International Journal of Industrial Engineering, 16(2), 147-159, 2009.

Strategic Paradigms for Manufacturing Management (Spmm): Key Elements and Conceptual Model

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This paper proposes a new concept in Manufacturing Management: Strategic Paradigm for Manufacturing Management (SPMM). This new concept aims to deal with the 20th century manufacturing management paradigms in a comparative and integrated way. To accomplish this goal four key elements are identified: drivers (market conditions that require SPMM implementation); performance objectives (representing the operation's strategic objectives that each SPMM gives priority to); principles (the SPMM fundamentals) and enablers (the tools, technologies and methods of each SPMM). The main contributions of this paper are: i) the presentation of a conceptual model that relates the SPMM to operation's strategic objectives; and, ii) the possibility of allowing comparisons and analyses of the manufacturing paradigms, facilitating the study and practical application of these paradigms. The proposed model deals with strategic questions in the Production/Operations Management context in a very pragmatic way. To illustrate the proposed model five case examples are presented.

Keywords: Strategic Manufacturing, Management Paradigms, Mass Manufacturing, Lean Manufacturing, Responsive Manufacturing, Mass Customisation, Agile Manufacturing.

(Received: 1 January 2008; Accepted in revised form: 3 July 2008)

1. INTRODUCTION

In the Manufacturing Management literature there are many paradigms presented with the aim of helping companies in the difficult task of remaining competitive in the present globalised world (Gunasekaran, 1999). Some examples are: Lean Manufacturing, Responsive Manufacturing, Agile Manufacturing, World Class Manufacturing, Mass Customisation, among other concepts.

The aim of this work is to present the main paradigms currently being used in Manufacturing Management, dealing with them in an integrated and comparative way. Therefore, a new term is proposed in this work: Strategic Paradigms for Manufacturing Management (SPMM). This new term deals with the new paradigms in modern manufacturing management literature in a connected, integrated way, by creating a conceptualisation and key elements (drivers, performance objectives, principles and enablers) which are common to these paradigms. From this new conceptualisation, it is possible to differentiate the manufacturing paradigms from other terms commonly found in the literature. It also allows to compare the paradigms (given their key elements), thus facilitating their study and applicability. The SPMMs provide a strategic aspect to manufacturing, since each SPMM is more focused on specific operation's strategic objectives. Referring to this question, this paper proposes a model that identifies the operation's strategic objectives that each SPMM prioritises. This model is positioned in relation to two other models (Booth, 1996; Fernandes and MacCarthy, 1999) found in the literature.

Vergara (2000) classifies research according to its aims (exploratory, descriptive, explicative, methodological, applied and interventionist) and its means (field research, laboratory research, documental, bibliographical, experimental, *ex post facto*, participatory, action research and case study). Our research is described (according to its aims) as exploratory, since it attempts to systematize knowledge which is not sufficiently integrated yet. In relation to its means, it is bibliographical research, but comprises analyses inspired by the authors' experience in a number of studies already carried out.

The present work is a tool for wider practical application of manufacturing paradigms, as it treats the SPMMs (very often considered as panaceas in the literature), in a realistic way, i.e., each of them directed towards certain specific situations, with principles, methods and tools aiming to reach certain operation's strategic objectives.

The structure of the article is as follows: in Section 2, the concept of SPMM is defined and the main SPMMs are presented; in Section 3, the four key elements of a SPMM are presented: the drivers, performance objectives, principles and enablers; in this Section, comparisons between the most important SPMMs are shown, especially in relation to their key elements; in Section 4, a model that identifies the operation's strategic objectives prioritised by each SPMM is proposed and to illustrate the proposed model five case examples are presented; in Section 5, final considerations are drawn up.

2. STRATEGIC PARADIGMS FOR MANUFACTURING MANAGEMENT (SPMMS): DEFINITION AND KEY ELEMENTS

In the Cambridge International Dictionary of English, a paradigm is a model or typical example of something. Infact, throughout the history of manufacturing, many paradigms were proposed in order to assist in the arduous task of manufacturing management. Firstly, Mass Manufacturing, created by Henry Ford at the beginning of the 20th Century. This paradigm, hereafter called Current Mass Manufacturing (CMM), is still used by companies worldwide, yet presenting some differences in relation to its original form. In the mid fifties in Japan, Lean Manufacturing (LM) started to emerge and was consolidated in the 1970s. More recently, at the end of the 80s and early 90s, three other important paradigms were developed: Competing against time (or Time-based competition) also called Responsive Manufacturing, by Kritchanchai and MacCarthy (1998) and Fernandes and MacCarthy (1999), initially proposed by Stalk and Hout (1990); Mass Customisation (MC), which started in 1987 with Stanley Davis in his famous book: "Future perfect" (Davis, 1987); finally, Agile Manufacturing (AM), which emerged and was popularised in 1991 by a group of researchers (see Goldman et al (1991)) from the Iaccoca Institute, at Lehigh University, in the United States, which predicted how competitiveness would develop in the following 20 years and proposing AM as a new paradigm for the environment of this period.

We believe that all these paradigms can be studied together so as to provide a better understanding, comparisons and more widespread practical use. Therefore we propose a new concept, which intends to comprehend the described paradigms: Strategic Paradigm for Manufacturing Management (SPMM). Strategic Paradigms for Manufacturing Management (SPMMs) are integrated, strategic management models or standards, directed at certain market situations, which propose to aid companies to reach specific manufacturing objective(s) (hence the term 'strategic'); the paradigms are composed of a series of principles and enablers (hence the term 'management') which enable the company, from its manufacturing function (hence we say 'manufacturing'), to meet such objectives, thus increasing its competitive advantages.

Following this explanation, we call SPMMs the following paradigms: Current Mass Manufacturing (CMM), Lean Manufacturing, Responsive Manufacturing (RM), Mass Customisation (MC) and Agile Manufacturing (AM).

We should highlight that these SPMMs are at different levels regarding their evidence, their application in real situations and their future application perspectives: CMM and LM are more consolidated, while RM, MC and AM have a promising growth rate, given the progress in information technology and the increasing wealth in some parts of the world.

From the previous definition, it can be said that a SPMM is composed of four key elements, which represent the pillars of a SPMM (Figure 1). These are:

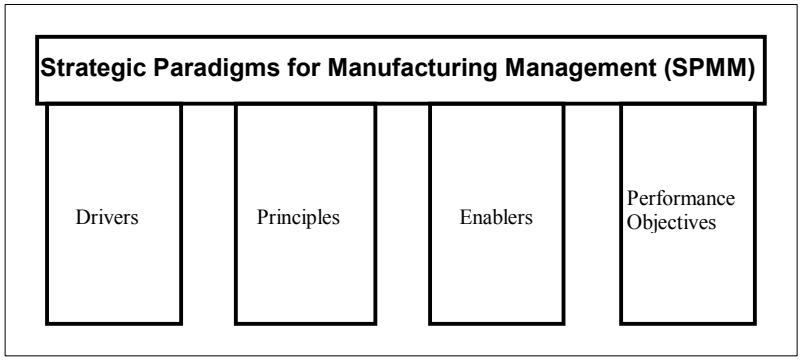

Figure 1. The four key elements in a Strategic Paradigm for Manufacturing Management

(i) Drivers

Drivers are the market conditions that enable, require or facilitate the implementation of a specific SPMM. From a review and critical analysis of the literature concerning the SPMMs (Sharp *et al*, 1999; Yusuf *et al* 1999, etc...) we researched the main drivers of each SPMM (Table 1).

Table 1. The SPMMs' drivers

Current Mass Manufacturing	Lean Manufacturing	Responsive Manufacturing	Mass Customisation	Agile Manufacturing
Homogeneous market	Stable market	Market characterised by competition based on time and on the diversification of products	Mass customisation should represent a differential characteristic, as a source of competitive advantage in the market; in addition to this, the products should be able to be customised	Totally unpredictable markets marked by sudden changes.
Customers that regard price as the main competitive differential	Customers that require price, quality and distinction	Customers who seek speed, dependability and a lot of variety, i.e., responsiveness	Customers that require customisation	Customers with the widest possible variety of requirements that can change, thus the company's need to meet this challenge

The term distinction that appears on Table 1 means, in this text, variety of similar products while, diversification means wide range of very different products.

(ii) Performance objectives
Each SPMM attempts to give the company a competitive advantage, as it prioritises performance objectives, also called operation's strategic objectives. Thus, a manufacturing objective is a criterion that strategically positions the company in relation to its main competitors. Therefore, each SPMM is related to a determined manufacturing objective, as discussed and proposed in Section 4. Given its importance for the model proposed in Section 4.3, Section 3 deals with this topic.

(iii) Principles
Principles are the ideas that guide an action or decision; in this case, they guide the company towards the performance objectives of a SPMM. The principles represent the "what" which should be achieved or endeavoured.

(iv) Enablers
Enablers are the tools, technologies and methods that should be implemented. The enablers represent "how" a principle can be achieved.

The relationship between these 4 key elements is worth emphasizing. From the drivers, performance objectives that the company should prioritize arise. Then, the company should focus on some ideas (principles) related to these objectives. The appropriate principles and their corresponding enablers are implemented so that the objectives can be achieved.

Although principles and enablers are easy to define, there is a close relationship between them, thus making it difficult to separate them in an unquestionable way: in order to carry out an X principle, a Y enabler is needed, which in turn requires a Z enabler. Therefore, for enabler Z, Y can be understood as a principle. For example, the principle of focusing on the customer who requires low prices, demand economies of scale, which may require highly specialised work; therefore economies of scale may be understood both as an enabler and as a principle. This relation is called a principle-enabler relationship chain, as illustrated in Figure 2. This article does not discuss this issue in detail, as it is not necessary to propose a model (Section 4.3), which is the focus of this work. What is needed is to identify, for each SPMM, which principles/enablers are more emphasised or eventually exclusive, from which follow the performance objectives that win the order. This is shown in Section 4.3.

3. PERFORMANCE OBJECTIVES

In this Section, performance objectives, also called operation's strategic objectives, will be dealt with. Manufacturing strategy is defined by Slack *et al* (2007) as a global standard of decisions and actions, which define the role, objectives and the manufacturing activities in such a way that these will support and contribute to the organisation's business strategy. In short, we can say that a manufacturing strategy first determines prioritising the performance objectives. Based on this prioritization of performance objectives, the general directions for each of the main areas of decision in manufacturing are established. These two steps are called the content of the manufacturing strategy, in the words of Slack *et al* (2007). Quezada *et al* (2003) present a methodology to formulate a manufacturing strategy.

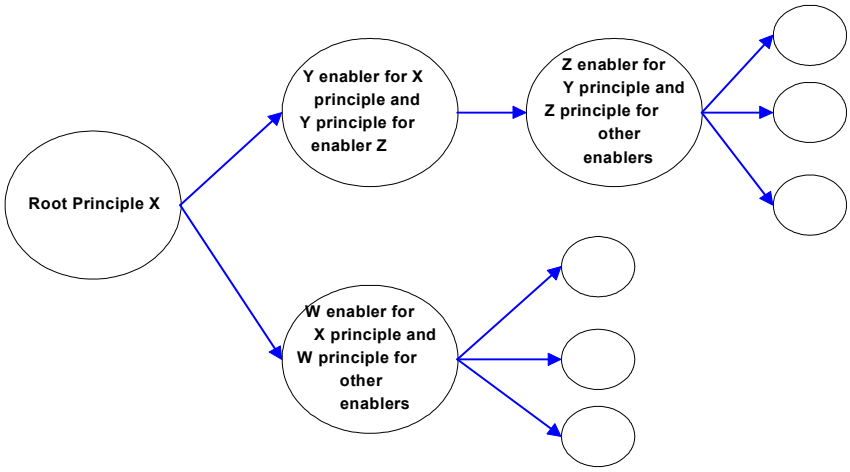

Figure 2. Example of a principle-enabler relationship chain.

From these definitions, we understand that the manufacturing function must contribute to the achievement of the corporate strategy (for a case study showing the linkages between manufacturing strategy and corporate strategy see Dangayach and Deshmukh (2004)). To be successful on this goal, the manufacturing function has to emphasize the performance of the operation's strategic objectives. According to Slack *et al* (2007), there are five objectives: quality, speed, dependability, flexibility and cost. We shall consider a larger number of objectives, since it is not possible to characterise the five paradigms of the model proposed in Section 4.3 with just these five objectives. These are the objectives considered:

- productivity: the manufacturing system (MS) ability to meet consumer demand in terms of low cost;
- quality 1: the MS ability to meet consumer demand in terms of adequacy to use;
- quality 2: the MS ability to meet demand in terms of performance or conforming to an acceptable price (approach based on value). This approach is the widest and most complete among the ones pointed out by Garvin (1988);
- flexibility 1: the MS ability to respond to changes in the product mix, within a limited range of options, i.e., the process can provide some distinction (a small variety of similar products). It depends on obtaining low times for set-up;
- flexibility 2: the MS ability to respond to big/considerable changes in the product mix, i.e., the process can provide diversification (wide variety of different products). It depends on obtaining low times for set-up, use of versatile and universal equipment, as well as versatile labour.
- speed: the MS ability to respond to changes in the volume of production. It depends on accelerating the process to obtain a reduction in the cycle time;
- dependability: the manufacturing system (MS) ability to meet the consumer demand in terms of the delivery deadline;
- customisation ability: the MS ability to provide individual solutions for differential customers, within a pre established product mix. The difference between customisation ability and what we called flexibility 2 can be explained through an example found in Duray *et al* (2000). According to this author, flexibility 2 implies in client choice, but not necessarily product specification, which is understood as customisation. For example: offering hundreds of possibilities for breakfast indicates flexibility 2, while specifying the exact menu/range of options for breakfast indicates customisation. Therefore, customisation is a wider objective than flexibility;
- adaptability: the MS ability to prosper in an environment of constant change, characterised by technological innovations and the endless need to launch completely new products. For Goranson (1999), it is the ability to deal and respond to change, whether they are constant or unexpected, adding to this the ability to take advantage of these changes, understanding them as opportunities. This last characteristic of adaptability is defended by authors such as Goldman, *et al* (1995) and Sharifi and Zhang (1999).

Two important concepts in the development of the model proposed in Section 4.3 are order-winning objectives and qualifying objectives. These concepts establish an order of priorities between the different performance objectives. They were developed by Hill (1989) and have been used by various authors, among who Slack *et al,* 2007 and Slack, 1995).

➡ order-winning objectives contribute directly to the closing of a business deal and are seen by the customer as key factors in competitiveness. An increase in performance of an order-winning objective will result in more business or at least an increased probability that the company will get more orders.
➡ qualifying objectives are also important for the company, but are not the main determining factors in competitive success. These objectives demand that the company should be above a specific level in order to be initially considered by customers as a possible supplier. Below this critical performance level, the company will probably not even be considered to make a bid. If the company is above this level, it starts to be considered by customers, but mainly in terms of its order-winning criteria. For a qualifying objective, any improvement above this level does not add big competitive benefits.

4. PROPOSAL FOR A MODEL THAT RELATES THE SPMMS TO THE OPERATION'S STRATEGIC OBJECTIVES

In this Section a model to relate the SPMMs to the operation's strategic objectives is proposed. Besides using the historical evolution of the SPMMs, as well as its principles and exclusive enablers, the proposed model is based on two fundamental points: i) previous models that relate some SPMMs and some operation's strategic objectives and ii) the existence of trade offs in manufacturing. Therefore, for a better understanding of the model, we will focus the next two Sections on these two themes, and then present the model itself. After presenting the model, we elaborate a final section showing five case examples where the proposed model is illustrated.

4.1 Two models that relate the operation's strategic objectives to the SPMMs

In this Section, we present two models found in the literature, which propose a relationship between some SPMMs and some performance objectives. The first one, proposed by Booth (1996), is shown in Figure 3. According to this model, each paradigm of manufacturing management has a high, medium or low focus on three performance objectives (cost, responsiveness and flexibility). According to this model, we can see that for, example, time-based manufacturing (time compression) has a high focus on responsiveness (time) and cost, and a medium focus on flexibility.

A second model (Fernandes and MacCarthy, 1999) shows a relation between some SPMMs and some performance objectives. This model is presented in Figure 4. As we can see in this Figure, as Repetitive Manufacturing moves towards Agile Manufacturing, new objectives are taken into account, without discarding the previously incorporated ones. For example, Lean Manufacturing incorporates the quality objective and encompasses the productivity/cost objective from Repetitive Manufacturing.

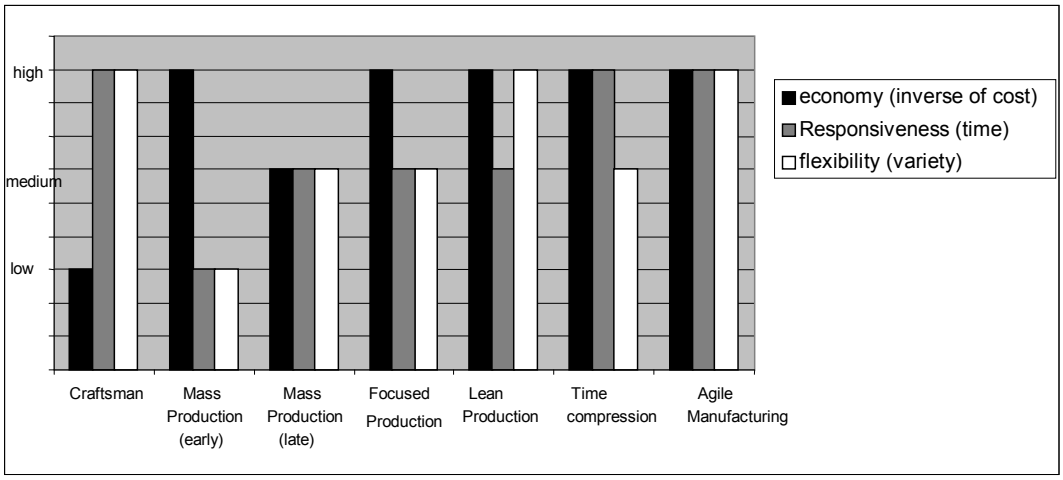

Figure 3. The first model that related some SPMMs to some operation's strategic objectives
Source Booth (1996)

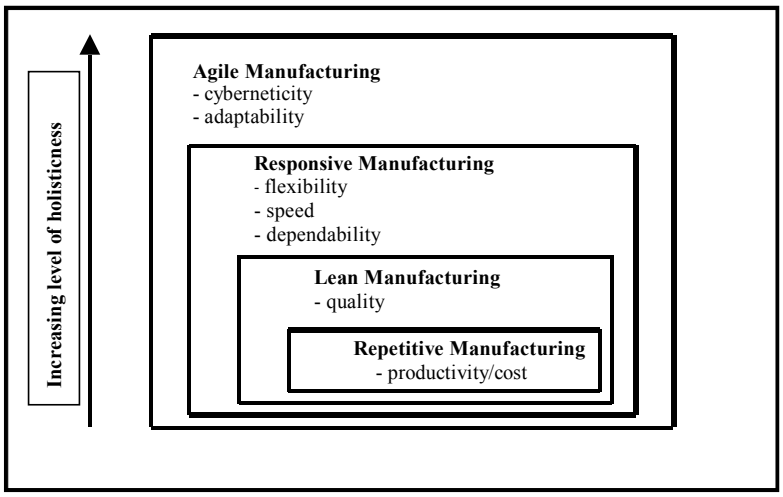

Figure 4. Second Model that relates some SPMMs and some operation's strategic objectives.
Source: Fernandez and McCarthy (1999)

4.2 Trade offs in manufacturing

The discussion regarding trade offs in manufacturing is one of the main points for the proposal of our model, since it is exactly the existence of trade offs in manufacturing that do not allow SPMMs to emphasise all the strategic objectives in the same way and at the same time.

The idea of trade offs among the performance objectives was first proposed by Skinner (1969). In his opinion, trade offs exist in the project and operations of production systems and this should be taken into account when production systems are designed. However, according to this author, companies should concentrate their efforts on a reduced number of objectives (preferably just one objective). This opinion is supported by other authors (Hayes and Wheelwright, 1984; Miller, 1983).

After reviewing the bibliography on the theme, we identified the co-existence of at least four different approaches in relation to trade offs in manufacturing. Two of these approaches seem quite radical (which we called first and second), while the other two are more realistic and appropriate (called third and fourth).

The first approach clearly defends the existence of trade offs in manufacturing, making it necessary for the company to focus on a few or only one manufacturing objective. This approach is proposed by authors such as Miller (1983); Hayes and Wheelwright (1984).

A second approach, represented by many supporters of Lean Manufacturing and World Class Manufacturing, defends that *trade offs* do not exist. The main representative of this approach is Schonberger (1990), followed by other authors (Corbett and Wassenhove, 1993; Hill, 1988).

A third, less radical approach, understands that some trade offs do exist, while others do not. On the other hand, there is no consensus as to which trade offs belong to which of these groups. Based on New (1992), Khouja and Mehrez (1994) and Koste and Malhotra (2000), we have compiled Table 2, which shows the main existing trade offs.

Table 2. The current *trade offs* in manufacturing

	Productivity	**Quality 1**	**Quality 2**	**Flexibility 1**	**Flexibility 2**	**Speed**	**Dependability**
Productivity	**X**	YES	YES	YES	YES		
Quality 1	YES	**X**			YES		
Quality 2	YES		**X**		YES	YES	YES
Flexibility 1	YES			**X**			
Flexibility 2	YES	YES	YES		**X**	YES	YES
Speed			YES		YES	**X**	
Dependability			YES		YES		**X**

Finally, the fourth approach defends the existence of trade offs; however, these are dynamic and not static, as considered in the past. This dynamism means that particular measures, varying from case to case, can be taken so that the two apparently inversely proportional aspects can be improved at the same time; obviously giving a higher priority to one of them. This view of trade offs, which are dynamic regarding the performance objectives, is shown by authors like Slack (1995), with his idea of "changing the focus", and Hayes and Pisano (1996), with their idea of how to

improve dynamically. Other authors in this fourth category are Skinner (1992), Hayes and Pisano (1994) and Da Silveira and Slack (2001).

It is obvious that even after this progress of ideas regarding trade offs in manufacturing, we believe that they exist, thus making it impossible for a company to improve all aspects at the same time. In the words of Correa (2001), "the competitive priorities of manufacturing are established because a manufacturing system can not be the best in all aspects at the same time". However, we agree with the more recent (third and fourth) approaches to trade offs, i.e. they still exist for some performance objectives (see Table 2), and the idea of dynamic trade offs is valid for trade offs.

4.3. The proposed model

The basic idea of our model is that new SPMMs will arise due to new market needs which demand different emphasis regarding performance objectives in order to be met. Figure 5, proposed by Bolwijin and Kumpe (1990), shows how market needs and the performance objectives related to these were altered throughout the last 40 years in the 20th century.

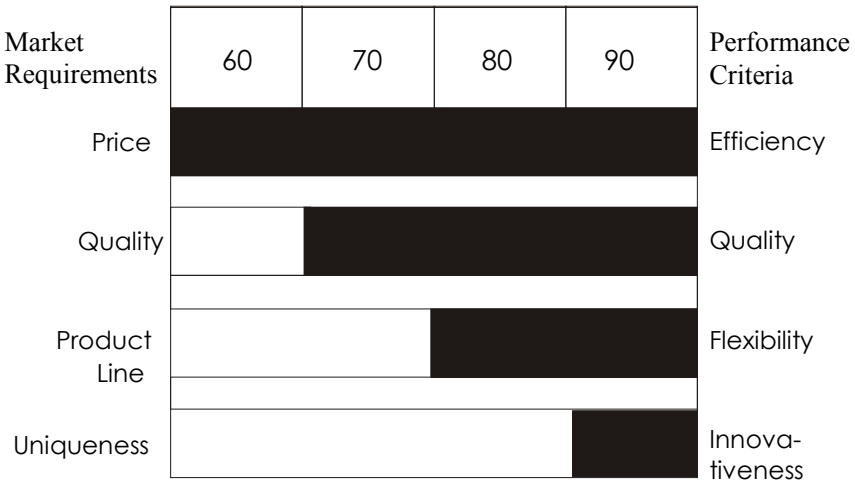

Figure 5. Evolution of market requirements and performance criteria for large manufacturing industry. Source: Bolwijin and Kumpe (1990)

Other support for the creation of our model was:

- literature on Mass, Lean, Responsive, Agile and Mass Customisation Manufacturing, more specifically regarding their most emphasized and sometimes exclusive principles (which can sometimes be understood as enablers, as stated at the end of Section 2). The order-winning objectives of each SPMM arise from them (Table 3);
- In the trade offs between the various operation's strategic objectives (shown in Table 2) ➡the manufacturing trade offs explain the lower performance of some performance objectives, as the order-winning objectives are changed;
- In the two previously described models (Figures 3 and 4), which will be compared to our proposed model, still in this Section.

Figure 6 represents our model of relationships between the SPMMs and the performance objectives. In Current Mass manufacturing, the order-winning objective is productivity; however, there is concern with two other qualifying objectives: quality 1 (Ford's T model was suitable for its use: robust to face dirt tracks full of holes and stones) and flexibility 1, since a certain distinction is desirable in Current Mass Manufacturing.

Lean Manufacturing started in Japan in the 1950s as it was impossible for them to prioritise productivity – which generally requires economy of scale – because large scale production of a single model would be unthinkable there. Therefore, the solution was to be different from competitors in terms of flexibility 1 and quality 2. Productivity is also an objective, since gains from this objective lead to bigger profitability; however, productivity can not have the same priority level as quality 2 and flexibility 1, since there are trade offs (see Section 4.2, Table 2) between productivity and quality 2, and between productivity and flexibility 1.

Table 3. SPMMs and their most emphasized or sometimes exclusive principles/enablers and the strategic order-winning performance objectives related to these.

SPMM	The most emphasized or sometimes exclusive principles/enablers and the strategic order-winning performance objectives resulting from these.	Related order-winning performance objectives
CMM	Focus on clients who require low prices; focus on product standardization, but allowing some distinction; focus on operational efficiency/high productivity; highly specialized work.	Productivity
LM	Focus on quality; focus on offering the customer a wide distinction of similar products, with low diversification; focus on identifying and eliminating waste; adopting *just-in-time* as a production control strategy, made up of various principles (pulled production etc.); autonomation.	Quality 2 and Flexibility 1
RM	Focus on meeting the needs of customers who prioritize product diversification, response time and meeting deadlines; adopting a production control strategy that focuses time based competition, in an environment with a wide range of products.	Responsiveness (Flexibility 2 + Speed + Dependability)
MC	Focus on meeting fragmented demand, for different needs/requirements; reducing product development cycle and product life cycle; customer participation in all steps of the product life cycle;	Customisation Ability
AM	Focus on identifying new business opportunities; management based on key competences; developing abilities to deal with change and uncertainty; virtual enterprise	Adaptability

Responsive Manufacturing emphasises responsiveness (flexibility 2 + speed + dependability) and has arisen from the need to make a wide range of products available, made to order, but with the shortest response time possible (= distribution lead time + assembly lead time + components production lead time + supply lead time, depending on whether or not the raw materials are in stock), since in this area competition is based on time. Due to the emphasis on flexibility 2, it is impossible to give the same emphasis to quality 1 and 2 and to productivity, since there are trade offs between these objectives. (see Table 2).

With globalisation, there are many big retailing companies that identify business opportunities based on a big volume of a personalised item. These companies order from manufacturers that have customisation as an order-winning objective, and thus these manufacturers adopt Mass Customisation. Other objectives still have to be treated, however, with less emphasis (as qualifiers), since customisation highly emphasises flexibility, taking it to the extreme). This extreme, in turn, presents trade offs with quality, productivity and response time (see Section 4.2).

Agile manufacturing started due to the opportunities for innovation in the market, and also because of the rise of new technologies and customers who are keen on and can afford to acquire innovative products. An agile company frequently changes its market segments and due to this, it is totally or almost totally without vertical integration, and the partners that do outsource production are substituted according to the product segments that are designed. Thus, adaptability is the order-winning objective and the others are qualifying ones, using a similar reasoning to what happens in Mass Customisation.

Finishing this Section, we compare the proposed model with the two previously described ones (respectively Figures 3 and 4). The model proposed by Fernandes and MacCarthy (1999) describes the historical progress of the emphasis in performance objectives (shown in Figure 5) in a much clearer way than Booth's model (1986). Our present model is an evolution of Fernandes and MacCarthy (1999) model, for the following reasons:

- The term CMM is less confusing than repetitive manufacturing;
- It makes explicit that in CMM there are qualifying objectives (quality 1 and flexibility 1);
- It distinguishes two kinds of flexibility (1 and 2);
- It distinguishes two kinds of quality (1 and 2);
- It introduces the Mass Customisation paradigm;

Still comparing the proposed model with Fernandez and McCarthy (1999) model, we can observe that both maintain the same idea: the objective(s) stated below the term SPMM (see Figure 6) are order-winning objectives, while the objectives that are in the internal rectangles are qualifying objectives. For example, in our model, responsiveness (flexibility 2 + speed + dependability) is the order-winning objective for Responsive Manufacturing, while quality 1 and 2, flexibility 1 and productivity are the qualifying objectives in this SPMM.

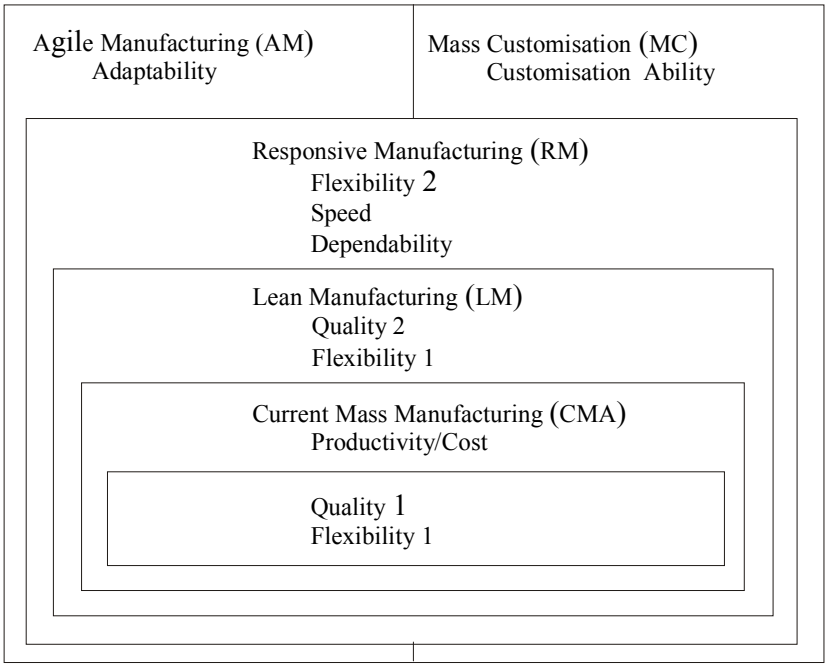

Figure 6. Model of relationships between the SPMMs and the operation's strategic objectives.

4.4 Case Examples

To illustrate our model we show in this section five illustrative examples. Each of these examples is related to one Strategic Paradigm for Manufacturing Management (SPMM). The first intention was to describe five cases in the Brazilian footwear industry, but, no case of Agile Manufacturing was found in this industry. Therefore only cases A, B, C and D are from Brazilian footwear industry. Case E (Agile Manufacturing) works in several industries at the same time.

4.4.1 Case Example A

An example of Current Mass Manufacturing is company A, which has been in business for almost 10 years. This company manufactures two types of footwear for children: tennis shoes and sandals. The number of employees is 250 and the company makes about 4000 pairs of products per day.

Company A is competing in an environment with a low turbulence level (this classification is due to Pine (1993)). Some characteristics of this low-turbulent market are: i) the demand is stable and easily anticipated; ii) the products are basic and simple; iii) clients requirements are easy to understand and to define; iv) client's desires are basically the same; v) clients are not sensible to fashion changes; vi) difficulty to substitute the company's products; vii) market characterized by low level of introduction of new technological innovations; viii) suppliers have low difficulty to achieve company´s requirements regarding price, time and quality, and; ix) the competitors have a high response time to company´s promotions and innovations.

Company A focuses on clients sensible to costs. For these clients, the price of the product is the most important competitive factor. Basically, company A focuses in selling products to low income population (classes C, D and E according to an economical classification very used in Brazil). According to a company´s industrial manager: "…despite our clients do not demand a high diversification, it would be impossible to sustain a good competitive position if the company did not offer at least the possibility of some changes in the product mix (for example, a tennis shoe with different colours and models), within a limited range of options." Therefore, regarding order-winning performance objectives, company A tries to achieve at the same time, a good performance on productivity and flexibility 1.

The principles/enablers utilized by the company are: a) highly specialized work; b) focus on operational efficiency/high productivity aiming to reduce costs; c) focus on product standardization in order to have high capacity utilization in all facilities; d) diversification (wide variety of very different products) must be avoided; e) some distinction (flexibility 1) is allowed (8 different models of sandals and 8 different models of tennis shoes); f) two productive units (both using a product layout) responsible to manufacture respectively tennis shoes and sandals (within the same productive unit the set up required is very low); g) new products are launched just two times per year and the product development department is focused on design products that do not change the process configuration; h) economy of scale; i) Interchangeable parts are used and thought since the early stages of product development; j) specialized machines are the main part of the production process; k) in some production steps it is used a paced

Assembly Line to guarantee continuous production flow; l) products are produced make-to-stock; m) spreadsheats are used for production control; n) get market-share focusing on clients who require low prices.

4.4.2 Case Example B

An example of Lean Manufacturing is company B, which has been in business since 1994. Company B manufactures 4 types of footwear for children: tennis shoes, shoes and two different types of sandals. This company produces almost 20000 pairs of products per day in three facilities, using about 1479 employees.

Company B is competing in a more turbulent market. This is due to the fact that the market where company B works has some of the same characteristics of company's A market (low turbulence level), such as: a very homogeneous market, with a stable and easily anticipated demand; and; low level of introduction of new technological innovations. Although these characteristics, company's B market has also some other characteristics that shows a more turbulent market, for example: clients are very sensible to fashion changes; the competitors have a low response time to company's promotions and innovations and the new product development activity is very more complex than company's A activity. Therefore, we are going to classify company's B market as being low-medium according to Pine (1993).

Company B considers quality (quality 2 as defined in section 3) as being the order-winning performance objective. Quality is the main factor that the future potential customers evaluate and compare with other competitors. Another important performance objective for company B is flexibility 1. So, the possibility of some changes in the product mix is also considered important for company B.

The principles/enablers used by company B are: a) pursuit of quality as a main competitive factor; b) elimination of non value-added activities; c) focus of continuous improvement; d) utilization of zero defect and six sigma techniques; e) visual management towards quality improvement; f) "one-piece-flow" management; g) some distinction (flexibility 1) is desirable (about 26 different models are manufactured in the three facilities).

4.4.3 Case Example C

An example of Responsive Manufacturing is company C, which has been in business since 1993. This company manufactures about 600 different models in 4 facilities using 1800 employees. Company C manufactures about 38000 pairs of women's footwear per day.

Company C works in a market more turbulent than companies A and B. Some characteristics of this market are: i) client's desires are very heterogeneous; ii) client's requirements are constantly changing; iii) clients are very sensible to fashion changes; iv) market is highly competitive, with competitors having a low response time to company's promotions and innovations; v) product life cycle is very short (average of about 2 and 3 months); vi) new product development activity is very complex (more than companies A and B). These characteristics define a medium turbulent market, according to Pine (1993).

The most important performance objectives for company C are: flexibility 2 (as defined in section 3), speed and dependability. According to a company's industrial manager: "... It is difficult having one day that any new product is launched to the production and/or an old product left the line definitively." Other important performance objectives (qualifying objectives) are: quality, cost and flexibility 1.

The principles/enablers used by company C are: a) an efficient production control function to achieve speed and dependability in an environment with high variety of products (Company C has a production control based on a scheduling that considers capacity, balancing, due dates and real-time monitoring based on barcode used in the production orders. Also, the parts supply is synchronized in the supply chain based on Master Production Schedule); ii) innovation activity is one of the most important competitive weapon of company C (company C is used as a benchmarking regarding innovations in the Brazilian women's footwear industry).

4.4.4 Case Example D

An example of Mass Customization is Company D. It produces a wide range of women's footwear (about 1000 different models manufactured in one year) in 4 facilities using 2500 employees. The design of company's C products is defined together with the client (big stores located in Europe). Company D manufactures about 16000 pair of products per year.

Company D also works in a medium-turbulent market. Some characteristics of this market are: i) luxury products; ii) client's requirements are constantly changing; iii) sales are very influenced by macroeconomic variables; iv) market is highly competitive, with competitors having a low response time to company's promotions and innovations; v) new product development activity is very complex (more than companies A, B and C).

The most important performance objective for company D is the customisation ability. This ability is the main source of competitive advantage for company D. Other important performance objectives (qualifying objectives) are: quality and cost.

The principles/enablers used by company D are: a) flexible production process, once the production is customised; ii) prices are higher than competitors due to customisation; iii) clients participate in all steps of the product life cycle; iv) intensive use of high technology to facilitate the customisation process (such as EDI, internet, etc.).

4.4.5 Case Example E

Company E is not directly related to any particular industry. This company focuses on opportunities that arise in several different industries (manufacturing or services). The majority of production processes are outsourced. Inside the company, only the most vital (in order to guard industrial secrets) processes steps are performed. Company E is a small company. Some examples of products that company E already launched into the market in the last few years are: i) machine to count coins; ii) vending machines; iii) equipment to change fuel in vehicles; iv) CNC machines to manufacture ice-creams; v) telephone services by internet; vi) GPS equipments to track vehicles; vii) laser technology to develop products for beauty industry.

The turbulence level for company E is extremely high, once the company works in several different industries. The only common characteristic to all of the company's products is the following core competence: utilization of cybernetics and micro-electronics.

The most important performance objective for company E is adaptability. In other words, company E has an ability to prosper in an environment of constant change, taking advantage of these changes, understanding them as opportunities. Other important performance objectives (qualifying objectives) are: quality, time and cost.

The principles/enablers used by company E are: a) development of partnerships, once the majority of production is outsourced; ii) high flexibility in order to have a quick reconfiguration in function of the different products/services offered; iii) a high technological competence regarding cybernetics and micro-electronics (core competence of company E); iv) concerns regarding quality, time and cost, once the majority of the products is outsourced.

4.4.6 An overview of the five case examples

The main information about the five case examples showed in this section is summarized in table 4.

Table 4. An overview of the five case examples (CE)

CE	SPMM	Drivers	Order-Winning Performance Objectives	The most emphasized or sometimes exclusive principles/enablers used
A	Current Mass Manufacturing	the demand is stable and easily anticipated; the products are basic and simple; clients requirements are easy to understand and to define; client's desires are basically the same; clients are not sensible to fashion changes.	Productivity/Cost	focus on operational efficiency/high productivity aiming to reduce costs; product standardization; no diversification; some distinction (flexibility 1); economy of scale; use of specialized machines and paced assembly line; make-to-stock (MTS) production; focus on clients who require low prices.
B	Lean Manufacturing	a very homogeneous market, with a stable and easily anticipated demand; low level of introduction of new technological innovations; clients are very sensible to fashion changes.	Quality and flexibility 1	pursuit of quality as a main competitive factor; elimination of non value-added activities; focus on continuous improvement; utilization of zero defect and six sigma techniques; medium level of distinction (flexibility 1).
C	Responsive Manufacturing	client's requirements are heterogeneous and very sensible to fashion changes.	Speed, Dependability and Flexibility 2	Efficient production control function to achieve responsiveness; focus on innovation
D	Mass Customisation	Luxury products; frequent changes in client's requirements that are very specific.	Customisation ability	Flexible production process; participation of the clients aiming customisation; intensive use of information technology.
E	Agile manufacturing	new market opportunities due to great changes in many types of business.	Adaptability	Development of partnerships; high flexibility; high technological competence regarding cybernetics and micro-electronics

In all the five case examples presented in this section, companies showed a lot of consistency between market drivers, order-winning performance objectives and principles/enablers used. Actually, these five examples were chosen intentionally (intentional sample, according to Patton (2001)) to illustrate the model proposed; therefore all of them present a consistency between market drivers, order-winning performance objectives and principles/enablers used. This consistency not always occurs. An example where this consistency does not occur is company F, which used to work

within Brazilian footwear industry. This company didn't present any strategic focus, manufacturing men's boots and shoes. Although 90% of their income came from boots, company F insisted on manufacturing a wide range of shoes, harming the performance of the boots regarding cost and speed. Company F tried to solve their problem implementing an ERP (Enterprise Resource Planning) system, which made the situation worse: company F went bankruptcy in 2006 after 10 years in the market. Company F should have focused only on boots sector and also have adopted the principles/enablers and performance objectives of Current Mass Manufacturing paradigm instead of trying to adopt a wide range of principles/enablers not related to their performance objectives and market drivers.

5. CONCLUSIONS

This article shows the progress and a better understanding of the main manufacturing management paradigms which arose in the 20th century. Based on this progress, we created a concept in Production Management, the concept of Strategic Paradigms for Manufacturing Management (SPMMs). The introduction of this concept, as well as the identification of its key elements meets some important objectives:

- It gives a pragmatic approach to strategic issues, within the scope of Production Management;
- It clarifies concepts within Production Management and enables the comparison between SPMMs and other frequently used terms in Production Management;
- It provides a basis for more knowledge, dissemination and broadening the research on the subject;
- It enables future comparative analysis between the SPMMs.

This work also presents a model that relates the SPMMs to the operation's strategic objectives. This model is more complete than the other existing models in the literature. It shows that there is a clear relationship between the SPMMs and the operation's strategic objectives. This model aims to show that each company should seek the most adequate SPMM in relation to its strategic objectives, and that there is not a single paradigm (e.g. Agile Manufacturing) that is the panacea to all situations. The paper also presents five case examples to illustrate the proposed model.

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