

The integration between Business Model Canvas and Manufacturing System Design

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Abstract. Business Model Canvas (BMC) is an increasingly popular business design tool especially for a start-up business and new business player. In general, BMC seeks a balance between effective working patterns with suppliers, good relation with customers and ability to understand and manage internal resources. This balance will expedite the implementation of Manufacturing System Design (MSD). The existing use of BMC and MSD is frequently applied separately at various business levels. BMC business plan is primarily to have engagement with customers and explore potential revenue to increase profits, while MSD primarily aims to meet production targets with available resources. The purpose of this research is to provide a roadmap to align BMC and MSD. A series of simple mathematical (modified) and integration models are created to connect BMC and MSD. Several results in various industries (new, developed and mature) are presented and used as examples of implementation.

1. Introduction

The competition of manufactured products is no longer on the track of achieving the best quality, the greatest quantity, the shortest production time and the similarity of products in one variant - but more to achieve the best level of flexibility. Flexibility is triggered by the dynamics of customer wants and needs with the choices from the manufacturers. Innovation is the key to reach flexibility, so that the formerly production equipment based on mass production should be transformed into dynamic production. Some concepts such as flexible manufacturing system, mass customization, and also additive manufacturing are offered to accommodate innovation based on the dynamic production system. Dynamic production systems, among others, provide the choice of the amount produced, the sequence of production processes and the variation of the product. This option is not an easy task because the risk of cost and the level production equipment requirement have a significant contribution [1].

BMC is widely used for the start-up business, as a tool that can show business entities to manage and information and for employees and business partners to understand [2][3]. BMC consists of 9 components that are connected. First, BMC provides an overview to identify costs and revenues for analysing the potential profit. Second, BMC provides an overview of opportunity identification and customer relationship management - including what values that need to be considered. Third, BMC provides an overview of supplier needs that can be combined with internal resources management and development. BMC can be used as the reference for new business development or changed business orientation for companies that are already operating [4]. In the requirement of innovation in responding to customer demand flexibility, the BMC needs to be rewritten accordingly with the changes that able



to answer the challenges [5]. Changes are not limited to offered values for customers or known as offer driven, but also on other parts of BMC as a business consequence. It is also driven by changes in infrastructure and partnerships (resource factor), changes in customer conditions (customer factor), changes in profit potential (finance factor), or a combination of multiple factors (multiple epicentres factor). BMC as a strategy guide is still limited to be used as a static guide for an early description of a business [6].

In the manufacturing industry, there is no product can be sold without production activities. The dynamics that can be generated by various factors in the BMC need to be answered with a good supplier's reliability and good internal production management (in some cases an internal and external combination - outsourcing) [7]. In an existing production system, various performance parameters can be measured easily in real time with the use of sensors. Problems arise when there are new products with variations in size, process or other specifications [8][9][10]. MSD is used to prepare a production system capability in responding to such changes [11]. Analysis and approximate estimation can be made with complex or simulated models [12][13]. For companies, the time to model and simulate is not equivalent with the need for rapid response to market. Furthermore, MSD needs to be used for internal synchronization of management with the support of reliable supply chain management capabilities [14][15][16][17][18]. A simple, straightforward MSD approach to the main parameters is an important thing for companies to do. Thus, the expected output of MSD is the basic layout design and the big picture mapping description.

Thus the integration between MSD and BMC is absolutely necessary especially in the dynamics of the competition [19][20][21][22][23]. Companies need a simple approach to accelerate response, without necessarily involving simulations with difficult models. The simplest approach should remain within the main BMC framework to provide an overview of the full business model and MSD framework to perform an effective and efficient production process. BMC remains aimed at customer satisfaction that leads to increased revenue, while MSD remains aimed at aligning due date from customers, manufacturing lead time and availability of raw materials from suppliers.

In this work, several sequential mathematical formulations are delivered with a simple BMC and MSD integration approach. The mathematical and integration formulations are further presented in different implementations for the industry in new, developing and mature levels - or generally understood as product life cycles. Hence, the proposed idea can be used at various business levels.

2. Method

In showing the potential profit of a business, BMC offers the concept of balance in the cost structure and revenue model. MSD, in this case, can be used to estimate the basic cost structure (cost of goods manufactured). In the start-up level, the cost is calculated in detail, while at the mature level the calculation is produced in percentage. Profit is the main goal of a business where the amount of revenue and the small cost will show efficiency. On the other hand, production management capabilities can be seen in supplier relationships, business processes, and resources - compared to potential customer management. MSD is an activity that can be used to assess the ability of BMC components in activities and resources.

The first step is to determine the scope of MSD. MSD is limited in nine components. Explanation of components accompanied by modification of the mathematical model becomes simpler. Modifications are made with a basic approach to the manufacturing principle that the number of inputs of production equals the number of production outputs. The main indicator is the degree of flexibility (dof), can also be used as an indicator of innovation (degree of innovation). The notation used in this simple mathematical model is as follows.

n	: the number of variant	Th_i	: handling time product i^*
Q_i	: the demand of product i	PC	: production capacity
TQ	: total number of demand	AT	: available time*
Tc_i	: cycle time product i^*	UT	: unavailable time*
Td_i	: delivery time product i^*	TPT	: total production time*

R_p : production rate

U : utilization

A : availability

N_F : number of facilities

W : weighted factor

WIP : number of work in progress

N_{days} : number of operating days within a year

N_{act} : number of activities

*All variable that contain time, should be determined in hour unit

2.1. Customer Demand or Product Variety (MSD1)

The variation of demand will be similar as product variety, where higher the number will result in higher the flexibility to meet the current trend in customer demand. Further analysis and extended capability is required where n_{demand} is greater than n_{capability}.

The number of demand can be described as follow:

$$TQ = \sum_{i=1}^n Q_i \quad (1)$$

The required processing time is

$$TPT = \sum_{i=1}^n Q_i \cdot Tc_i \quad (2)$$

Then the degree of flexibility MSD1 is

$$dof_{MSD1} = \frac{n_{capability} - n_{demand}}{n_{demand}} \quad (3)$$

2.2. Production Capacity (MSD2)

Production capacity is normally calculated by dividing the total available time by the time needed to produce the whole product [24]. These parameters can be calculated in units of days, weeks, months or years. Production capacity may vary starting with the number of products ordered in a number of demands for a particular product, with no demand for other products. Or, by giving the same amount in each product variation, so it can use the average cycle time. The ratio between planned production capacity and installed capacity reflects the level of system flexibility.

$$PC = \frac{AT}{\frac{\sum_{i=1}^n Tc_i}{n}} \quad (4)$$

Then the degree of flexibility MSD2 is

$$dof_{MSD2} = \frac{PC_{planned}}{PC_{installed}} \quad (5)$$

2.3. Production Rate (MSD3)

This parameter shows the amount that can be produced per unit of time [24], so it is the opposite of T_c. The greater the production rate indicates an increasingly flexible manufacturing system, as it can produce larger quantities with a variety of products.

$$R_p = \frac{1}{\frac{\sum_{i=1}^n Tc_i}{n}} \quad (6)$$

Then the degree of flexibility MSD3 is

$$dof_{MSD3} = \frac{R_p \cdot TPT}{PC} \quad (7)$$

2.4. Utilization (MSD4)

In general, this parameter is calculated by the use of overall manufacturing system facilities to produce output [24]. The utility level can also be used as a measure of flexibility which means it can maximize the use of facilities to produce various products.

$$U = \frac{TPT}{AT} \quad (8)$$

Then the degree of flexibility MSD4 is

$$dof_{MSD4} = U \quad (9)$$

2.5. Availability (MSD5)

The availability level is affected by the layout of the manufacturing system facility. Availability is a description of the reliability of a facility that depends on the structure of the series or parallel. Unavailability can be caused by machine malfunction, setup, or anything else [24]. When simplified, the production process layout can be divided into several stages in accordance with the stages of the process. The proportion of series and parallel will determine the degree of flexibility, where a large number of parallel facilities will increase flexibility.

$$A = (AT_{serial} - UT_{serial}) + (AT_{parallel} - UT_{parallel}) \quad (10)$$

Then the degree of flexibility MSD5 is

$$dof_{MSD5} = \frac{NF_{parallel}}{NF_{series} + NF_{parallel}} \quad (11)$$

2.6. Manufacturing Lead Time (MSD6)

This parameter is used to measure the time required for a product on the production floor [24]. The same number can be used as input for big picture mapping. The setup time is the time taken to perform a series of activities after the production order is approved until the production process begins. While the delivery time is a series of activities after the production process is completed until the product is ready to be sent to the customer. The measure of flexibility used is the proportion of cycle time to setup time and delivery time.

$$MLT_i = T_{su_i} + T_{c_i} + T_{d_i} \quad (12)$$

Then the degree of flexibility MSD6 is

$$dof_{MSD6} = \frac{\sum_{i=1}^n \frac{T_{c_i}}{MLT_i}}{n} \quad (13)$$

2.7. Work in Progress (MSD7)

Minimizing the number of work in progress will increase flexibility because in different time periods it does not require additional setup time.

$$WIP = (AT_{daily} - TPT_{daily}) \times N_{days} \quad (14)$$

Then the degree of flexibility MSD7 is

$$dof_{MSD7} = \frac{\sum_{i=1}^n QFG_i \cdot T_{c_i}}{AT_{daily}} \quad (15)$$

Where QFG_i is number of finished good i within an operating day.

2.8. Basic Layout Design (MSD8)

The basic layout will determine the flow of the production process, the product variation gives a longer travel time. The flexibility of the manufacturing system is measured by the total travel time of each product as short as possible. An example of using a basic layout can be seen in Figure 1. Then the degree of flexibility MSD8 is

$$dof_{MSD8} = \frac{\sum_{i=1}^n \frac{T_{c_i} - T_{h_i}}{T_{c_i}}}{n} \quad (16)$$

2.9. Big Picture Mapping (MSD9)

The approach of manufacturing patterns in a big picture mapping can be simplified in the form as shown in Figure 2. The flexibility of these parameters will be measured using lean manufacturing principles, the proportion of value added activities to the total number of activities [25]. Then the degree of flexibility MSD9 is

$$dof_{MSD9} = \frac{Nact_{VA}}{Nact_{VA} + Nact_{NVA} + Nact_{NNVA}} \quad (17)$$

Where,

VA : value added

NVA : non value added

NNVA : necessary but non value added.

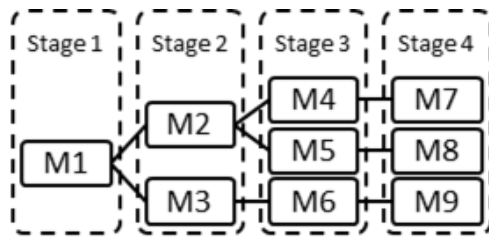


Figure 1. A typical basic layout design

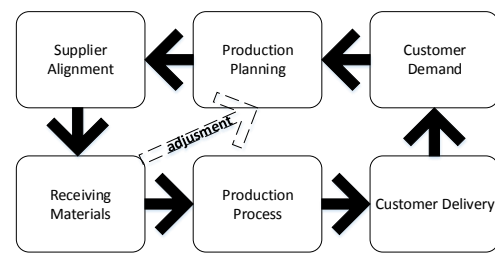


Figure 2. A typical big picture mapping

The second step is about determining of how to integrate MSD elements into the following BMC element.

- | | |
|---------------------------------|-----------------------------|
| 1. Key Partners (BMC1) | 6. Channels (BMC6) |
| 2. Activities (BMC2) | 7. Customer Segments (BMC7) |
| 3. Resources (BMC3) | 8. Cost Structure (BMC8) |
| 4. Value Proposition (BMC4) | 9. Revenue Model (BMC9) |
| 5. Customer Relationship (BMC5) | |

The integration is to connect all elements of MSD into each BMC element, through a weighted factor. The weight of the contribution of the MSD element in BMC can be defined by the user of the model, through the use of the W_{ij} variable where i is the variable number of the MSD and j is the BMC variable number. MSD1 (customer demand) will be able to have a significant influence on BMC1 (key partner), with the more variation of the desired product the supplier's flexibility will also increase. A good deal with suppliers will determine the availability of raw materials. Contribution weights can vary at each level of the company and also between companies at the same level.

$$dof_{BMC_j} = \sum_{i=1}^n W_{ij} \cdot dof_{MSD_i} \quad (18)$$

The third step is to provide a simple calculation example of the integration model. The calculation begins by assigning a weight to the W_{ij} parameter and performing the calculation for each dof value of the MSD element. The flexibility value of the BMC element (dof_{BMC}) will be obtained by multiplying the weights by the flexibility value of the MSD element according to the formula.

3. Result and Discussion

Numerical experiments were conducted on several companies with start-up, developing and mature level. Where the difference calculation will lie in the quantity and variation of demand. A new company has a small amount of product variation. In recent developments, product innovation is required and product variation is a challenge for new companies. Companies in the developed level show a greater number of product variations. While companies with mature levels have the most variety of products, with better production and innovation levels.

The results indicate that BMF elements degree of flexibility will also depend on the company's experience. Experience determines which MSD elements affect a particular BMC element. Determination of the right weights will result in the accuracy of the strategy result. The weighted value also shows the company's efforts to strengthen certain elements that are expected to deliver good results. Further, the value of MSD elements such as the production rate, availability and etc. can also be used as a preliminary description of the company competitiveness.

The model can be used to measure the company's innovation capability through the description of BMC elements. When companies want to increase business flexibility then the elements of MSD that support BMC elements should be expedited. BMC is no longer merely as a business strategy guide containing descriptions, but it can be estimated the value of business capability achievement in the current period.

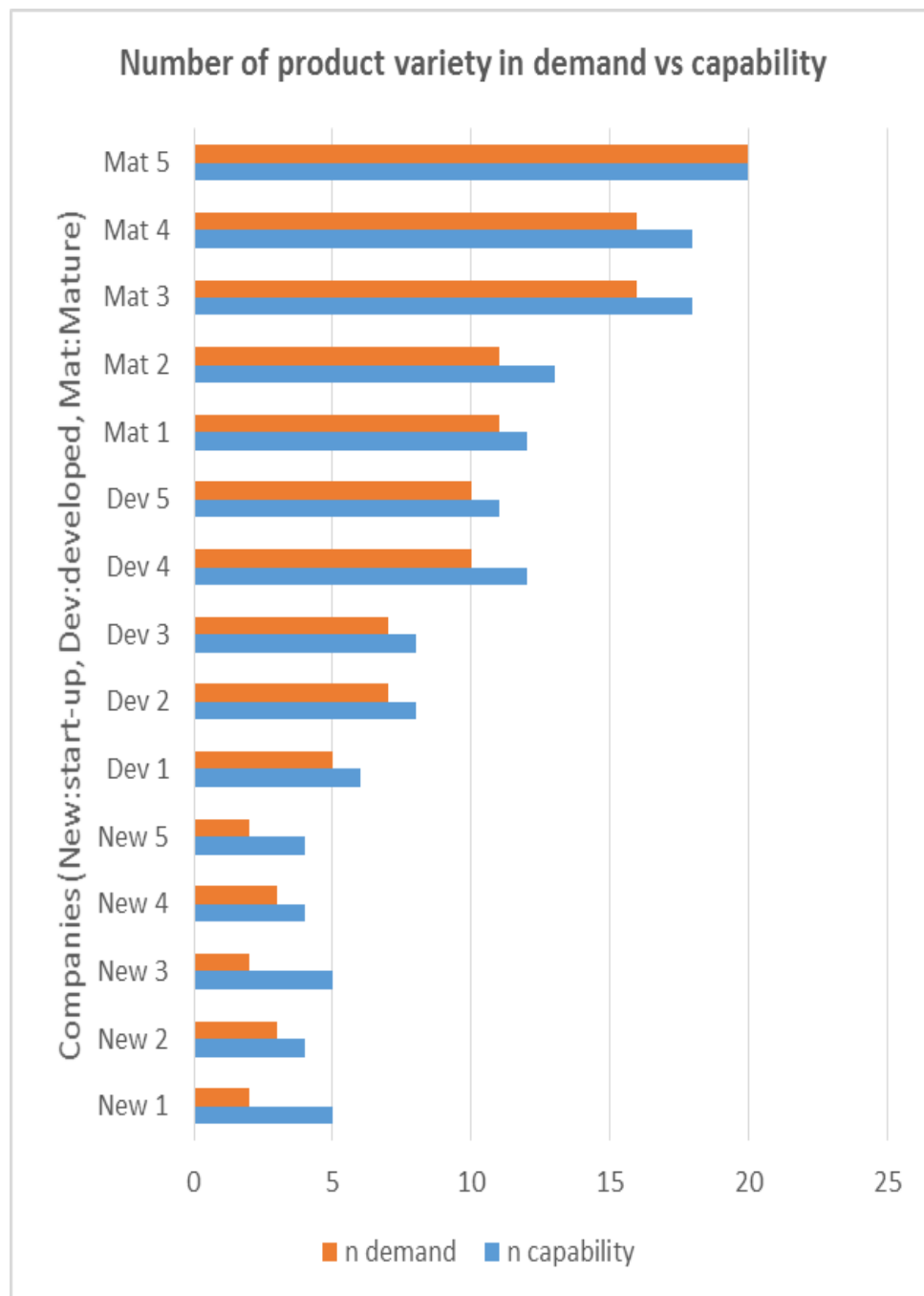


Figure 3. Degree of flexibility MSD1 input – demand and capability comparison

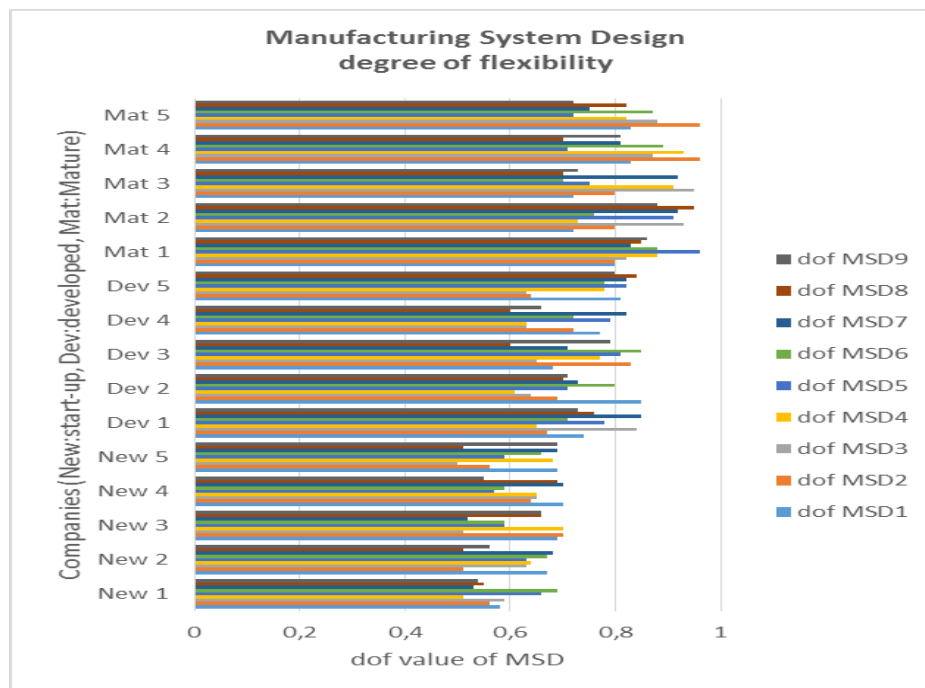


Figure 4. Degree of flexibility MSD elements

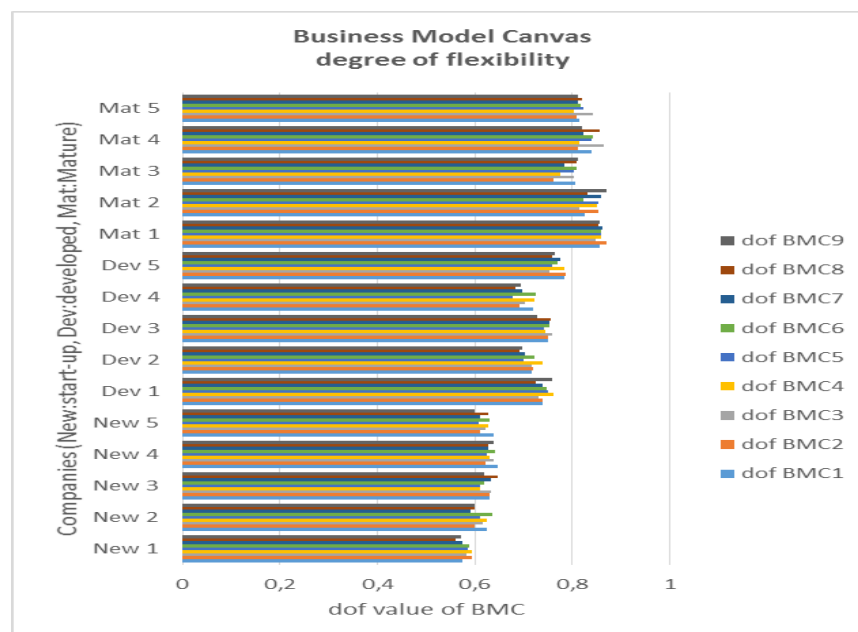


Figure 5. Degree of flexibility BMC elements

4. Conclusion

BMC can be used as a means to describe the corporate strategy that prioritizes flexibility, while MSD is a technical design to meet demand. A simple mathematical formula for integrating MSD into BMC has been described with the main degree of flexibility indicator to answer to the current growing customer demand. Numerical experiment in several corporates level has been transposed into varying degree of flexibility values. This simple integration model can then be used to determine the company's ability to meet demand.

5. References

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