Manufacturing agility: Construct and instrument development

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Manufacturing Agility: Construct and Instrument Development

P. Sud-on, A. Abareshi, S. Pittayachawan, L. Teo

Abstract—Manufacturing agility is emerging as an essential competency for organisations to deal with uncertainties in today’s fast-changing environment. Despite that the beneficial impact of manufacturing agility is widely recognised, little empirical research exists to explain its construct. The manufacturing agility metric is difficult to develop due to its multidimensional and fuzzy nature. This paper aims to develop a research instrument to access manufacturing agility. Through a comprehensive literature review, the agility components are identified and are used to perform an exploratory analysis in order to provide a research-ready instrument. The instrument is tested for both construct validity and reliability based on a large scale survey using an online-based methodology. The data was collected from 263 Thai automotive manufacturers with a response rate of 12%. The results show four distinctive agility components, namely responsiveness, flexibility, competency, and quickness/speed. These capabilities are proved to be the key elements to promote manufacturing agility. The development of instrument provides a validated tool for organisations to measure its manufacturing agility. It helps to transform a philosophy into concrete actions and create a better understanding how manufacturing agility can be measured.

Keywords—Manufacturing Agility, Dynamic Capability, Resource-Based View, Instrument.

I. INTRODUCTION

Technological innovations and economic uncertainties have changed the environment of global makers that resulted in many industries progressing from slow moving, stable oligopolies to hypercompetitive environment [1]. Today’s marketplace is characterised as volatile highly competitive, time-sensitive customer demand, and shorter-product lifecycle [2], [3]. The business turbulences have resulted in the competitive advantage is swiftly created, duplicated and exhausted [4], [5]. The traditional market competition deviated from merely lowest prices to increased duplication and exhausted [4], [5]. The traditional market competition deviated from merely lowest prices to increased demands of customised production, quality and lower lead time [6]. Many industrial companies have started to reinvestigate how their businesses are structured and managed, in order to respond to the increasing market complexity.

Agility is particularly important concept if the manufactures have to remain competitiveness within a highly volatile marketplace [7]. Several literatures have proposed the concept of manufacturing agility capabilities to quickly respond to the market turbulences. The term includes a comprehensive response to the challenges posed by a business environment dominated by change and uncertainty [8]. It is often involved a speed of changes in process, or system without compromising daily operations or subsequent change processes [9]. Increasingly, the manufacturing enterprises have paid more attention in improving their performance through manufacturing agility adoption [10]-[12].

While the opportunities of manufacturing agility might be attractive, a measure of its construct has not been provided in extant literature. Moreover, to date, the research for manufacturing agility have been focused in industrialised nations, and neglecting newly industrialised or developing nations is still lacking [13]. This leads to the significant of a further investigation on to what extent the concept of manufacturing agility is applicable to use in different environment context.

The aim of this paper is to aid the process of theorisation of manufacturing agility by addressing the questions of “what capabilities do firms need to become agile?” and “how can the dimensions of these capabilities be assessed?” The study defines manufacturing agility to clarify the capabilities businesses need to promote competitiveness under a highly volatile marketplace. It makes a contribution to advance the sustainable operations management through theorisation, model construction, and measurement development.

The remaining part of the paper is organised as follows. Section II reviews the conceptual foundations of agile construct drawing from the resource-based view and dynamic capability view, manufacturing operations and supply chain management. Next, the development of manufacturing agility construct is presented including instrument development and preliminary validation. Fourth, the implications of the model are discussed. Finally, conclusion is drawn and limitations of the study are identified with suggestions for future research.

II. CONCEPTUAL BACKGROUND

The conceptual foundation of the manufacturing agility framework is drawn from the theories of resource-based view and dynamic capability of agility business operations.

- Agility, Dynamic Capability and Resource-Based View

The problem of how firms can successfully deal with dynamic, unpredictable environments has been a topic of substantial interest both in practice and academia for several
The resource-based view (RBV) first suggests that organisations achieve the competitive advantage by acquiring assets and resources that different from those of rivals [15]-[17]. Since internal resources are the primary source of company profits, it is seen as the determinants of sustained performance [18]-[20]. Through the lens of RBV, organisations are conceptualised as bundles of internal resources that are heterogeneously distributed and persist over time [21].

The dynamic capability view (DCV) literature, however, suggests that beyond the resources and assets; much of which can be replicated by competitors [22], it is ultimately the unique capabilities engendered by organisations that form sustained competitive advantage [23], [24]. Considered on how resources are developed, integrated and released have been underexplored [25], RBV alone may not be enough to explain on how firms can remain competitive in continuous changing environment [26], [27]. While the premise of DVC literature is rooted in RBV with its foundation on sustained competitive advantage, the DCV theory has argued that resources per se may not generate competitive advantage unless it is used to do something [28]. It suggests organisation acquire capabilities by which its idiosyncratic resources can be manipulated to match with changing market environment [29], [30].

The concept of agility is drawn upon the dynamic capability for sustaining a competitive advantage [31]. Through the DCV lens, agility helps to explain how organisations can leverage the internal resources to acquire necessary competencies in dealing with hypercompetitive marketplace [32], [33]. DVC has divided agility into the capabilities of being sense and response [34]. This includes the degree to which an organisation is able to sense and respond quickly to customer-based opportunities for innovation and competitive action [35]. Prior research suggests that strong sensing capabilities and responding capabilities are critical to firm success in turbulent environments [36]. Sensing new opportunities include the capabilities to scan, learn, and interpretive activity [37]. Once an opportunity for competitive action is sensed, it is then addressed by mobilising firm’s existing processes [38].

- **Manufacturing Agility**

The concept of manufacturing agility (MA), as a part of agility philosophy involves the development of manufacturing capabilities to achieve sustained competitive advantage under unpredictable environment [39], [40]. The term manufacturing agility was first identified by Goldman, Nagel, Preiss and Dove [41] in their 21st Century Manufacturing Enterprise Strategy report at Iacocca Institute of Lehigh University. Four MA principle objectives i) customer enrichment through one-of-a-kind products at the cost of mass production; ii) organising to master change by competing from multiple fronts with reconfigurable resources; iii) intra and inter-enterprise cooperation and; iv) leveraging of enterprise knowledge by means of advanced technologies [42]. These principles are considered important as sources of today’s competitive advantage constructs [43].

The recent literature has widely adapted the concept of agility to the areas of contemporary business necessary to overcome volatility of demand, imbalance between supply and demand, and business disruptions [35], [44]-[46]. MA is typically understood as the ability to rapidly change by adapting the initial stable configuration [47]. Sheppard and Young [48] have related MA to the ability to change the position efficiently through a combination and recombination of isolated capabilities. The decision on these capabilities is crucial for the success of MA implementation.

Different capabilities were mentioned in the literature as associated to MA. The studies of Yusuf et al. [49] and Ramasesh et al. [50] have defined MA as the successful exploration of competitive base such as speed, flexible, innovation competency, proactive, quality and profitable. Goldman et al. [41] refers to MA as the abilities of being “quick” and “adaptive” to respond to changes. Moreover, more recent studies have asserted the term “responsiveness” as one of the critical dimensions of MA [13], [51]. According to Sharifi and Zhang [52], the ability to respond to change in proper ways and exploiting and taking advantages of changes are the main factors of agility.

Despite the differences, most literatures have emphasised on quickness/speed and flexibility/adaptive as the primary attributes of MA [49], [53], [54]. An equally important capability is being responsiveness to change and uncertainty [8], [51], [52]. Yet, the next common component of MA is competency with a focus on innovation [55]-[58]. Based on these studies four MA capabilities have been proposed including responsiveness, flexibility, competency and quickness/speed [52], [54].

**III. DEVELOPMENT OF THE AGILITY FRAMEWORK**

MA is the main construct of interest in this research. In order to develop the MA framework and ensure the accuracy and validity of its measuring instrument, the structured procedure developed by Chirchill [59] was employed. The first stage involves defining the domain construct of MA. Stage two operationalises the construct by generating measuring items to ensure content validity. In stage three, sample design and data collection issues are covered. Stage four contains data analysis to test the validity and reliability of the developed model and instrument. In this study, MA capabilities defined by Sharifi and Zhang [52], [54] are adopted with certain modifications.

- **Responsiveness**

Responsiveness is the ability to identify changes and respond to them [52]. This includes the ability of sensing, perceiving and anticipating changes [54]. Given the impact of environment uncertainty, responsiveness is considered a primary determinant of organisational performance [60]. While being responsive can mean different things to different people, it is important to determine what actually constitute responsiveness. According to Holweg [51], MA implies the organisation’s responsibility to sense and respond to changes of customer requirements. It is often include the
manufacturing capability to change the production capacity to match with informed customer requirements [61]. Given the fact that customer is today’s key market driver, responsiveness is required as one of the most important agility attribute needed for organization to achieve sustained competitive advantage [62], [63]. In this study, the capability of responsiveness will be measured as “Customer Responsiveness”.

- **Flexibility**

  Sharifi et al. [54] refers to flexibility as the ability to achieve different objectives with the same facilities. Flexibility allows organisations to adjust manufacturing output often in the areas of product model and volume [52]. The recent studies have argued that being flexible would enable organisations to avoid major modification and disruption to current capacity [51], [64]. According to Yiwei et al. [65], a high level of flexibility provides possibilities to make changes at low cost within a short time frame. By improving flexibility, organisations can obtain a high level of MA through the achievement of time and cost efficient productioncustomisation while maintaining highest performance [66], [67]. Moreover, volume flexibility implies the ability to remain profitability through various operating output levels [68], [69].

- **Competency**

  Competency contains the abilities of being productivity, efficiency, and effectiveness of activities towards the aims and goals of the company [54]. According to Sharifi et al. [52], competency can be referred to a wide range of abilities for example, appropriate use of technology, product and service quality, change of management, cooperation and integration. Given the broad definition, it make difficult to justify the elements required to become competency. The literatures suggest that MA entails the organisation’s capability to acquire knowledge and skills that cannot be easily duplicate by competitors [70], [71]. Competency is often associated with being innovative as a mean to improve the frequency of new product introduction [50]. Such Innovation competency is considered important capability to enable existing knowledge and skill to be reconﬁgured and/or reused to match with changing environment [72]. In this study, the capability of competency will be measured as “Innovation Competency”.

- **Quickness**

  Quickness is defined as the ability to carry out tasks and operations in the shortest possible time [52]. Quickness is oriented towards a strong customer focus and speed time-to-market [73]. The literatures have associated MA with the ability of being the ﬁrst mover to outperform the competitors [71]. According to Brown et al. [74], quickness involves speed delivery of ﬁnished product that would ultimately lead to an improvement of MA. Given the intense competition, MA and its capability to quickly delivery market requirements has become vital. This often includes guaranteeing of the shortest lead time throughout the production development process [70]. Increasingly, firms are forced to introduce a new product faster to remain competitiveness [75]. In this study, the capability of quickness will be measured as “Speed Delivery”.

### Generation and Evaluation of Measurement Items

The very basic requirement for a good measure is content validity, which means the measurement items contained in an instrument should cover the major content of a construct [59]. Content validity was achieved through a comprehensive literature review and interviews with practitioners and academics. Using the manufacturing agility dimensions discussed in the previous sections, an initial pool of items was created. This includes a total of 23 initial items [76].

Next, the items for the various constructs were reviewed by three academics and a doctoral student, and further re-evaluated through a structured interview with seven content experts. The focus was to check the relevancy of each construct’s definition and clarity of wordings of sample questionnaire items. Based on the feedback from the academics and content experts, redundant and ambiguous items were either modiﬁed or eliminated. New items were added whenever deemed necessary. While there were no new items discovered in this stage, three items have been deleted. Table I has summarized the remaining questions with the total four pools and 20 items: five customer responsiveness items, five ﬂexibility items, ﬁve innovation competency items, and ﬁve speed delivery.

<table>
<thead>
<tr>
<th>Code</th>
<th>Initial Instrument</th>
<th>Customer Responsiveness</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>The ability to quickly identify changes in market demand</td>
<td>Self-development</td>
<td>√</td>
</tr>
<tr>
<td>R2</td>
<td>The ability to respond quickly to emergency customer orders</td>
<td>[77]</td>
<td>√</td>
</tr>
<tr>
<td>R3</td>
<td>The ability to reconfigure equipment quickly to address demand changes</td>
<td>[77]</td>
<td>√</td>
</tr>
<tr>
<td>R4</td>
<td>The ability to reallocate people quickly to address demand changes</td>
<td>[77]</td>
<td>√</td>
</tr>
<tr>
<td>R5</td>
<td>The ability to adjust capacity quickly to address demand changes</td>
<td>[77]</td>
<td>√</td>
</tr>
<tr>
<td>R6</td>
<td>The ability to ensure no shortage of stock at order time</td>
<td>Self-development</td>
<td>√</td>
</tr>
<tr>
<td>R7</td>
<td>The ability to act promptly in customer requirements</td>
<td>Mapes et al. [78]</td>
<td>X</td>
</tr>
</tbody>
</table>

#### Flexibility

- **F1** The ability to effectively customise the products to match customer requirements [79] √
- **F2** The ability to effectively produce a range of products for different types of customer requirements [79] √
- **F3** The ability to effectively adjust the production volumes to match customer requirements [79] √
- **F4** The ability to effectively adjust manufacturing throughout times to match customer requirements Self-development √
- **F5** The ability to effectively produce both large and small orders [79] √

#### Competency

- **C1** The ability to increase the number of new products introduced each year to cope with new market competition [54] √
- **C2** The ability to increase the frequencies of new products introduction Self-development √
- **C3** The ability to develop new skills and competencies Self-development √
- **C4** The ability to acquiring the skills necessary for business process change Self-development √
- **C5** The ability of being innovative in operation management [52] √

#### Quickness

- **Q1** The ability to decrease manufacturing lead time Self-development √
- **Q2** The ability to decrease new product development cycle time Self-development √
- **Q3** The ability to perform product delivery quickness [80] √
- **Q4** The ability to perform product delivery timeliness [80] √
- **Q5** The ability to spend up time-to-market of new products Self-development √
The interrater agreement analysis is performed in order to test the degree of agreement among raters. This is important to identify the consistency of scores across different informants from different raters [81]. Interrater agreement helps us determine if a particular item/scale is appropriate for measuring a particular construct. The agreement with respect to a single target using a multi-item rating scale is applied [82]. The formula to calculate interrater agreement has been introduced by Lindell [82]. The formula is as following:

$$r_{wg}(J) = 1 - \frac{s_{E(S)}^2}{s_{U(S)}^2}$$

where $J$ is the number of items, $s_{E(S)}^2$ is the variance of the ratings, and $s_{U(S)}^2$ is the variance of the uniform distribution.

Based on an examination of the small-sample behaviour of $r_{wg}(J)$, sample sizes of 10 or more raters are recommended [83]. The sample size includes 20 Thai automotive companies. The results of interrater agreement with their corresponding $p$ value and power analyses are presented in Table II. Three assumptions were adopted for decision to which items to be deleted. Dropping items are based the three criteria recommended by the literatures [82], [84], [85];

1. Drop item when $r_{wg}$ is below mid-point
2. Drop items left from 1) when $p > .05$
3. Drop items left from 2) when power < .8

According to these criteria, one item (COM2) was removed. The results reveal in Table II with the total number of 19 items remained.

### Table II

<table>
<thead>
<tr>
<th>Items</th>
<th>$r_{wg}(J)$</th>
<th>$P$</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>3.65</td>
<td>0.000</td>
<td>1.00</td>
</tr>
<tr>
<td>R2</td>
<td>3.50</td>
<td>0.000</td>
<td>1.00</td>
</tr>
<tr>
<td>R3</td>
<td>4.10</td>
<td>0.000</td>
<td>1.00</td>
</tr>
<tr>
<td>R4</td>
<td>4.15</td>
<td>0.000</td>
<td>1.00</td>
</tr>
<tr>
<td>R5</td>
<td>3.80</td>
<td>0.001</td>
<td>0.97</td>
</tr>
</tbody>
</table>

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### Sample Design and Data Collection (Main Study)

Data was collected using a web-based survey. Since this study has a supply chain and operations management focus, the target respondents were the people working in the areas of operations, manufacturing, procurement, materials and R&D. The majority of respondents held the title of senior manager and director as they were deemed to have best knowledge in the interested areas of research. The respondents are working in the automotive enterprises and are members of Industrial Estate Authority of Thailand (IEAT). IEAT is working under the Ministry of Industry in developing regional industrial sectors where factories from various industries are orderly and systematically clustered together [86]. There are currently approximately 41 industrial estates located in 15 provinces nationwide under IEAT. The IEAT membership was the main criteria when obtaining email lists. The email lists were collected from four different sources. These are Industrial Estate Authority of Thailand, Board of Investment of Thailand, Thailand Automotive Institution, and Thai Automotive Industry Association, giving the total names of 3929 automotive organisations. Out of this initial organisation pool, 415 were excluded due to duplication, thus giving the researchers 3514 organisations. The invitations to participate in the survey were sent out to the respondents one week earlier the actual survey. There were 141 automated emails replied mentioning that the person is out of office and therefore, were removed from the list. Moreover, there were 318 emails refused to participate in the survey. The refinement gave the final email lists of 3055.

The data collection was carried from 1st April to 9th June 2013 for the total of 10 weeks. To ensure a reasonable response rate, the survey was sent in two waves 1-5 weeks and 6-10 weeks. There were a total of 372 returned survey. Of these responses, 8 questions were incomplete and provided were removed out of the sample. The total completed number of survey was 364. Out of 364, the first wave produces 238 responses, and the second wave generated 126 responses.

### Sample Demographic and Data Screening

More than half of the respondents (62%) indicate their organisations were categorised as supplier tier 1, while 38% of respondents were Original Equipment Manufacturing (OEM). Other demographic characteristics are given in Table III.

### Verification of Non-response Bias

To ensure that the sample of responses obtained was representative of the population, non-response bias developed by Rogelberg et al., [87] adopted. This includes the comparison of the first wave respondents (week 1–week 5) and second wave respondents (week 6–week 10). Differences in the distribution between response waves were analysed by cross-
tabulation. Statistical significance was estimated by chi-squared tests. A $P$ value $\leq 0.05$ was considered significant. The results revealed the significant value of more than 0.05 in all variables. Thus it can be concluded that there is no significant demographically differences between the early and late respondents. The results are as follows;

- Instrument Assessment

The common techniques used to evaluate the measurement properties are unidimensionality, convergent validity and discriminant validity [88]. The unidimensionality test is first conducted through the exploratory factor analysis (EFA) method following by the test of convergent validity and discriminant validity.

- Exploratory Factor Analysis (EFA)

EFA was applied to evaluate the measurement properties of a construct. The objective of EFA was to identify domain substrata and not to reduce the number of items. Kaiser’s criterion (i.e., eigenvalue > 1) was used to determine the number of factors. Moreover, Parallel Analysis (PA) was conducted to make comparison against the eigenvalue obtained from the EFA analysis of the actual data to estimate the maximum possible number of factors that can be extracted [89]. PA involves comparing the size of the eigenvalues with those obtained from a randomly generated data set of the same size [90]. This approach to identifying the correct number of components to retain has been shown to be the most accurate, with both Kaiser’s criterion and Catell’s scree test tending to overestimate the number of components [91], [92]. To undertake PA, we ran O’Connor’s [89] SPSS script, randomly generated 1,000 data sets, and used the 95th percentile of eigenvalues calculated from the random data as the comparison baseline. Only those eigenvalues that exceed the corresponding values from the random data set are retained. The factorability of the data is tested through the Kaiser–Meyer–Olkin measure of sampling adequacy (KMOMSA) and Bartlett’s test of sphericity. Generally data are factorable if the KMOMSA is between 0.5 and 0.1 and the Bartlett’s Test of Sphericity (BToS) is significant below 0.05. The results of EFA analysis with their corresponding Cronbach’s $\alpha$ and PA are presented in Table IV and Fig. 1. All Cronbach’s $\alpha$ values are greater than 0.7, indicating reliability of extracted domain substrata.

![Fig. 1 Manufacturing Agility’s Parallel Analysis](image)

- Convergent and Discriminant Validity Assessment

Following the establishment of the unidimensionality step, the reliability and validity of the underlying constructs were assessed [93]. For this purpose, the factors obtained from EFA were assessed for reliability average variance extracted (AVE), construct reliability (CR) and discriminant validity. In using confirmatory factor analysis, construct/composite reliability (CR) and variance extraction (AVE) measures are also used to estimate scale or construct reliability. AVE and CR are calculated from the model estimates, using formulae given by Fornell and Larcker [94]. Bagozzi and Yi [95] recommended that AVE should be equal to or greater than 0.50, and C.R. should be equal to or greater than 0.60. Table 4 summarised findings. All the four factors are found to meet all the convergent validity criteria. The formulae are as follows;

$$\text{AVE} = \frac{\sum \lambda^2}{\sum \lambda^2 + \sum \xi}$$
where $\lambda_i$ is the standardised loading for each observed variable, $\varepsilon_i$ is the error variance associated with each observed variable, and $\rho_{ij}$ is the measure of construct reliability.

The analysis results in Table V confirmed the discriminant validity, in which the square root of AVE for each construct is greater than the levels of correlations involving the latent constructs. The results of inter-construct correlations also show that each construct shares larger variance with its own measures than with other measures.

### IV. DISCUSSION

Despite the concept of MA has been around since 1990s, only the impact of its concept has made popularised in the 21st century as a key strategic tool in dealing with today’s environment volatility [55]. Like other research fields, the manufacturing agility requires theorization, model construction, and measurement development. This is because theory construction and a cumulative tradition, the ultimate objectives of a research field, are inseparable from measurement [96, p. 192]. For any field of study to progress in theorization, clear definition of a construct is an essential first step. Indeed defining a construct using rigorous approach is an important aspect of theory building as lack of rigor often leads to competing and fuzzy conceptualizations [97].

This study, drawing from the manufacturing, agility, resource-based view and dynamic capability view theories, develops the manufacturing agility construct. The theories provide rigorous foundations to the conceptualization of manufacturing agility. The proposed structure suggests that the manufacturing agility can be measured using four dimensions of customer responsiveness, flexibility, innovation competency, and speed delivery (see Fig. 2). Such a structure would allow the investigation of manufacturing agility at different levels of abstraction and granularity.

- **Customer responsiveness** is comprised of items that reflect the ability to make responsiveness to customer demands concern in the manufacturing area. These items tap into the manufacturers quickly identifying the change and manage to respond to it within a customer’s preferred period of time. Due to fierce competition, the manufacturing firms are required to be as responsiveness as possible to customer requirements to become competitiveness.

- **Flexibility** items reflect organisations’ capability of being adjustment on their products and production process. This includes the ability to effectively and efficiently produce both large and small quantity of orders. This is important as customer’s demand has become even more specified.

The ability to customise the production process to match with customer demand is important if firm has to deal with highly competitive marketplace.

- **Innovation Competency** embraces the ability to acquire new skills or even reconfigure existing ones to match with market necessary. This focuses mainly on being an innovative in product offering to the market. The ability to differentiate itself by acquiring critical competencies is increasingly recognised as a key factor dealing with market volatility.

- **Speed Delivery** contains the ability to make improve a manufacturing lead-time whether in terms of new product development, product delivery and time-to-market. Delivery speed should be defined by the needs required by the market or customer. Such ability to make improvement on time-to-market is crucial for firm to outperform the competitors and retaining its competitiveness.

### Theoretical Implications

By combining the theoretical approach from extant theories, a manufacturing agility model is developed and tested. The manufacturing agility represents an original contribution to the supply chain and production system literature. From an agile environment perspective in a developing country, this study makes an absolute contribution to enrich the body of knowledge by producing a reliable instrument to be used in the areas of supply chain and operational management.

### Practical Implications

To be able to develop agility capabilities, it is important that the manufacturers understand the concept. The development of MA construct is useful for practitioners to understand the areas that needed to be built or improved in order to become MA. Rather than viewing MA from one domain, the model allow organisation to approach MA from different perspectives. Moreover, the instrument provides a mean for an organisation to assess and benchmark MA capabilities and progress; particularly against the competitors in the same industry. Assessment of a current state is an essential step in any strategy development. The model offers practitioners both a framework and an assessment tool to strategies MA.

### Limitations

Certain limitations can be recognised in this study. First, while both academic and practitioner literature is used to identify items to operationalize the manufacturing agility construct, there is lack of an in in-depth case studies conducted. Such results from an in-depth case study may result in potential items pool that is missed from the current study being identified. Second, the study is based only on exploratory analysis to test the basic content and construct validity. The further analytical methods, such as Confirmatory Factor Analysis (CFA) is required to identify the goodness-of-fit. Thus, the model can be considered only as preliminary and needs further confirmation. Lastly, the data is limited only in Thai automotive industry.
Fig. 2 The Manufacturing Agility Model

V. CONCLUSIONS AND FUTURE RESEARCH

Technological innovations and economic uncertainties have changed the environment of global makers that resulted in many industries progressing from slow moving, stable oligopolies to hypercompetitive environment. Firms are forced to reinvestigate how their operations are structured and managed, in order to respond to the increasing market complexity, turbulence and uncertainty. It is recommended that the key to survival for organisations dealing with more innovative products such as electronics is creation of responsive or agile supply chains.

The current study has made an original contribution in defining the agility construct and model and developing the components that constitute it. It also provides a research-ready instrument whose properties are sufficiently validated. The rigorous procedure was followed in assessing the instrument reliability and validity. The paper may be helpful for practitioners as a decision tool to locate, measure, and manage their production capability and identify strategies to improve it. Further using the model it will be possible to calculate manufacturing agility indices at different levels of abstraction and detail.

Future tests and refinements of the proposed model will be extremely useful to advance knowledge on manufacturing agility. Given the effect of market uncertainty which has raised the role of manufacturing capabilities, researchers should continue investigating the preliminary model developed here. This can be achieved by refining the measures and factors proposed in this model, by testing the relationship among the different agile factors, and by exploring the relationship between the agile factors and other antecedent and/or consequent variables of interest.

REFERENCES


