Application of Expert System for Strategy Selection

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Abstract

Changing business environment and trying to achieve a competitive advantage or maintaining a prominent position in the market, motivates firms to plan manufacturing strategies. It became too complicated task when a firm emphasizes two or more competitive priorities. In this study we propose an expert system which can help in strategy selection in such situations. This system acquires knowledge about the problem and learns different strategy. Thus the system become able to make decision for given situation.

Keywords: Manufacturing strategy; Expert system; Strategy selection; Rule-base

1. Introduction

Today's firm has to tackle in a complex and rapidly changing situation because of the global competition, market performance, and changing technology. It is expected that this deal become a stronger and greater deal in future. So firms are trying to find strategies which can help them in such environments. In order to stay in the competitive environments, not only they should adapt their strategies with changes but also have competitive advantages. In the other words, they should develop manufacturing capabilities to meet market needs.

Skinner (1969) considers the manufacturing strategy as a trade-off among competitive advantages. Because there is not any strategy that works well for every situation, the trade-off should be done on the firms performance measure (quality, dependability, flexibility and etc.) which should be optimize through the strategy. Skinner (1969) and Wheelwright (1984) defined manufacturing strategy in three levels, hierarchically: business strategy; manufacturing competitive priorities; and manufacturing decision areas. Kim and Arnold (1996) noticed making decisions based on both competitive advantages and action plans.

Quinn [11] believed that large diversified organizations cannot decide based on a single formal plan. He mentioned that in these firms, strategies tend to emerge incrementally from strategic subsystems within the corporation. "Generic strategies" concept was proposed by Porter [26] for this trade-off. His work was developed by some manufacturing strategy theorists [12, 13]. Schroeder and Lahr, (1990) defined manufacturing strategy as an effective plan of manufacturing capability for the achievement of business goals. Some dimensions of manufacturing strategy are presented as cost, quality, delivery, and flexibility by Ettlie and Penner-Hahn (1994) and Kim and Lee (1993).

In order to do such trade-offs and decision makings variety of questions should be answered. But if there are vague and uncertain data, managers become unable to find a good choice for their

firms. The selection of manufacturing strategy can be simplified by the use of an expert system. An expert system is learnt using vast number of instances and their relative manufacturing strategies. So this intelligent system would make a good decision in the given situations. The considerable effect of expert system on improving and controlling the manufacturing systems is investigated by Wilson (1985). Manufacturing industry was introduced as one of the most applied area for expert system by Durkin (1996). Wong et al. (1994) presented a study of ES application in manufacturing among the 500 largest companies in the USA. They concluded that scheduling is the most common application area of ES. A review the use of Expert System in the area of production planning and scheduling is presented by Metaxiotis (2002).

This paper discusses the development of an expert system which will aid the process of selection of a manufacturing strategy in firms. To the best of our knowledge, this paper represents the first attempt that applies ES for strategy selection in the field of manufacturing strategy.The remainder of this paper is organized as follows: we present a brief explanation of the manufacturing strategy in next section. The definition for the problem is then presented in section3. Section4 provides a description of expert system and its application. Finally in section5 a brief conclusion of this study is discussed.

2. Manufacturing strategy

In fact there is not clear difference between operation strategy and operation management. In operation management resources and processes which lead to production and services would be managed. In contrast, operations strategy is related to the whole business process instead of a single process. In the other word, it is beyond a single decision, it consists of a total pattern of decisions for operation's long term capabilities and their participation in the organization's whole strategy. It faces with changes in competitive environment and determine the firms performance in current and future challenges. It also designs the development of resources and processes in order to create sustainable advantages. These decisions of the firms are known as strategic because:

- They have vast effect and
- They define the situation of the organization with respect to the environment.
- They lead the organization to it long term goals.

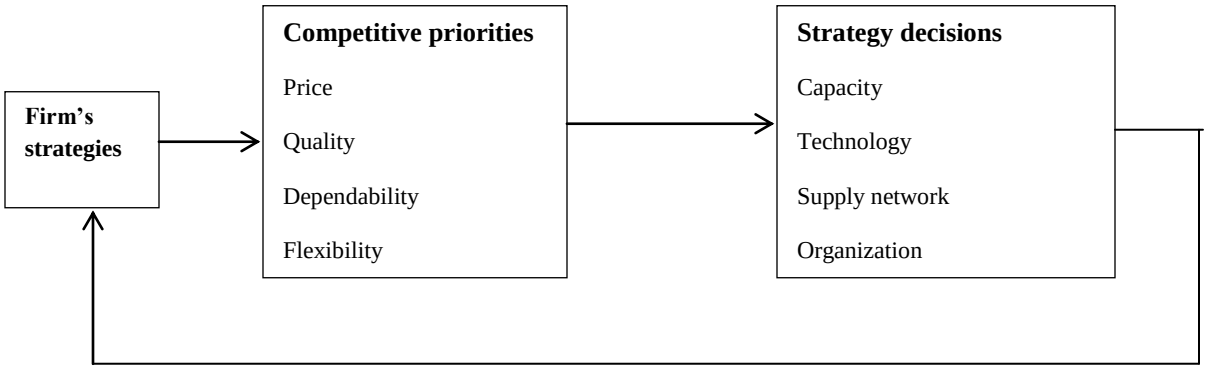

Figure1: Framework of manufacturing strategy

Now we should determine aspects of operations performance through which the operation meets the market's requirements. These aspects are firms' competitive priorities which state the market requirements for firm's operations. For example a firm can determine its position in the market based on the price, quality and etc. and compete based on them.
In the other words to have a good selection of operation strategy, we should first consider the competitive priority of the firm. Each firm may has one or some of the following objectives as its competitive priorities. They would be determined considering customers' requirements, position in the market and the competitors. The competitive priorities are as follows:

Quality: Quality can be defined using products and services specifications (Manufacture of products with high quality or performance standards (Spring and Boaden (1997))). One of the best ways of improvement in competitiveness of an organization is quality improvement.
Speed: Time between beginning of an operation process and its end is named as speed which may be (React quickly to customer orders (Spring and Boaden (1997))).
Dependability: keeping delivery schedules or promises.
Flexibility: Ease in moving between possible states. There are four type of flexibility in operations:

- Product flexibility
- Mix flexibility
- Volume flexibility
- Delivery flexibility

Cost: Any financial input to the operation that enable it to produce its products. These inputs can be divided in three groups:

- Operating expenditure (labor, material, energy, …)
- Capital expenditure (machinery, building, vehicles, …)

- Working capital (financial input required for supporting activities during the inflows and outflows)

This system should collect the current status of the firm and then presents the strategy that the firm should apply to improve the current position. For this reason we apply the Platts and Gregory procedure. This procedure consists of three following stages:

- Developing the knowledge about the market (finding factors which are required for the market) and then comparing these factors with the achieved competitive priority.
- Finding the capabilities of the operations
- Structuring the components to investigate different alternatives for improving and extending a new operation strategy

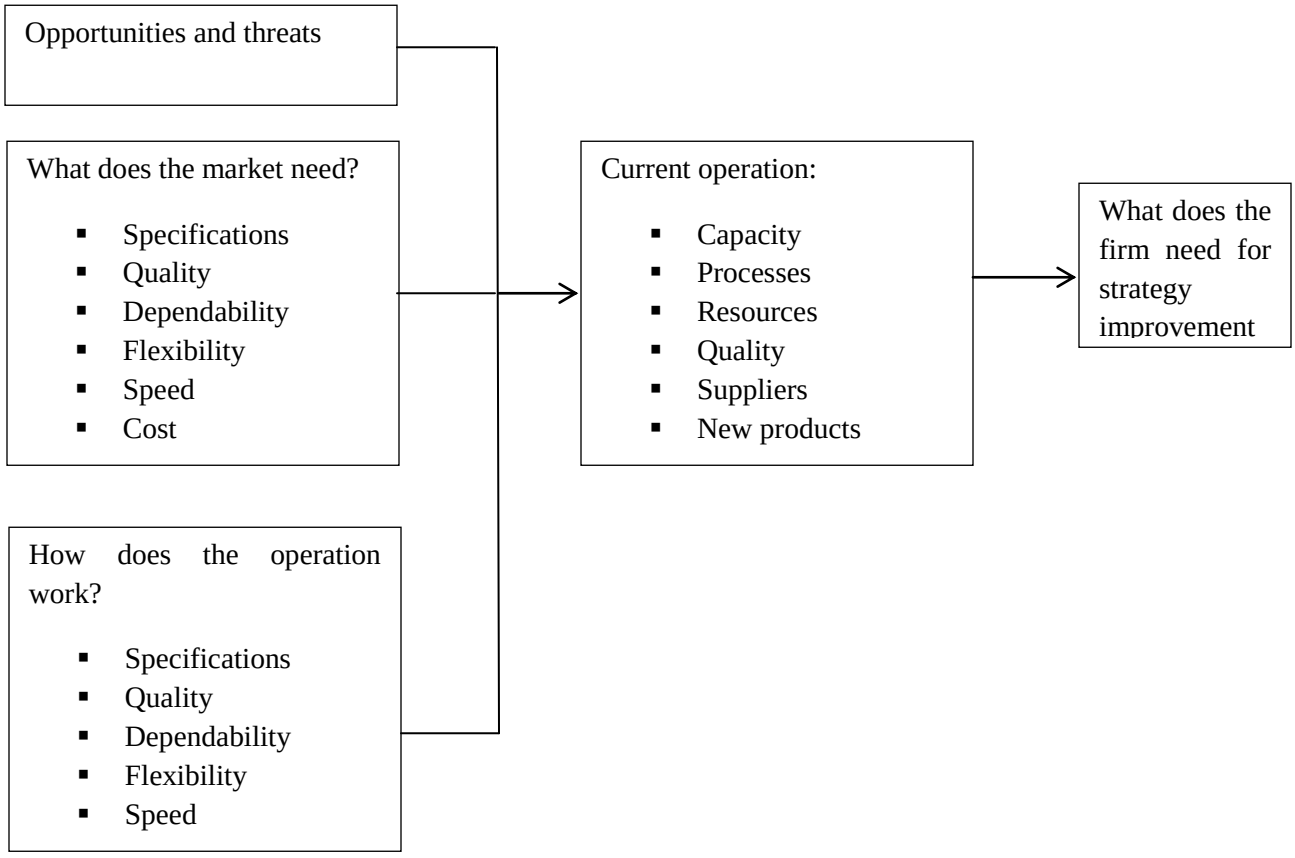

Figure2: Platts and Gregory procedure (Slack(2002))

This is a Gap based procedure which guide the improvement. Herein the differences between the customers point of view and the real-word performance of the operation is evaluated.

3. Problem definition

So based on these information and the knowledge base of the system, it is concluded that in which parts of the decision areas the improvement would happen. Decision areas can be introduced as follows; capacity, process technology, supply networks and Operations development and improvement.

In each of these areas different factor should be considered that some of them are described below. For example, according to the figure above if the change is selected in the capacity, the firm has to consider some more aspects. These aspects will be described in the following:

3.1. Capacity

Capacity strategy of an operation is the pattern of decisions concerned with how operations configure and change their capacity to achieve a particular level of output potential (slack 2002). The first decision in capacity change is the time when to make the changes. The most important factor in these decisions is forecasting the capacity levels. Since there are multiple numbers of feasible times to change the capacity, this is a hard and time consuming time. But three generic strategies exist for this time's determination (slack 2002):

Capacity lead demand- In this strategy, always there is enough capacity to meet demands.

Capacity lag demand- In this strategy, demand always equal to or greater than capacity.

Smoothing with stock- In this strategy, there is coordination between two latter strategies. So it uses the excess production in the periods with capacity leading demand to use in the others with capacity lagging demand.

3.2. Supply network

A supply network is an interconnection of organizations which relate to each other through upstream and downstream linkage between the different processes and activities that produce value in the form of products and services to the ultimate customer. Relationship in the supply network differs in degree of doing activities (from doing all activities to outsourcing all activities), in importance of doing activities (from outsourcing minor activities to major and strategic activities), in contact structure in the market (from having large number of suppliers for a similar set to small number of suppliers) or type of contact in the market (transactional communications to close communications).

3.2.1. Different strategy based on Supply network

3.2.1.1. Vertical integration

Development of a firm until it possess the network which it is a part. It means assessing the wisdom of acquiring suppliers or customers or in the other words deciding whether to make a particular component or buy it. Verification should be done on different aspects of the firm like (Core competency, dependable delivery, low cost, economy of scale, flexibility, and innovation) to check if the firm tends to vertical integration?

3.2.1.2. Traditional market-based supply

In contrast to vertical integration, there is another strategy in which the customer and supplier relationship is based on the market. The main idea of this strategy is on the competition among supplier to attract customer.

3.2.1.3. Partnership supply

Development of partnership relationship between suppliers and customers in the supply network is an intermediate level of vertical integration and traditional market-based supply. This strategy tries to achieve efficiency of coordination in vertical integration without possessing supply resources. It also creates the tending to continuous improvement of traditional market-based supply without imposing cost management of vertical integration.

3.3. Process technology

Technology has a significant effect on all organizations. So each operation which is competing on goods and services in the market should apply process technology in its competitive advantages. Process technology is appliances of science to any operation process and is different from product or services technology.

There are different drivers of investment in new technology for a firm such as demand side drivers, supply side drivers and internal drivers. These drivers may be caused by some factors which are presented in the following [Slack]:

- Demand side drivers:
  - Evolving costumer need
  - Competitive behavior
- Supply side drivers:
  - Learning and capability building over time
  - Limit to technological development
- Internal drivers:
  - Overcoming geographical constraints
  - Integration

A firm may become able to improve its performance through application of process technologies and implementing new technology.

3.4. Operations development and improvement

In most of the operations, improvements are consists of breakthrough or continuous improvement. Big and radical improvements are taken place in breakthrough improvement which needs big investments. But in continuous improvements more and incremental changes happen. These improvements become a natural way of working [slack].

This strategy would be applied through an improvement cycle which starts with a directing performance which is got from the intended competitive position in the marketplace. This

direction has a great effect on operation's resources and processes. Then it would followed by developing operations capabilities through learning to create operation's capabilities. These capabilities should be deployed in the market which is related to the packing up these capabilities in the organization. All potential competitive positions in the market are not feasible and should be investigated.

Table1: Different measures and different firm's situation relative to these measure

Measures	**Alternatives**
A. Respond to demand according to condition	1. Not fast (because customer are willing to wait) 2. Fast (because of competitive condition)
B. The status of product in the life cycle	1. Introduction 2. Growth 3. Maturity
C. Firm's main financial strategy	1. Improve profitability and increase long term cash 2. Reduce long term cash even though not yield high level of short term profitability
D. The contact structure in the market	1.Low(having small number of suppliers for a similar set) 2. Medium 3. High (having large number of suppliers for a similar set)
E. The type of contact in the market. (from transactional to close)	1.Low (transactional) 2. Medium 3. High (close)
F. The degree of doing activities	1:Outsourcing all activities 2:Doing all activities
G. The importance of doing activities	1:Outsourcing minor activities 2: Outsourcing major activities
H. Evolving costumer need	1. Low 2. High
I. Competitive behavior	1. Low 2. High
J. Learning and capability building over time	1. Low 2. High
K. Limit to technological development	1. Low 2. High

L. Overcoming geographical constraints	1. Low 2. High
M. Firm's grade in comparison with competitors	1. Low 2. High
N. Firm's grade for importance of competitive priority for costumers	1. Low 2. High

Using the measures in the above table we accumulate information about all factors presented in Fig1. Now an expert system can be learnt.

Firm should take in to account two major factors:

- Firm's performance in each competitive priority in comparison with competitors
- Importance of each competitive priority for costumers

Table2 :Different process structure and strategies that a firm can apply

Process structure	**Strategies should be used**
Capacity	Capacity lead demand Smoothing with stock Capacity lag demand
Supply Network	Vertical integration Partnership Traditional market supply
Process Technology	New technology
Operations development and improvement	Development / Urgent action Excess capability / Appropriate capability

4. Expert systems

A computer program which can imitate human's action in solving problems is called expert system. Experts should give different knowledge and methods for solving a problem to the system for future use. In the other word, expert systems should have large amount of knowledge about the domain and also the ability to infer the solution from this knowledge for different situations. As we should tackle uncertainty in most today's decision making problems, it is an appropriate tool for this reason because it is able to handle vague and incomplete data and uncertainty easily. Expert systems have three modules: the knowledge base; the inference engine and the working memory. Knowledge base is the main module, which contain the knowledge,

facts and heuristics about the domain of application. Among different technique of representation, often through If-Then rules this knowledge would be represented. The inference procedure which generates the solution through reasoning the content of the knowledge base is called inference engine.

Expert systems have several advantages: the knowledge base is usually permanent and easy to maintain, the system is relatively inexpensive to maintain, it can be used in several locations at the same time, it is easy to document, and it produces consistent results (Pigford and Baur(1995)).

4.1. Attribute-driven induction

Attribute-driven induction is one of the database mining methods which extract rules. The method uses the deduction process to explore the database and extract clustering rules. The induction algorithm substitutes the low-level concept in a tuple with its corresponding higher-level concept, and then generalizes the relationship by eliminating identical tuples and using a threshold to control the generalization process (Han & Fu, 1996). This methodology tries to replace the low-level concepts with their relative high level concept and also generalize these relationships (Koonce and Tsai (2000)).

A concept hierarchy defines a sequence of mapping from a set of concepts to their higher-level correspondences. Concept hierarchies, representing necessary background knowledge, are key to the generalization process in attribute-oriented induction. They can be directly provided by users, implicitly stored in the database, or constructed automatically based on clustering behavior and data statistics. They are usually partially ordered according to a general-to-specific ordering (Han & Fu, 1996). Using concept hierarchies, the discovered rules can be represented in terms of generalized concepts which users define, and stated in a simple and explicit form (Koonce and Tsai (2000)).

4.2. Solution procedure

As considering all different probable state of the system is time and cost consuming, using simulation we generate set of 100 instances based on different values of measures randomly. These instances are presented to some experts and based upon their idea the appropriate response of the firm in such situation are gathered.

Table3: Simulated instances and appropriate strategy selected for them.

Case number	Measures														Process structure	Strategy
	A	B	C	D	E	F	G	H	I	J	K	L	M	N		
1	L	L	L	H	H	L	H	L	L	H	H	L	H	L	Capacity	Capacity lead demand
2	H	L	L	H	H	L	L	H	H	L	L	H	H	L	Process Technology	New technology
3	H	M	H	M	L	L	L	H	L	L	H	H	L	H	Supply Network	Vertical integration
4	L	H	H	M	M	H	L	L	L	H	L	L	L	H	Capacity	Capacity lag demand
5	H	M	L	L	M	H	H	L	H	L	L	L	H	L	Supply Network	Partnership
6	L	L	L	M	M	L	H	H	L	L	H	H	H	H	Supply Network	Partnership
7	H	H	H	L	H	L	L	H	L	H	H	L	H	H	Development and organizations	Urgent action
8	H	M	L	M	L	H	H	L	H	H	L	L	L	L	Supply Network	Vertical integration
9	H	H	L	M	M	L	H	H	L	L	H	H	L	L	Process Technology	New technology
10	L	L	H	H	H	L	L	L	H	H	L	L	H	H	Capacity	Smoothing with stock
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This knowledge is applied in an *attribute-driven deduction algorithm* to explore the relationship between performance measures and the required manufacturing strategy. Then set of rules is created which constitute the Knowledge base of our expert system.

Then in the future situations whenever a user enters its firm's situations, the expert system use the rule-base to offer the appropriate strategy for the firm.

Because the large number of the rules, we present one of them to show the rule structure for our problem:

If respond to demand according to condition is high
And the status of product in the life cycle is introduction
And Firm's main financial strategy is low
And the contact structure in the market is high
And the type of contact in the market is high (close)
And the degree of doing activities is low
And Learning and capability building over time low
And Firm's grade for importance of competitive priority for costumers
Then the process structure is process technology
And the strategy which the firm should apply is presenting new technology

5. Conclusion

The selection of manufacturing strategy is one of the most important processes in operations. Because of the rapid changes in the market places, firms should intelligently check the situations and make decisions.

The decision is so complicated since various criteria should be considered. In this research, an expert system is proposed for selection of the strategy for the current position of the firm in the market. It considers different important measures for this decision and finds the area in which changes should be happen. Then it finds the strategy for this change implementation. Also better solution may be found for this problem but the advantage of this approach is the intelligent problem solving procedure and considering all aspects which may not be considered by an expert itself. It also can find the solution if the vague knowledge are available.

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