ABSTRACT

An issue in operations literature is the ideal sequence composing operational capabilities. Studies of the sand cone model have been conducted on a huge amount of countries, but few of them on emerging countries. So, this study aims to analyze the sequence of operational capabilities in Brazilian industry.

Keywords: cumulative capabilities, Brazilian industry, sand cone model

INTRODUCTION

A discussion on competitive priorities begins with Skinner (1969) in which the author reports that companies need to establish what are your criteria for success. For the author, the production system inevitably involves setting in which competitive criteria the company will focus its organizational efforts to differentiate themselves from their competitors and gain competitive advantage, meaning to say that operations managers need to use trade-off in their decision making. The article suggests the trade-off among competitive criteria, but does not state explicitly whether it is referring to the priorities or capability, however, the subsequent discussion it focuses on both concepts (Rosenzweig and Easton, 2010).

Complementary to the seminal work of Skinner (1969), Wheelwright (1984) establishes the criteria for the competitive strategy to be followed by the area of operations, namely cost, quality, reliability and flexibility. One of the advantages in defining the competitive criteria is to understand their effect on the structural and tactical decisions of the organization, because once defined, the role of production is to manage them and strengthen them.

For the law of trade-offs, the factory cannot obtain simultaneously high level of competition in quality, flexibility and delivery of the product and still have the lowest manufacturing cost (Schmenner and Swink, 1998). Being reckless for the company trying to compete in all dimensions since it may end up being the second best in each of them; other companies will be dedicating more resources in a specific dimension, developing competitive advantage on it (Hayes and Wheelwright, 1984).

However, considering the advent of technology, Ferdows and DeMeyer (1990) warned about the complexity of the relationship between trade-offs and operational capabilities. For the authors, depending on the complexity of the capabilities, they can change or even enhance each other, becoming cumulative. The seminal work of Ferdows and De Meyer (1990) shows the cumulative capabilities making a metaphor to a sand cone, they would be developed
sequentially, where one another and strengthen organizations should consider two factors for this: (i) the lowest capability would have to be well designed to focus on the next move, within the sequence, and (ii) passing to the next, the focus shouldn’t be alone in it, but also to further develop the above capabilities. This would happen throughout the sequence, so that the organization would be possible not only to develop different capabilities at the same time, but also that they were enduring. Thus, since quality is established, other capabilities are occurring simultaneously. This sequence established by the authors is called the model of 'sand cone' and quality starts, goes to delivery, flexibility and finishes with costs.

The cumulative capabilities in the area of operations allow organizations develop enduring advantages over their competitors. Ferdows and De Meyer (1990) showed that plants that develop quality and delivery confidence respond to market faster and achieve even lower costs. The authors' findings combined with the performance of Japanese companies in the 80s gave strength to the discussion of the ability of organizations to develop capabilities cumulatively.

The cumulative efforts of research with the capabilities were beginning to see whether companies could actually develop these capabilities cumulatively. Over the years, a much-discussed issue is whether there is an optimal sequence for composing capabilities because since the presentation of the sand cone model proposed by Ferdows and DeMeyer (1990) in which the ideal cumulative development of capabilities followed the sequence order of quality, delivery, flexibility and cost, many authors such as Noble (1995), Flynn and Flynn (2004), Schroeder et al. (2011), seek to answer whether this can be considered a universal or even if there is a sequence single or ideal sequence for the model, however, so far not achieved a consensus on the subject.

The objective of this study is to analyze the cumulative effect of operational capabilities in an emerging economy.

In this paper, the concept will be presented, followed by definitions of the methodology, results and final discussions.

1. CONCEPTUAL DEFINITIONS

This section presents the evolution of the cumulative capabilities as well as their operationalization in empirical studies.

1.1 Cumulative Capabilities

Discussion on competitive priorities begins with Skinner (1969). For the author, the production manager needs to define which competitive criteria the company will focus its organizational efforts to differentiate themselves from their competitors and gain competitive advantage, i.e., need to make a trade-off between competitive priorities defined by Wheelwright (1984) as cost, quality, reliability and flexibility.

But considering the advent of technology, Ferdows and DeMeyer (1990) authors questioned the law of trade-off warning about the complexity of the relationship involving the operational capabilities, warning of the possibility of amending or even reinforce each other. Thus, since quality is established, other capabilities are occurring simultaneously. Thus, the sequence established by the authors called the model of 'sand cone' starts quality follows for delivery, flexibility and costs ends, as viewed in Figure 1.
It is noteworthy that the authors at no time deny the existence of trade-offs, but rather propose that the improvement of a capability may impact the evolution of another, and so on.

Evidence supporting the sand cone model of Ferdows and DeMeyer (1990) were found by Noble (1995), Kathuria (2000) and Grossler Grübner (2006), among others.

Noble (1995), through an analysis of companies in North America, Europe and Korea, found better performance for those who used the cumulative model. Furthermore, the authors noted that the choice strategy of companies located in different countries tends to influence the sequence of the template. The scales tested in study were quality, reliability (punctuality), delivery, cost, flexibility and innovation. Other studies, such as Grossler and Grübner (2006) showed that quality is the basis for delivery, which is the basis for flexibility and cost, the relationship between flexibility and cost was not clearly identified. According to the authors the fact that “flexibility " and "cost " are contrary or simultaneous, may be related to the implementation of certain programs for improvement.

It is noticed that Noble (1995) adapted the proposal by Ferdows and DeMeyer (1990) scale. The same happened in many other studies that had to study the effectiveness or otherwise of the sand cone model, such as seen in Table 1.

Table 1 – Measurement range

<table>
<thead>
<tr>
<th>SCALES</th>
<th>YEAR</th>
<th>AUTHOR(S)</th>
<th>TITLE OF THE ARTICLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price offered, Quality of products, Product line breadth, Order fill rate, Order cycle time, Order/shipment information, Frequency of delivery</td>
<td>1999</td>
<td>Tracey, Vonderembse and Lim</td>
<td>Manufacturing technology and strategy formulation: keys to enhancing competitiveness and improving performance</td>
</tr>
</tbody>
</table>
As each study presented in Table 1 possessed different goals, the results also showed different conclusions. However, it was observed that in all capabilities shown to be positively related to performance of the searched area. For example, the study of Tracey, Vonderembse and Lim (1999) demonstrated that high levels of competitive capabilities lead to better performance, mediated by customer satisfaction and performance marketing. Kathuria (2000) emphasized that companies using the four competitive priorities longer have better performance in customer satisfaction than the beginners. Flynn and Flynn (2004) found evidence that cumulative capabilities are related to plant performance. Staughton and Johnston (2005) concluded that traditional operational performance criteria need to be expanded to “ways of working” and “competitive environment”. Pen et al. (2008) suggested that the internal set of routines - also considered capabilities - is positively related to operating performance, this set being hard to imitate and therefore a source of generating competitive advantage for the organization. And finally, Avella et al. (2011) identified that the capabilities of manufacturing can happen gradually or incompatibilities without trade-offs. More specifically, a direct, positive and significant relationship between quality and delivery was found. Likewise, similar results were observed for the other direct relations capabilities. Another point was that the research supported the hypothesis that flexibility has a direct, positive and significant effect in relation to environmental protection, which also occurred in relation to these practices and cost. The results indicated that non-adjacent capabilities have an indirect effect on their subsequent strengthening of the sand cone sequence.

1.2 Evolution of the concept of cumulative capabilities

A well debated question is whether there is an optimal sequence for composing capabilities? Since the presentation of the sand cone model proposed by Ferdows and DeMeyer (1990) in which the ideal medium for development of cumulative capabilities sequence followed the order of quality, delivery, flexibility and cost, many authors such as Noble (1995), Flynn and Flynn (2004), Schroeder et al. (2011), seek to answer whether this can be considered a universal sequence or even if there is a single or ideal sequence for the model, however, so far not achieved a consensus on the subject. One reason is related to the competitive environment the company is established.
The choice strategy of companies located in different countries tends to influence the result of the model (Noble, 1995). Flynn and Flynn (2004) report that global competition in which firms are embedded inevitably affect the way in which they build their capabilities operational, leading different countries to different strategic initiatives. Contingency factors hinder an ideal sequence, as environmental contingencies affect patterns of cumulative capabilities. Furthermore, the type of industry in which the company operates may differentiate their competitive factors, also changing this sequence.

 Flynn and Flynn (2004), however, does not intend to tell whether there is an ideal sequence which manages a competitive advantage, but it depends on the differences and contingency is very unlikely that the same result can meet all circumstances generated by the organizational world. Even so, the authors found strong evidence linking cumulative capability and plant performance, it is important to understand the accumulation of capabilities, but not necessarily in the sequence proposed by Ferdows and DeMeyer (1990), this cannot be considered a universal phenomenon.

 Schroeder et al. (2011) also tested the sand cone model in 189 companies and showed similar results to the Flynn and Flynn (2004). The authors concluded that not all companies follow the proposed model, and that the sequence was linked strategic choices, and the contingent factors (contingency theory) inherent in each company. Still, according to the authors when considering the intense competition and the advancement of production technology, the cumulative capabilities are adequate (Noble, 1995, Schroeder et al., 2011). But when the production is close to the efficient frontier, particularly when it is static, the trade-off theory is more suitable.

 Corroborating the idea Schroeder et al. (2011), Schmenner and Swink (1998, p. 107) show that trade-offs and cumulative capabilities are two separate proposals. Trade-offs between plants is compared at a given point in time, while the predicted cumulative capability is the improvement in the factory over time. Therefore, they are not conflicting.

Operational capabilities are unique, not easily imitable and difficult to access by competitors to be generated from a non-standard and idiosyncratic (Schroeder et al., 2002). Studies on the operational capabilities in the firm internal environment are recurring, but Swink and Way (1995) identified a lack of study on the environmental contingencies affecting the cumulative capabilities. In order to check this relation Flynn and Flynn (2004) conducted a survey of 165 plants from 5 different countries, in which they identified differences in patterns of cumulative capabilities across countries, indicating that the allied environmental contingencies strategic choices influence the sequence in which they will be related. This was one of several studies on capabilities in industrialized countries, because there is much discussion about his training or an ideal sequence for them, however, studies have neglected the context of developing and emerging countries (Schoenherr et al., 2012).

Research conducted in industrialized countries - Australia, Austria, Canada, Finland, Germany, Ireland, Italy, Sweden, Switzerland and the U.S., emerging countries - Brazil, China, Hungary, Korea, Mexico, Poland and Taiwan, and developing - Albania, Ghana, Macedonia and Nigeria, Schoenherr et al. (2012) observed that in industrialized countries, even being considered important to maintain competitive advantage, capabilities have reached a level of maturity in the nature of capabilities and thus they have less importance as a valuable, rare and inimitable resource. Contrary to what occurs in less developed countries, where they are still regarded as a powerful resource and can serve as a qualitative leap in the development of environmental economic partner. In these countries the influence of the four competitive capabilities - quality,
delivery, flexibility, and cost - possessed a greater impact on the performance of the factory business. These findings demonstrate that local decision makers need to consider such matters to support their strategic decisions.

2. METHODOLOGY

2.1 Development of the instrument

The development of the instrument for data collection was based on a detailed review of the literature by a group of researchers in major journals. The selected articles have undergone a review in their abstracts in order to remove those that do not address the topic operation capability. Remained 89 (eighty nine) items, which went through a reassessment, leaving 31artigos that were analyzed in detail, considering its references, its constructs and their metrics. The following steps have undergone purification, including Q-sort. At the end were 06 questions each with 4 items.

The study population is Brazilian companies with number of employees between 100 and 5000. Population was defined from the NCEA table three digits, the total of 500 companies contacted by telephone. Total sample was 160 responses. Non-respondent bias was assessed by ANOVA for each item, comparing the first half of the respondents with the second half being found satisfactory results (Armstrong and Overton, 1977). Sample consists mainly of medium and large (40.9 % and 50 % respectively).

Profile of the sample revealed that approximately 80% are production managers or industrial manager, 56% with experience of over 10 years in the company they work for, 54% with more than 5 years in industry and 70% working more than 10.

2.2 Common method variance

To reduce the threat of common method variance, as Podsakoff (2003) and others, the following measures were adopted: ensured anonymity and confidentiality of respondents, different scales were used for the dependent and independent variables, we applied the method Q -Sort to reduce the ambiguity of the items and the Harman single factor (Podsakoff and Organ, 1986) test, performing a factor analysis on all items to see if there is a general factor. Seven factors were found with more than 1 (one) eigenvalue and the first factor accounted for only 33.1 % of the total variance.

3. RESULTS

3.1 Templates measurement

The descriptive analysis of the items showed no significant deviations from univariate normality. The asymmetry index ranged from -0.523 to 0.722, and kurtosis between -0.892 and 0.389. Kline (2005, p. 49-50) suggests maximum permissible values of 3 and 10 for skewness and kurtosis respectively, so the data from this study show within a normal range.

Of absolute fit measures were employed in selected dimensions, such as chi-square likelihood ratio ($\chi^2$) and root mean squared residue, in order to ensure adequate representation of the entire set of casual relations. Value of chi-square of 260.841, with 179 degrees of freedom, is
It is sought is a value not significant chi-square, since H0 indicates that the data fit the model. However, it is possible to divide the chi-square value by the degrees of freedom ($\chi^2 / GL$) resulting in a value of 1.45, this measure less than 3 and therefore acceptable as Kline (2005).

Incremental fit measures (RMSEA, CFI, IFI and NFI) were also performed to demonstrate the levels of fit of the model. The charges for all indicators in their respective constructs were positive and statistically significant ($p < 0.001$). The low values of the correlations between the latent variables suggest discriminant and convergent validity. The good fit of the model and generation tool based on the literature procedure indicate the unidimensionality of the constructs and contribute to content validity.

Considering the model fit and accuracy in choosing the items, it can be stated that the scales are validated and reliable, ensuring that the scales used properly represent the latent constructs. Table 2 shows the correlation matrix and descriptive data for all indicators used.

### Table 2 - Means, standard deviations and correlations

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>quality</th>
<th>delivery</th>
<th>flexibility</th>
<th>cost</th>
<th>innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>quality</td>
<td>4.03</td>
<td>0.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>delivery</td>
<td>3.65</td>
<td>0.81</td>
<td>0.509**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>flexibility</td>
<td>3.57</td>
<td>0.57</td>
<td>0.487**</td>
<td>0.283</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cost</td>
<td>3.10</td>
<td>0.55</td>
<td>0.303*</td>
<td>0.232</td>
<td>0.199</td>
<td></td>
<td></td>
</tr>
<tr>
<td>innovation</td>
<td>3.15</td>
<td>0.60</td>
<td>0.518**</td>
<td>0.331*</td>
<td>0.720**</td>
<td>0.347*</td>
<td></td>
</tr>
</tbody>
</table>

*p<0.10, ** p<0.05, ***p<0.01

### 3.2 Regression Analysis

### Table 3 - Regression Analysis

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Independent Variables</th>
<th>R2</th>
<th>quality</th>
<th>delivery</th>
<th>flexibility</th>
<th>cost</th>
<th>innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>quality</td>
<td>quality</td>
<td>0.121</td>
<td>0.161***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>delivery</td>
<td>quality</td>
<td>0.083</td>
<td>0.245**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>flexibility</td>
<td>quality</td>
<td>0.246</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cost</td>
<td>quality</td>
<td>0.091</td>
<td>0.156*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>innovation</td>
<td>quality</td>
<td>0.281</td>
<td></td>
<td>0.473***</td>
<td>0.250***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<0.10, ** p<0.05, ***p<0.01

Regression analysis shows different relationships between cumulative capabilities. Contrary to the results of Amoako-Gyampah and Meredith (2007), in which plants in Ghana had
significant positive relationships between four capabilities (cost, delivery, flexibility and quality), in Brazil this relationship did not appear linear.

You can see four groups:

1st group: quality as dependent variable, delivery and innovation as independent variables with significance levels <0.01.

2nd group: flexibility and innovation as dependent variable as an independent variable with a significance level of <0.05.

3rd group: cost as dependent variable, quality and innovation as independent variables with significance levels of <0.10 and <0.01, respectively.

4rd group: innovation as a dependent variable, flexibility and cost as independent variables with significance levels <0.01.

4. DISCUSSION AND CONCLUSION

Studies on the cumulative capabilities show different results. Initially, the purpose of the articles was to identify whether the companies were able to accumulate those proposed by Ferdows and De Meyer (1990) operational capabilities. Some studies completely, others partially supported and there were those who found results that support the sand cone model.

Then the focus turned to studies of the existence of an optimal sequence. At this point, studies like Flynn and Flynn (2004), Amoako - Gyampah and Meredith (2007) and Schroeder et al. (2011) showed that contingency factors and the strategy adopted by company interfere in this process and that hardly a single sequence could be adopted universally. Although cumulative effect occurred largely from studies investigating the sand cone model, the sequence is altered depending on the type of company, industry or country in which it is hosted. To this end, the aim of this study is to analyze the cumulative effect of operational capabilities in an emerging economy.

Kathuria (2000), for example, did three cumulative capabilities clusters in his set of studied companies in India. They called 'Efficient conformers' which presents a significant emphasis on cost and quality, 'Speedy conformers' which also focuses on delivery and quality, and 'Do All', which presents active in the four operational capabilities. Amoako - Gyampah and Meredith (2007) found that the results, however, endured with a significant difference in their sequence. At the base of the model was then identified the quality cost, and at the top, following delivery flexibility, this difference, according to the authors, is a recurrent economic condition of the country, where the cost is a strategic component for companies.

In Brazil, as well as studies of Kathuria (2000) and Amoako - Gyampah and Meredith (2007), the results showed cumulative, but not to the sequence of the template or sand cone with the same type and variables. The results were divided into four groups:

It first group with variables of quality, delivery and innovation. Delivery variable in some cases means trust in the information system, so their approach to item quality. When it comes to delivery of products/services, this is also a logical relationship, because if the product is of inferior quality, this fact will affect negatively the delivery, which will rework, and cannot meet the customer satisfaction. With respect to innovation, the short life cycle of products and the speed in which new products are developed and implemented, may affect its quality, because every change requires adaptation and during this learning process errors may occur, impacting the quality level established by the company.
It second group, flexibility and innovation. Flexibility can be used in various ways, such as production volume, changes in the production system, change in design, product customization. Thus, innovation is very close to the construct of flexibility, since its concept is the speed and frequency that new products are created and marketed, depending on the capacity of production flexibility to get good results.

It third group, cost, quality and innovation. Quality and innovation need investments, these aspects can impact in the short-term operating costs. Other hand, low-cost strategies are compatible and differentiation of two types of economic environments. In the first case, companies are located in an emerging economy, characterized by high growth, significant learning, economies of scale and potential for product differentiation. In the second type of economic environment, hosts mature companies that test technological changes. In this environment, companies seek strategies both low cost and differentiation, looking thoroughly overcome the learning curve and achieves minimum cost position (Hill, 1988).

It fourth group, innovation, flexibility and cost. Relationship between innovation and flexibility has been properly addressed, with respect to cost; this represents a positioning of the company’s operating strategy, and is linked to the ability to minimize total cost of production (labor, material and operational costs) by operations, processes and economies of scale efficient technology or economy of scale. Being in the same group as innovation and flexibility, indicate that more flexible and prone companies’ innovation may be more affected by the cost, since investments must be constant for the company to achieve good results.

Even the cumulative effect presenting viable in several studies, there are issues that are beginning to emerge and suggestions for future research first, this would be it - quality, delivery, flexibility, and cost - the correct composition of operational capabilities? Cumulative effect would be the best way to investigate them? And finally, what factors the company needs to focus on developing operational capabilities in its production process?

Another point that draws attention in investigated studies is that mostly the research method used was surveys, which may somehow limit the results. Thus, a study with a quantitative and qualitative approach focusing on the model of operational capabilities can bring findings that contribute to evolution of knowledge about this area.

REFERENCES


