ABSTRACT

Agility is now a key competitive factor in industry. Responsiveness is a significant performance of an agile system. In the authors’ previous research (Kritchanchai and MacCarthy, 1999), the meaning of responsiveness has been investigated. Four components of responsiveness - stimuli, awareness, capabilities and goals - emerge from an analysis of the literature. The study also develops a generic responsiveness framework that incorporates both strategic and operational viewpoints. At the same time, over the last decade, several papers have published the strategy of mass customisation and attempt to propose ways to respond to any customised order by being beneficial from mass production. In this paper, we recognise the role of responsiveness in achieving mass customisation strategy. In order to provide practical solution, we propose that the framework of responsiveness can be mapped and applied to mass customised environment. Mass customisation is then interpreted with respect to responsiveness perspective in apparel supply chain case studies. Finally the paper identifies the directions to develop mass customised strategy by using responsiveness framework.

KEY WORDS
Responsiveness, Responsiveness Framework, Mass Customisation, Apparel Supply Chain

1. Introduction

In the author’s previous research [1], responsiveness has been defined and explicitly interpreted. It has been transformed from an ambitious dream to a tangible set of operational measures in order fulfillment process. It is found that responsiveness can be seen differently in different environment. Industry applies responsiveness at different areas with different capabilities according to stimuli they face. Having proposed the responsiveness framework, we found that responsiveness can be used as a tool to analyse industry’s characters and competitive capabilities.

From 1990 to 2000, the concepts of Mass Customization (MC) were focused [2]. Although many authors provide understanding of the content and process of MC strategies focusing on the organisational structures, modularity, and technologies as well as levels of customisation, MC has not been adequately studied in the practical level [3]. An MC operational control system has not been explored. It is obvious that when a firm applies MC improperly, lots of problems will follow. In addition, the firm employing MC unsystematically will get higher cost and worse responsiveness [4, 5, and 6]. These problems, e.g. unhurried design, low quality, inappropriate line balancing, and the complexity of logistics and supply chains, emerge from a variety of products and services which are now and then futile [7].

From many literatures, we found that problems emerged in industry at operational level can be considered as factors stimulate system performances. Then the system attempts to respond to those stimuli by its internal capabilities. In the system employing MC strategy, we see the strategy as a condition of the system. With respect to responsiveness definition, the system under an MC condition needs to create responsiveness capabilities in order to facilitate the condition of customisation as well as enjoying the benefits of mass production. Stimuli in this environment also need to be identified in particularly representing MC concept such as product variety.

As a result, in this paper, we attempt to apply responsiveness definition and framework for interpreting characters of MC at operational level. Case studies in garment industry are presented and responsiveness definition is mapped into the findings in order to identify the MC capabilities.

2. Literature Review

2.1. Responsiveness

The field and case study evidence in the previous research [1] is used to develop more precise and informed definitions and descriptions of each of components of responsiveness. We proposed a generic framework for understanding and gaining insight into responsiveness in manufacturing enterprises.
### 2.1.1. Responsiveness components [1]

**Stimuli:**
These are the factors, events and issues that have, or could have an impact on system activities and expected or desired goals. Stimuli are the major factors driving any firm to respond and hence provide the impetus to develop responsiveness capabilities. Stimuli will vary depending on the environment, the nature of the industry and its products, and operational characteristics.

**Awareness:**
This refers to a firm's knowledge and recognition of stimuli that occur or may occur, and the preparation and responses necessary to address them, whether they emanate from customer needs, environmental uncertainties, competitors or market conditions. Awareness is a fairly soft concept and is often detected by the presence of specific capabilities, discussed below. In the case study companies examples of practices demonstrating awareness include: keeping safety stock, calculating machine breakdown likelihood, forecasting materials and labour requirements, and holding excess machine capacity.

**Capabilities:**
This component refers to the activities and processes that enable a company to respond appropriately to the stimuli. By capability in this context we mean more than just a technical ability to respond. Capability requires the existence of knowledge and decision making structures necessary to use or deploy basic abilities. Thus it implies a system or a business process viewpoint. Capabilities should match the relevant stimuli. Examples of the practices from the case studies that demonstrated capabilities included adjusting daily production plans to respond to customer demand fluctuations, rotating stock from elsewhere to respond to shortage of inventory, having good relationships with suppliers to cope with urgent, unusual or unpredicted requirements.

**Goals:**
Responsiveness is goal driven. However, not all firms will be driven to respond to every stimulus at a similar level and the same goals may not be appropriate in different environments. Firms decide their goals within the context of their business and operational environment. In addressing this issue we highlight the need for clarity and commitment to both achieving stated goals and maintaining a desired level of performance. In focusing on the order fulfilment process the generic goal is to meet the demands placed on the manufacturing business.

### 2.1.2. A generic framework for responsiveness [1]

Our discussion of the components of responsiveness implies that a particular firm is subject to specific stimuli that necessitate specific responses and that different capabilities to respond are necessary depending on the nature of the firm and its business environment. This raises the question of a company's overall approach to responsiveness. What sets the strategic direction and constraints in each firm that then impact on the level of responsiveness?

From our studies it is clear that companies tend to be responsive with respect to their strategic directions and the key issues are then to determine the appropriate ways to respond and the appropriate levels of responsiveness. Essentially there are three fundamental decisions: are we going to respond and, if so, how and at what level should we respond? It is useful in this context to view responsiveness from two perspectives - business strategy and operations strategy. Figure 1 illustrates our conceptual framework for responsiveness in a manufacturing organisation.

### 2.2. Mass Customisation

Papers from the literature that has influenced understanding and perspectives are briefly reviewed. The literature review on Mass Customisation is first considered and then literature related to levels of customisation is considered [3].

#### 2.2.1. Mass customisation structure

Several authors broadly note that MC is a hybrid of mass production and customisation. Narrowing down in its details, some of them provide ambiguous meanings to respond this sentence. From MacCarthy et al. [8]'s point of view, they define that MC attempts to combine the provision of customised products without losing the benefits of high productivity, low costs, consistent quality, and fast response. MC is, over and above, the combination of degree of customisation concerning with the customer involvement and the modularity relating to the repetitive production. The concept of MC pierces into many sectors such as business, product development, information, manufacturing and so on. The prerequisite of implementing mass customisation is the application of advanced technology, such as the flexible manufacturing system, computer-integrated manufacturing, computer-aided design, and advanced computer technology. The aspect of operational models for MC bases on supplier networks, factory, and customer order/delivery processes.
2.2.2. Levels of customisation

To date, many papers that propose strategic policies on customisation levels are grouped and compared by Silveira et al. [9]. One of them is Lampel and Mintzberg (1996)'s an influential work [10]. For MC, they note that there is a trend toward customised standardisation or assembling standardised components. Because the wide-scale adoption of MC lacks the direction of the operating concept, modelled are generic

![Diagram of responsiveness framework]

Figure 1: Responsiveness framework

operational systems under Lampel and Mintzberg’s concept being composed of Post Delivery, Deliver to Order, Assemble to Order, Fabricate to Order, and Design to Order [11]. As their research does not specify for any industry, here the meaning of MC is covered to quickly respond customer satisfaction by searching orders being produced in line or stocked as finished products, producing new placed orders and even using self-customised products after sales.

3. Empirical findings

Although clothes are a basic need of the customers providing comfort and hygiene, it also depends greatly upon customers’ personalities and preferences. The general premise comes from the fact that customers expect different value from various clothes. Therefore the manufacturer has to provide the clothes with obvious attributes or features in order to respond to the customers' value [12]. We found that to study this research in this...
apparel cases are best suited to represent the operational level under an MC environment. Thus, data are obtained from an exploratory interview in five Thai companies of apparel industry.

**Company A**

This company designs, manufactures and sales casual apparel for men, women and children. As an OEM, the retailers provide designs for new products. The production line is now a progressive bundle production. High inventory of raw material also contributes to the achievement of production flexibility. The information from sales executives all goes through the commercial planner and to the master planner. The master planner then co-ordinates with the plant manager. He is also responsible for working with the buyers on the plan for purchasing raw materials. The master planner, in consulting with the plant managers, makes master production schedule (MPS) which shows the weekly production capacity for each product type, workload scheduling based on orders and capacity balance. The MPS is updated at time a week. The master planner can reschedule workload if there is a capacity problem. He is also responsible for scheduling urgent orders and order changes by considering the capacity balance. MC levels for this company are mixed between a design-to-order (DTO) manufacturer and a make-to-order (MTO) or fabricate-to-order (FTO) manufacturer.

**Company B**

This MTO manufacturer company mainly produces suits and sportswear exporting to Europe under its own brand. Raw materials supply is an important problem. Its suppliers are in Taiwan and Thailand. Production capacity is about 120,000 pieces per month. Customers provide the company with information on demand for the next twelve months, of which the first six months may be orders and the rest are forecast. At present, the production line is set up by modular production. Worker assignment is allocated with the combination of different skills. Minimum volumes per day are determined and data are collected to calculate cost per unit.

**Company C**

In the past, the minimum order is 100 pieces and the maximum is 500 pieces. After economic crisis recently, a manager gets a new idea to respond customers under 25-100 pieces per order. Its capability is about 20,000 pieces per month. Some products are repeated. Line balancing is a typical problem. Product variety is 12-15 products per one line. The company plans to be DTO in the future. Customers place order before next season 60-90 days. The delivery lead time is determined within 3 months.

The production line of this company is produced on the modular production line.

**Company D**

Products are shirts, blouses and uniform with standard design. There are three plant locations and each plant operates independently. Its capacity is approximately 80,000 – 100,000 pieces per month for a basic products and 50,000 pieces per month for fashion products. A computer assists to place markers, print drawing and then cutting them manually. All Fabrics are composed of weaving 75 percent and knitting 25 percent. Van Heusen and Granslam are its retailers. Products are designed every four months in each collection. The Tega2 program is used for production planning and scheduling. Barcode is employed to control raw materials and bundles throughout production systems to packing. Approximate lead time in the processes of knitting, dying and cutting and sewing take about 30 days in each operation. Long lead time might be resulted due to waiting for order confirmation from a customer. Future plan pays lot of attentions on quick response and product differentiation.

**Company E**

Over 85-90 percent of the company’s product export to Europe (40%), Japan (30%) and South East Asia (15-20%) the rest (10-15%) is for local market. The company is as the Original Equipment Manufacturer (OEM) but has its own brand name. The company employs four progressive bundle production lines. The production lines A and B are set for mass-produced orders. The C and D lines manufacture customised orders. The company has around 125 orders per month with ninety-five percentage of customised orders and five percentage of repeated orders. For the fashion line, minimum orders are 20 pieces per style and maximum orders are 200 pieces per style. Typical problems in this company are information linkage among department and line balancing.

### 4. Analysis and Discussion

From our case studies observations, responsiveness definition is mapped into the findings. This can be summarized in the Table 1.

<table>
<thead>
<tr>
<th>Responsiveness/Case study</th>
<th>Stimuli</th>
<th>Awareness</th>
<th>Capabilities</th>
<th>Goal</th>
</tr>
</thead>
</table>

**Table 1:** Responsiveness Definition in MC Environment
4.1. Product Variety

From the findings above, it is clear that responsiveness stimuli identified are product variety in customer demand. This is reflected by customer demand fluctuations on patterns, fashion and volume. It must be noted that both of simultaneous variety and the sequential variety (variety spread over time) need to be considered and distinguished under responsiveness environment. The product variety within plants has potentially undesirable effects on the key features of MC system, that is, on cost, quality and responsiveness [13]. Therefore product variety must be considered in the MC context.

4.2. System capabilities

By analysing under responsiveness perspectives, it can be seen in Table 2 that awareness and capabilities in the system are built according to the stimuli, i.e., product variety. It can be said that product variety results in the imbalance workload in the system. It drives the system to respond by adjusting production plan, rescheduling capacity plan and master production schedule. Line balancing also plays an important role. This all aims at minimising work in progress and lead time with production smooth flow. Furthermore, Sirovetnukul et al. [3] recommend some other elements in creating system awareness and capabilities as follows.

Table 2: System Awareness and Capabilities for MC Strategy

<table>
<thead>
<tr>
<th>Awareness and Capabilities</th>
<th>Results and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Elicitation of customers’ needs via internet</td>
<td>A firm believes it is not too hard to deal with elicitation of customer needs via the internet. There are ten pros to do on-line business via internet [14].</td>
</tr>
<tr>
<td>2. Technologies to facilitate customer choices</td>
<td>High technologies such as CAM and digital scanner are not necessary in the early phase due to too much to investment. Because size ranges will be pasted on screen, a customer can measure each position like neck, chest, and wrists by self and compare with a table of size ranges. In other words, the standard size is adjusted to fit individual consumer specifications.</td>
</tr>
<tr>
<td>3. Interpretation of customer needs</td>
<td>Additional personalised design by customers is not considered except for the basic catalogue designed by a company. A salesperson does hardly interpret customer needs as soon as that catalogue is offered.</td>
</tr>
<tr>
<td>4. Design of modular products</td>
<td>The company intends to develop modular subassemblies composed of parts that are common to all mass-customised products such as collars, cuffs, and pockets. The module supply and inventory may be less subject to risk than the differentiated supply and inventory.</td>
</tr>
<tr>
<td>5. Design of postponement</td>
<td>In the early phase, a general manager said that modular assemblies are not customised by including additional parts such as initials on the basis of customer’s unique needs.</td>
</tr>
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</table>
order. For that reasons, a postponement of product differentiation is not referred. Making several unique products there are a number of options in each component part, so no intermediate assembled parts are stocked. It is difficult to stock them which customers do not want. However, it might be called the postponement of differentiation at the stage of design.

6. Flexible manufacturing systems

It is necessary to use flexible manufacturing system to reduce changeover time and set-up commonality between adjacent orders so that a process can be repeated on the next sequence of orders. For example, the pink shirt is produced by the pink thread, so it takes set-up time to change to the new blue shirt. Thus, the computer modelling software might be used to (1) records a customer’s specific orders, (2) translates the orders into an overall product design, and (3) schedules the processes to minimize changeover time. Some technological machines such as Computer Spreader and Computer Cutter may be installed but a firm is concerned about the facet of economy.

7. Use of barcode and scanner

A company would like to set up it in the future soon. The use of bar codes and scanners as an essential component of a logistics information system enable a firm to track virtually every part and product from the assembly line through to the warehouse.

8. Resource for mass-produced and mass-customised products simultaneously

The nature of garment is different from any industry such as automobile that invests high capital cost for production line. Thus, it is suitable for breaking the line of mass-produced and mass-customised lines independent.

5. Conclusion

Developing responsiveness framework and its performance on mass customisation environment intentionally results in related factors from responsiveness components. All five companies set the same goal that desire to fulfill customer needs with product variety under efficient operational performances. Thus, product variety in customer demand urges as the particular stimuli. Factors in the awareness component cannot divide into either MTO or DTO manufacturer. Both of them be aware of information linkage, arrival customer demand, and capacity changes. To deal with them, capabilities that are arranged into those factors are real-time scheduling and capacity adjustment, modular production, and multi-model or mixed-model assembly line balancing. In addition to previous capabilities, the end of this paper put in some other elements such as modular clothes and postponement helping us to complete awareness and capabilities in apparel supply chain. Further research will be focusing on responsiveness performance in an MC environment. Also, there are some rooms for simulation modeling and further case studies.

References


