. Malaysia (2013) has construct a new guideline in classifying manufacturing firms based on size of employees or turnover. There are three types of industry involved in this survey where the respondents from large industry 66.7 % medium, small and microenterprise are 17.6 %, 13.7% and 2 % respectively. Respondents' industry product group data shows 19.6 % from automotive, 13.7 % from petroleum and chemical while the third ranking with 9.8 % shared among four product groups namely food and beverages; rubber, plastic and non-metal; computer, electronic and optical; and machinery and equipment. The fraction distribution on product characteristic shows 52.9 % respondents' firm have manufactured to order while for engineered to order, assembled to order and make to stock are 15.7 %, 17.6 % and 13.7 % respectively. The product characteristic data is important because

different characteristic has different manufacturing routines. Lastly, the questionnaire collects data for certification of ISO 9000 (quality management system), ISO 14000 (environmental management) and ISO 26000 (social responsibility). The result shows that there are 64.7 %, 54.9 % and 5.9 % certified with those certifications where one manufacturing firm may have more than one certification. These show that more than half respondents' firms have implemented proper management system by ISO 9000 certification. Besides that, more than half of the firms also have followed the regulations and guidelines in managing environment by ISO 14000 certification. This also concluded that Malaysian industry has a good awareness on environment and authority requirement.

### **Perception on Manufacturing Complexity**

Different people, culture, infrastructure, policies and regulations have different perceptions on MC (Subramanian et al., 2015). There are five questions to assess respondents' basic perceptions on MC. The data shows that the respondents do not have a clear view on MC since the mean score of B1, B2 and B3 are hugging the neutral line and hugging between 3.7 and 4. The number does not clearly mean the disagreeing nor agreeing strongly on these questions. In opposite, for B4, majority of respondents with 74.5 % choose to control complexity rather than reduce or avoid it while none agree to encourage complexity. These four main strategies are suggested by Götzfried (2013) to get the general view of MC alongside to know the respondents' strategies in dealing with MC. Lastly, respondents clearly appointed production/engineering department (86.3 %) and top management (74.5 %) to be responsible in managing MC.

### **Level of Internal and External Manufacturing Complexity**

The level of elements in questionnaire can be represent by the mean of that particular elements. Figure 2 clearly shows the level of internal and external MC. The dotted red shows that top three for both internal MC and external MC.

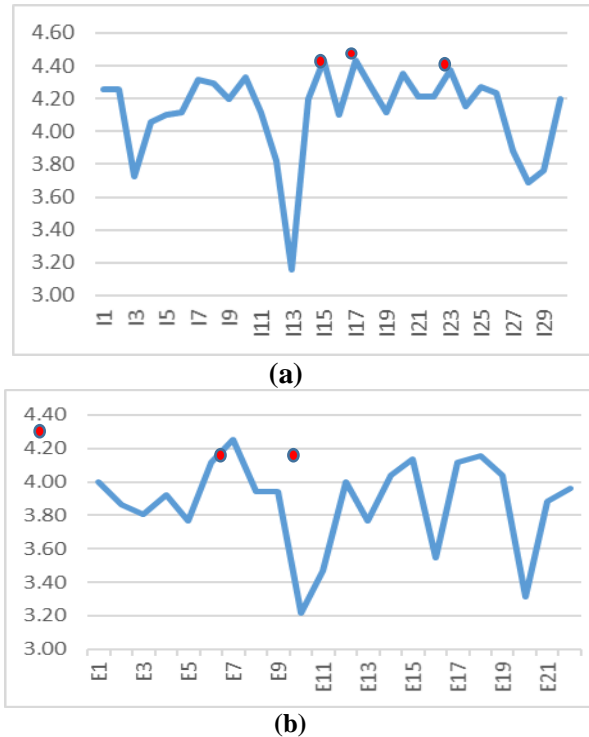


Figure 2: Mean Score for Manufacturing Complexity (a) Internal, (b) External

The top three rankings for internal MC are I15 (increase sales and revenues), I17 (capability of top management) and I23 (establish standard operation procedure) with mean score of 4.43, 4.43 and 4.37 respectively. This result is parallel with the recent research related with MC. Park and Okudan Kremer (2015) supports the importance of elements I15 and I17 with the statement that managing MC wisely will increase firm's profitability and the negative impacts of MC come from managerial perspective. Besides, there are several research agreed with I15 (Samy et al., 2015; Götzfried, 2013; Bose and Luo, 2012; Isik 2011) and IM17 (Rolstadås et al., 2014; Josephson and Bjorkman, 2013; Samy and Elmaraghy, 2012; Mahler and Bahulkar, 2009).

In general, standard operation procedure (SOP) eases the work routine and ensuring the quality of the product or outcome. Behind that, during the establishment of SOP, detail study including all perspectives need to be considered such as user's position level (Emiliani, 2008), rapid changes in technology (Lin et al., 2011), the rigidity and flexibility (Brodbeck, 2002) and human or user's background (Gardner and Deadrick, 2012). This issue has been raised decades ago by Berger (1997). Next, the ranking of external MC goes to E7 (action of

competitor), E18 (variety of machine required) and E15 (availability of skillful workers) with the mean score of 4.25, 4.16 and 4.14 respectively. Hong et al. (2016) relates both E7 and E15 by stated that in order to manage MC originated from competitor, manufacturing firm needs to use the expert resource available in-house to train and instruct outsiders or new recruitment to be familiar with the particular industry.

Several research clearly stated that competitors' action increased MC externally which support the obtained survey result (Wanke and Corrêa, 2014; Serdarasan, 2013; Isik, 2011). According to Rathje et al. (2014) and Poulis and Jackson (2005), employing skillful workers is limited due to scarce resources and rapid technology changes. Lastly, corresponding to the rapid improvement in technology, there are numbers of new machines available and required to be used (Robinson et al., 2014) to deal with process variety which is crystal clear to be an important MC sources.

### Correlation Test

The last test is Spearman's rho correlation between internal and external MC. Correlation test is very important to define the reaction between internal and external MC elements. The purpose is to ensure the suitable steps taken to overcome MC challenge. Table 1 shows the strong correlated value, at significant level of 0.01 between internal and external MC using SPSS software with coefficient value ranging from 0.358 to 0.646. Based on Table 1, only one element of internal MC does not have strong correlation with any external MC elements which is I18 (improve organization's culture) while for external MC, there are four elements namely E4 (demand variability in volume), E9 (globalization of supplier chain), E10 (incompetent supplier) and E11 (size of supplier). Even though those elements not categorized to have strong correlation, most of the correlation value coefficient shows positive value which indicates the existence of correlation. The majority elements from external MC related with supplier which most employees do not have direct contact with supplier except purchasing department.

Table 1: Spearman Correlation Coefficient between Internal and External MC

Item	External MC	External MC	Item	Internal MC
<b>IM1</b>	E5, E12, E19	<b>IM23</b>	<b>EM1</b>	E2, E6, E7, E8, E9, E12, E14, E15, E16, E17, E18, E19, E21, E22 I3, I4, I6, I7, I9, I16, I19, I21, I26
<b>IM2</b>	E3, E8, E14, E19	<b>IM24</b>	<b>EM2</b>	E2, <b>E6</b> , E8, E9, E12, E16, E17, E18, E19, <b>E21</b> , E22 I6, I7, I8, I9, I10, I14, I15, I17, I23, I24, I26, I30
<b>IM3</b>	E1, E22	<b>IM25</b>	<b>EM3</b>	E6, E12, E16, E17, E18, E19, E21, E22 I2, I7, I8, I9, I16
<b>IM4</b>	E1, E14, E22	<b>IM26</b>	<b>EM4</b>	E1, E2, E5, E6, E12, E16, E17, E18, E19,

			E21, <b>E22</b>		
<b>IM5</b>	E14, E19	<b>IM27</b>	E14, E15, <b>E16</b> , E17, E19, E21, E22	<b>EM5</b>	I1, I11, I12I, I13, I14, I15, I16, I26
<b>IM6</b>	E1, E2, E8, E18, E19	<b>IM28</b>	E16	<b>EM6</b>	I8, I9, I10, I11, I14, I16, I17, I19, I20, I23, <b>I24</b> , I25, I26
<b>IM7</b>	E1, E2, E3, E19, E22	<b>IM29</b>	E16, E19, E22	<b>EM7</b>	I15, I20, I21, I23
<b>IM8</b>	E2, E3, E6, E8, E13, E18, E19, E21, <b>E22</b>	<b>IM30</b>	E2, E12, E16, E17, E18, E19, E22	<b>EM8</b>	I2, I6, I8, I19, I21, I22, I23, I24
<b>IM9</b>	E1, E2, E3, E6, E13, E16, E20, <b>E22</b>			<b>EM9</b>	
<b>IM10</b>	E2, E6, E12, E15, E16, E21, E22			<b>EM10</b>	
<b>IM11</b>	E5, E6, E12, E16, E17, E18, E19, E21, E22			<b>EM11</b>	
<b>IM12</b>	E5, E12, E15, E17, E18, E20			<b>EM12</b>	I1, I10, I11, I12, I14, I15, I17, I20, I23, I24, I25, I26, I30
<b>IM13</b>	E5			<b>EM13</b>	I8, I9, I14, I19
<b>IM14</b>	E2, E5, E6, E12, E13, E16, E17, E18, E19, E21, E22			<b>EM14</b>	I2, I4, I5, I21, I22, I23
<b>IM15</b>	E2, E5, E7, E12			<b>EM15</b>	I10, I12, I16, I17, I21, I22, I23, I27
<b>IM16</b>	E1, E3, E5, E6, E15, E16, E18, E22			<b>EM16</b>	I9, I10, I11, I14, I16, I17, I19, I20, I21, I22, I23, I24, I25, I26, <b>I27</b> , I28, I29, I30
<b>IM17</b>	E2, E6, E9, E12, E15, E16, E17, E18, E19, E21, <b>E22</b>			<b>EM17</b>	I11, I12, I14, I17, I20, I21, I23, I24, I25, I26, I27, I30
<b>IM18</b>				<b>EM18</b>	I6, I8, I10, I11, I12, I14, I16, I17, I20, I21, I23, I24, I25, I26, I30
<b>IM19</b>	E1, E6, E8, E13, E16, E19, E22			<b>EM19</b>	I1, I2, I5, I6, I7, I8, I11, I14, I17, I19, I20, I21, I22, I23, I24, I25, I26, I28, I29, I30
<b>IM20</b>	E6, E7, E12, E16, E17, E18, E19, E22			<b>EM20</b>	I9, I11, I12
<b>IM21</b>	E1, E7, E8, E14, E15, E16, E17, E18, E19, E22			<b>EM21</b>	I8, I10, I14, I17, I22, I23, <b>I24</b> , I25, I26, I27
<b>IM22</b>	E8, E14, E15, E16, E19, E21, E22			<b>EM22</b>	I3, I4, I7, <b>I8, I9</b> , I10, I11, I14, I16, <b>I17</b> , I19, I20, I21, I22, I23, I24, I25, <b>I26</b> , I27, I29, I30

I23 (establish standard operation procedure) hold the biggest number of significance correlation with external MC among internal MC elements with 14 elements while E22 (needs to use user friendly machine/equipment) has significance correlation with 21 internal MC elements. This shows that I23 and



E22 are both the most influential by the other side's elements. The numbers in red in Table 1 indicates that the correlation exists are among the highest which exceeding 0.6 correlation coefficient. The highest value is 0.646 between E22 and I17, secondly between E22 and I9 (quality inspection equipment) with 0.63 and in third position between E22 and I26 (maintenance management). Again, the result concluded that E22 is the most correlated external MC elements with internal MC elements. The strongest correlation exists between user friendly machine/equipment and capability of top management.

The result supported by Park and Okudan (2015) and Jung et al. (2015) by agreeing on a statement that machine need to be operated by a human while human need machine to complete the tasks. Top management has to appropriately manage resources especially human and machines/equipment in order to get the desired outcome in the highest level.

## **CONCLUSION**

In conclusion, understanding and awareness on MC among Malaysian manufacturing industry is considered still in early stage. MC is not compulsory to be considered, but it will worth a lot if manufacturing firm especially in Malaysia can manage it in a proper way. In order to do so, knowledge on MC both internal and external is essential. The result showed that two elements shared the highest level of internal MC which are increase sale and revenue and capability of top management while for external MC is action of competitors.

As an initial study, these elements can be considered important and in need to do further research to get better result. It is also proven that internal and external MC has significant correlation in most elements. This concludes that internal MC may influence external MC and same on the other way. For future research, a model to manage MC has to be constructed to help manufacturing firms managing MC well in the simplest way.

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