A CASE STUDY OF DECISION MAKING PROCESS OF BUYING IN AGILE MANUFACTURING SYSTEMS

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Abstract : In a competitive environment companies have to choose the most profitable manufacturing system to respond changing customer demand trends effectively and fast.Chosen manufacturing system should provide to be capable of operating profitably.Nowadays "agility" is an indispensible characteristic of manufacturing systems. So it is necessary to identify the maximum benefits of the various manufacturing systems with regard to this criteria.

In this research three manufacturing systems are evaluated. These are; dedicated,agile and flexible manufacturing systems.Aim of this research is to explain superiors of agile manufacturing system according to dedicated and flexible manufacturing systems by using decision tree model in the automotive spare part industry.

Keywords: Agile manufacturing system, manufacturing systems, decision tree

1. Introduction

Global competition has brought about changes that are characterized by product proliferation with shorter and uncertain life cycles, innovative process technologies, and customer who simultaneously demand quick response, lower cost, and greater customization (Dowlatshahi and Cao, 2006). Rapidly changing markets and rapid introduction of new products have created a growing need for agile and responsive manufacturing (Shimizu and Sahara, 2000).

Agility addresses new ways of running companies to meet these challenges. Agility is about casting off those old ways of doing things that are no longer appropriate-changing pattern of traditional operation (Gould, 1997).

Agile manufacturing is the means of production and management in industrial enterprise for the 21st century, emphasizing an enterprise's capacity for rapid response and efficient reengineering when facing market oppurtunity (Lü et al.,2004). Agile Manufacturing (AM) is an emerging manufacturing paradigm, which considers agility a key concept necessary to survive against competitors under an unexpectedly turbulent and changing environment (Dowlatshahi and Cao, 2006). The agile manufacturing suggests that smaller scale, modular production facilities, and cooperation between enterprises would be the principal pattern of competitiveness for the next generation (Sahin, 2000). Agile manufacturing is not about small-scale continuous improvements, but an entirely different way of doing business. Gunasekaran (1999) describes agile manufacturing as ''the capability to survive and prosper in a competitive environment of continuous and unexpected change by reacting quickly and effectively to changing markets, driven by customer-designed products and services.'' Agile manufacturing requires to meet the changing market requirements by suitable alliances based on core-competencies, organizing to manage change and uncertainty, and leveraging people and information. Goldman have a slightly different definition, with agile manufacturing allowing companies to be capable of operating profitably in a competitive environment of continually and unpredictably changing customer opportunities (Elkins et al., 2004). Agile manufacturing includes rapid product realization, highly flexible manufacturing, and distributed enterprise integration. Technology alone does not make an agile enterprise. Every company must find the right combination of culture, business practices, and technology that are necessary to make itself agile (Gunasekaran,1999). Design of agile manufacturing systems

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requires tremendous team effort with information, knowledge and expertise from customers,system analysts,designers and engineers in many disciplines (Zhou and Venkatesh,1999).

The remainder of the paper is organized as follows. In section 2, we briefly review the literature on agile systems. Section 3 summarizes the differences between dedicated, agile ans flexible manufacturing systems. In section 4, we propose a decision model and use this model to provide insights into the business case for invesment in agile manufacturing systems. Section 5 summarizes the insights gained for future research.

2. Agile manufacturing: theoretical background

In the last decade the industrial environment has undergone substantial changes characterised not only by their breadth and depth but also by their speed. In this context, firms in general, and those dedicated to manufacturing in particular, are finding it difficult to attain a sustainable competitive advantage or even ensure their survival due to the high levels of complexity, dynamism and uncertainty they face (Va´ zquez-Bustelo and Avella, 2006).

Academic groups and founded research institutes world wide have carried out research programmes in order to understand and diagnose the roots, causes and effects of the new business circumstances. Outstanding effort that was conducted by a group from Iacocca Institue in USA resulted in a report in 1991. The report that soon became a focal point of manufacturing system studies, stated that a new competitive environment is emerging which is acting as a driving force for change in manufacturing. It argues that the new foundations of the competition criteria are: continuous change, rapid response,quality improvement and social responsibility (Sharifi and Zhang,1999).This industry collobarative project was motivated by Toyota's *lean* manufacturing initiative as exposed by which put US manufacturers at a competitive disadvantage (Dove, 2006).The study concluded that the frequency and variety of technology and market change was accelerating, and already surpassing the abilities of organizations to adapt. Viable enterprise would need systems that could respond effectively to unpredictable requirements on shorter and shorter notice. The problem was defined and the objective was envisioned with that study, but no engineering clues were offered for designing and operating these magical agile systems (Dove, 2006).The research that was pursued under Agility Forum introduced drivers of manufacturing business towards the new form of competition and called this new concept agile manufacturing (Sharifi, Zhang, 1999).Initially the Agility Forum at the Iacocca Institute defined Agile Manufacturing as: “The ability of an organisation to thrive in the competitive environment of continuous and unanticipated change and to respond quickly to rapidly changing markets driven by customer based valuing of products and services (Ismail et al., 2006).” Agile manufacturing is based on three basic resources: i) an innovative management organisation and structure, ii) a worker base consisting of highly trained, motivated and empowered people and iii) advanced, flexible and intelligent technologies. Agility is obtained by integrating these three resources in an interdependent and coordinated system (Va´zquez-Bustelo and Avella, 2006). With this move towards a new agility-based paradigm, the term ‘‘agile manufacturing’’ has arisen, a concept that has been increasingly used in literature on Operations Management and Business Administration to denominatea model of flexible manufacturing, capable of rapidly adapting to changes in the environment and of placing a large variety of products on the market to satisfy the needs of increasingly demanding and well-informed customers (Gunasekaran, 1999). For Goldman and Nagel (1993), agility is a global response to changes imposed by a new business environment dominated by a set of forces that attempt to break with mass production systems and are characterised by change and uncertainty. These authors identify four dimensions or foundational elements of agile manufacturing: enriching the customer, cooperating to enhance competitiveness, mastering change and uncertainty and leveraging the impact of people and information. For each of these dimensions they establish a list of characteristics of the agile firm that have been considered by many authors as the starting point in their works on agility.

The business environment, as a source of change and generator of uncertainty, has been considered the main motivator or agility driver. In fact, agile manufacturing describes" a comprehensive response to a new competitive environment shaped by forces that have undermined the dominance of the mass-production system'' (Gunasekaran et al., 2002). Thus, new forces and changes in the market's competitive landscape are identified as precursors of agile manufacturing in that they are forcing firms to adopt practices linked to the new manufacturing paradigm. So, agility is reflected in the ''capability to survive and prosper by reacting quickly and effectively to a continuously and unpredictably changing, customer-driven and competitive environment'' (Va´ zquez-Bustelo and Avella, 2006). Yusuf et al. (1999) proposed that agility is the successful application of competitive bases such as speed, flexibility, innovation, and quality by the means of the integration of reconfigurable resources and best practices of knowledge-rich environment to provide customer-driven products and services in a fast changing environment. An equally important attribute of agility is the effective response to change and uncertainty (Goldman et al., 1993). Some authors (Sharifi and Zhang, 1999) state that responding to change in proper ways and exploiting and taking advantages of changes are the main factors of agility.

As the brief overview of the agility definitions shows, this concept comprised both characteristics of adaptability and flexibility. It seems that these two terms represent the evolution of the idea of the organization or enterprise that is able to adjust. (Sherehiy et al., 2007).

3.Characterizations of Dedicated, Flexible and Agile Manufacturing System

Owing to the pressure of international competition and market globalisation in the 21st century, there continues to be a strong driving force in the industry to compete effectively by reducing manufacturing times and costs while assuring high quality products and services (Onuh et al.,2006). So companies evaluate characterizations of different manufacturing systems to oppose against pressure of competition.

Dedicated Manufacturing System can produce a single model of a product class. Dedicated systems are the least expensive technology for machining applications. The equipment is specialized for one particular model of a general product class. Dedicated systems are valuable for high volume production and yield low investment per unit. Dedicated systems are preferable when the demand volume for a product is high and the life span of the product is relatively long (Elkins et al, 2004).

Flexible Manufacturing System is an adaptable and versatile machining system that can change quickly and easily to produce a planned range of product classes and product models within a designed machining envelope (Elkins et al, 2004). Flexibility construct includes both internal(adaptation to the environment) and external (influence on the environment) flexibilities (Llorens et al, 2005).

Flexibility signifies a manufacturing system's ability to adjust to customers'preferences (Zhou and Venkatesh,1999). Flexible systems permit introduction of new product models,but with a significant time and cost penalty incurred. Tools, fixtures and material handling are more expensive because they have more all purpose utility for a variety of machining applications (Elkins et al,2004). Flexible systems allow a company to produce its outputs at shorter expected delivery time (Tseng,2004).

Agile Manufacturing System is a machining system that can change quickly and easily to produce a planned range of product models in a product class, and be rapidly and cost effectively reconfigured to respond to new model introductions (Elkins et al,2004).Agility means the system's speed in reconfiguring itself to meet changing demands (Zhou and Venkatesh,1999).

Agile systems allow several product models within a product class to be made on the same line with quick changeovers from model to model. Agile systems are preferable when the demand volume for each model is relatively low and the life span of the product is comparatively short (Elkins et al ,2004).

According to industry perception and comparison among dedicated, flexible and agile manufacturing systems.

Dedicated systems are perceived to have the lowest investment costs and highest production volume among the three system types. *Flexible systems* have the highest equipment reusability,but highest investment cost.*Agile systems* have the lowest changeover costs and highest capability to introduce new products (Elkins et al, 2004).

4. Decision Making of Buying by Using Decision Tree Model

With the rapid changes taking place in the global market, manufacturing success and survival are becoming more and more difficult to ensure. While companies are deciding which manufacturing system is the best reply for the global market, agility of manufacturing systems are evaluated.

Aim of this paper is; revealing differences of agile manufacturing system ,which is called manufacturing system of 21st century, according to dedicated and flexible manufacturing systems.And applying "decision tree" model to gain insights on the financial benefits of agility.

Limitations of this paper is: "Decision tree" model is applied in the automotive spare part industry. Reason of choosing this industry is;response to innovations fast also effectiveness of invest and productivity can be evaluated easily. The decision tree focuses on minimizing costs of buying a system to produce the current and future generations of product models. And financial benefits of agility is considered under the condition of making one model change.

For decision tree model all manufacturing systems include three types of future change oppurtunities: No change, a family model change and a completely new model.The main criticism of this model is how to obtain the subjective probabilities of the types of future changes."Expert opinions" are recommended as a response (Elkins et al.,2004).

Decision tree is a decision support tool that uses a graph or model of decisions and their possible consequences including change event outcomes, resource costs and utility. A decision tree is used to identify the strategy to reach goal.

After designing "decision tree model" it evaluates the expected NPV(Net Present Value) for each line type,where the expected NPV per line type is given by (Elkins et al.,2004).

NPV(line type)= $\sum$ [initial cost + changeover cost$(1,146)^{-n}$] x P{model change type occuring}

The annual discount rate used is %14,6

"n" is the number of years into the future when the model change occurs.n is a random variable,sampled from a triangular (1, 4, 8) distribution and rounded to the closest integer.

Table 1 and 2 provide the triangular distrubution parameters for initial costs and changeover costs used in the model.

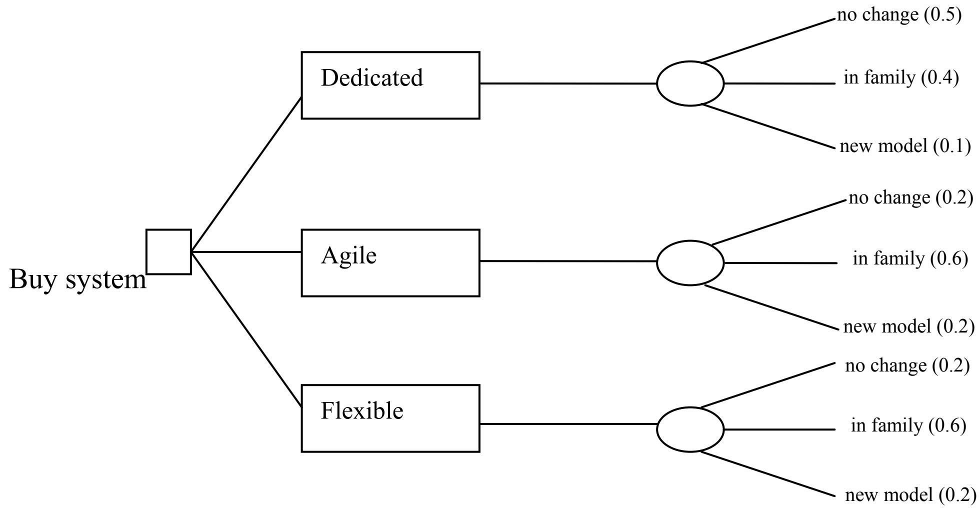

Figure 1.Decision Tree Model

Table 1. Initial investment costs for different manufacturing systems

Initial Costs	Dedicated	Agile	Flexible
Minimum($) Most Likely($) Maximum($)	184.247$ 186.349$ 188.499$	180.328$ 204.900$ 218.257$	259.947$ 266.295$ 272.693$
Calculated Average($)	186.365$	201.200$	266.311$

Table 2. Changeover costs for different manufacturing systems

Changeover costs	Dedicated	Agile	Flexible
Minimum($) Most Likely($) Maximum($)	184.247$ 186.349$ 188.499$	32.100$ 35.500$ 42.350$	75.700$ 79.946$ 84.194$
Calculated Average($)	186.365$	36.650$	79.946$

Table 3 explains an example of results of the simulation and helps company to decide between different manufacturing systems.The results indicate that the agile system is the best response of question which one provide fast changes at minimal cost.

Table 3. Simulation results for the decision tree model studying system purchase decisions

Decision Expected Cost	**Dedicated System**	**Agile System**	**Flexible System**	**Overall Decision-*Buy Agile***
Minimum ($)	217.683$	211.054$	287.806$	*211.054$*
Mean ($)	240.382$	218.196$	303.386$	*218.196$*
Maximum ($)	267.675$	226.784$	322.119$	*226.784$*

5.Summary

Increasing competition brings the necessity of keeping pace with related to products and production amount together. The only way to keep pace with this quick change is agile manufacturing system.

Many companies currently face a very dynamic environment. A company whose objective is the increased competitiveness should aim to apply manufacturing system that will allow to compete effectively in the future.

In this paper, agile manufacturing system is discussed with the help of a case study made in automotive spare industry. A decision tree model is built and then the returns of the agility of the system are determined. It is concluded that agile manufacturing system satisfies more efficiently the expectations of the enterprise for meeting the low cost applications in passing to the new products, dynamic capacity and unpredictable demand than the other systems.

Consequently each manufacturing system has different advantages and disadvantages. Dedicated manufacturing systems have the lowest investment cost but unsuccesful at adoptation of new products.Flexible manufacturing systems have the highest equipment reusability but investment cost is very high.In other words agile manufacturing systems have the lowest changeover costs and highest capability to introduce new products.

Companies should know that; the more agile the manufacturing system is, the more competitive the company will be.

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