Analysis of the congruence between manufacturing strategy and production system in SMME

Kristina Säfsten[1] and Mats Winroth[2]

[1]Department of Mechanical Engineering, Division of Production Systems, Linköping University, SE-581 83 Linköping, Sweden
E-mail: krisa@ikp.liu.se

[2]School of Engineering, Mechanical Department, Jönköping University,
SE-551 11 Jönköping, Sweden
E-mail: mats.winroth@ing.hj.se

Abstract

A production system must reflect a company's manufacturing strategy and the chosen competitive priorities. Tools to assess the congruence between the manufacturing strategy and the production system can hence support the companies' competitive position. In this paper, the usability of an analysis model suggested by Miltenburg (1995), aiming at mapping manufacturing strategy and production system is investigated. The usability of the analysis model is investigated in terms of the ease to use it and in terms of the obtained results. The investigation is performed by means of empirical studies in two medium sized manufacturing companies. The result is that the model seems to be useable in the senses that, if knowledge about the underlying principles in the analysis model is at hand, it is possible to investigate the congruence between manufacturing strategy and production system. It is, however, believed that the analysis model needs some further development to be considered an easy to use tool for e.g. the SMME production manager.

Keywords:

Manufacturing strategy, production system, analysis model, SMME

1 Introduction

If a manufacturing company is to be successful, the manufacturing function must be supportive in the achievement of appropriate competitive priorities. It is essential that the production system reflects the chosen manufacturing strategy. According to Hill (1995) a manufacturing strategy comprises:

> "a series of decisions concerning process and infrastructure investment, which, over time, provide the necessary support for the relevant order-winners and qualifiers of the different market segments of a company." (Hill, 1995, p. 57)

Is it possible to determine or at least give some indications whether a manufacturing system is supportive to the achievement of a company's competitive priorities? Different analysis models have been developed describing the congruence between various aspects of the manufacturing strategy and the production system. Some indications on how to assess the support from the operations function are given by Slack *et al.* (1998). They describe the role and contribution from the operations function in four stages, from internally neutral to externally supportive. This description is to a large extent based on Hayes and Wheelwright (1984), who provide a tool for the assessment of manufacturing's strategic role. Hayes and Wheelwright (1979) also introduced the well-known product/process matrix. Hill (1995) suggested product profiling as an analysis model for assessment of the match between market, product, and process.

As a mixture of these models and tools, Miltenburg (1995) suggested an overall framework for analysis of a company's manufacturing strategy in terms of congruence with the production system, its products, and its capabilities.

Most of the examples given in the literature, where those tools are used, are from larger companies in the UK or the USA. Due to its comprehensive structure the analysis model described by Miltenburg is assumed to be a suitable tool for a smaller company with restricted resources. One single framework is sufficient to get an overview of the manufacturing situation in terms of congruence between manufacturing strategies and production systems. Apart from the relevance of investigating the usefulness of the analysis model *per se* it is also interesting to do it within small and medium sized manufacturing companies[1].

The purpose of the research described in this paper is to investigate the usability of the framework suggested by Miltenburg (1995) in small and medium sized manufacturing companies. The main questions raised in this paper are the following:

- Is it possible to use the model, i.e. can the model, as described by Miltenburg, be used in practice to investigate the congruence between the manufacturing strategy and the production system or does the model need any modification?
- Are the results from an analysis in accordance with the company's own opinion about the congruence between the manufacturing strategy and the production system?

The rest of the paper is structured as follows, in section 2 the material and methods used are described. Section 3 presents the analysis model as it appears after the empirical studies and the consequent modifications. Section 4 and 5 are brief descriptions of the empirical studies and how each study contributed to the development of the analysis model, and finally in section 6 the results are summarised.

2 Material and methods

The work described in this paper is done in several stages. Initially it was observed that the data collection could be simplified and improved by providing a set of questions to ask for each step in the analysis. Consequently, the first stage was to formulate a number of questions to cover all areas embraced in the model. When an estimated sufficient amount of questions was formulated a suitable company was required. The selection was made on the basis that the company should be a small to medium sized manufacturing company, aware of its manufacturing strategy, and be "quite good". A medium sized Swedish manufacturing company was selected, Company A. In this case study the usability of the chosen analysis model was first tested. After modifications, according to the experiences in this case, another company was contacted and the usability of the model, modified according to the experiences in the first case, was tested. For the second case another medium sized manufacturing company was selected, Company B. In this case no criteria were put on the company to be "quite good". The idea was to study an average company.

The methods used in both companies were interviews and observations to collect the required information. Interview guides were used in the interviews. The interviews were structured and open-ended. The questions were asked subsequently according to the interview guides and the respondents were free to answer, as they liked, without given alternatives. In Company A, two persons were interviewed, the manager for the industrial engineering and plant maintenance and the division manager. Since these two respondents complemented each other in knowledge, it seemed to be a satisfactory amount of respondents in a company of the selected size. In Company B the production manager was interviewed, which seemed satisfactory since he had a good overall view of the company. The different steps in the subsequent analysis, the

[1] A distinction between Small and Medium-sized Enterprises (SME) and Small and Medium-sized Manufacturing Enterprises (SMME) can be useful when focusing on the manufacturing organisations (Greatbanks *et al*., 1998).

result and the recommendations were finally discussed with the respondents in order to get their comments on the obtained result.

3 The analysis model

As a result of the work in Company A and Company B a modified analysis model has evolved, see Figure 1. The model presented in this section is the analysis model as it appears after the modifications made. How each case contributed to the modifications and complements is described after each case description in section 4 and 5.

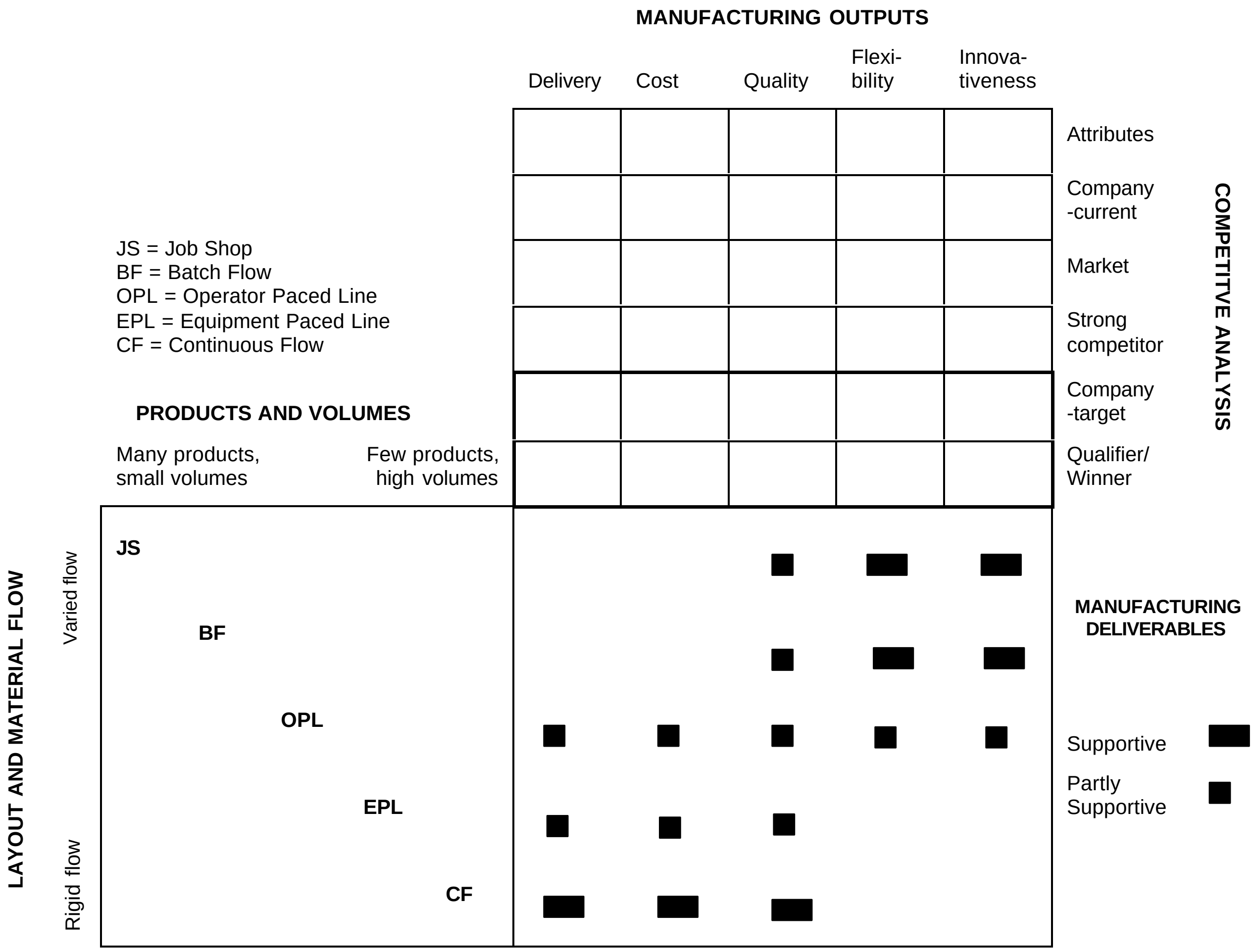

Figure 1 The evolved analysis model

The work with the analysis model comprises five steps, which are briefly described below.

Step 1 Survey current manufacturing capability

The purpose of the first step is to make a survey of the manufacturing function and its current capabilities. The manufacturing function can be described as constituting a number of areas. Miltenburg (1995) denoted those areas manufacturing levers. Similar denomination, and more common in the manufacturing strategy theory, is decision areas or decision categories (Säfsten, 1998). In the original model the areas included are human resources, organisation structure and control, sourcing, production planning and control, process technology and facilities. An addendum of capacity and quality management are made since these areas are considered important for an overall judgement of manufacturing capabilities. The decision areas and their main characteristics are summarised in Figure 2.

Decision area	Characteristics
Process technology	• flexibility, type of equipment, technology level, layout
Facilities	• location, size, focus
Capacity	• amount, acquisition time, type
Vertical integration	• amount, degree, relations
Quality management	• definition, responsibility, reporting
Work force	• skill level, wage, training and promotion policies, employment security
Organisation structure and control	• relationship between groups, decision,
Production planning and control	• responsibility, rules and systems

Figure 2 The decision areas and their main characteristics

A number of questions are formulated for each decision area, to get an overview and describe each area, which is essential in order to form an opinion about the manufacturing capability.

Four levels of manufacturing capability are given according to Figure 3. For each decision area, the capability is graded according to these four levels. It might, however, vary between branches what to be considered as world-class. Depending on where the company competes, different areas can be more or less crucial. It is not necessarily most advantageous to be world-class in all areas.

Level 1 - Infant	Level 2 - Average	Level 3 – Adult	Level 4 – World Class
The production system makes little or no contribution to the organisations success. Manufacturing is low tech and unskilled. *(internally neutrality)*	*Manufacturing is satisfied to keep up with its competitors and maintain the status quo.* Manufacturing consists of standard, routine activities. *(externally neutral)*	The production system provides order qualifying and order winning outputs at target levels. All manufacturing decisions are consistent with the manufacturing strategy. *(internally supportive)*	The production system strives to be the best in the world in all activities in the manufacturing subsystems. The production system is a major source of competitive advantage. *(externally supportive)*

Figure 3 The four levels of manufacturing capability (Miltenburg, 1995; Hayes and Wheelwright, 1984)

Step 2 Survey products and production systems

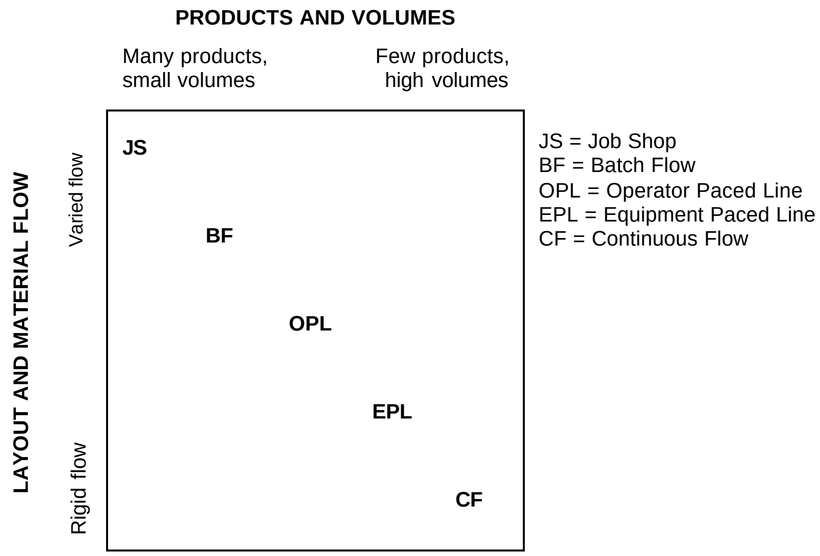

Figure 4 The product/process matrix (from Miltenburg, 1995)

The purpose of Step 2 is to determine where the company is today in terms of production system layout and flow, and products and their volumes. The process of positioning the production system on the worksheet involves a close study of the workshop, combined with knowledge of products and quantities. The aim is to position the current production system in the product/process-matrix described in Figure 4. The diagonal in the product/process matrix represents a natural lowest cost position for an operation (Slack *et al.*, 1998). The diagonal stretches from job shop, with the combination of many products in small volumes with a varied material flow, to the continuous line flow system producing one product in very high volumes with a rigid material flow.

Step 3 Strategy and competitive analysis

What are the present manufacturing strategies and what changes are necessary if a company is to get competitive advantages and meet the requirements of the customers? The purpose of Step 3 is to do a competitive analysis and to identify the order winner and qualifiers among the manufacturing outputs. The main manufacturing outputs, or competitive priorities, are delivery, cost, quality, flexibility, and innovativeness. All of these outputs are clarified in the aspect of important attributes.

- *Delivery* involves attributes as delivering on time, at short times etc.
- *Cost* deals with attributes as e.g. unit production cost, production capacity, and productivity.
- *Quality* embraces attributes as defective ratio, cost for warranty, scrap and rework, and the quality of parts bought from suppliers.
- *Flexibility* is about the ability to change such as the number of different products, order size, lot size, and the possibility to place an order close to production start.
- *Innovativeness* concerns how often new products are introduced and the lead time to change the design of a product.

For each attribute the present situation at the company, market demands, the position of a strong competitor, the objectives of the company, and whether the factor is regarded as a qualifying or an order winning criteria is investigated. Qualifiers are defined as those criteria that a company must meet to even be considered as a possible supplier. Order winners are those criteria that win the order (Hill, 1995).

Step 4 Link production system with competitive priorities

How are the production system and the competitive priorities linked together? The different production systems support the competitive priorities in various aspects, see Figure 5. Each production system supports different attributes of the competitive priorities better or worse than others do. It is, however, difficult to grade this support, other than just to relate the systems to each other. The manufacturing deliverables concerning support of the competitive priorities from each production system are graded as supportive or partly supportive.

The purpose of Step 4 is to investigate the match between the order winners and the qualifiers identified in Step 3 with the production system determined in Step 2. The match between the current situation and the preferred direction is analysed in the lower right-hand corner of Figure 1. A comparison is done between the manufacturing deliverables from the current production system and the required deliverables to match the preferred direction given in the competitive analysis.

	Delivery	Cost	Quality	Flexibility	Innovativeness
Job shop	On time, but longer distances and more difficult scheduling prolong the delivery time.	Satisfactory. Difficult match competitors using specialized equipment in a line flow system.	Satisfactory, but difficult to meet tight specifications.	Large variety of products, very low volumes. Equipment and tooling general purpose. Highly skilled operators.	Easy to make product changes and introduce new products due to the flexibility.
Batch flow	Long delivery time and low delivery time reliability.	Higher volumes. Repeated orders. More cost sensitive.	Hard to compete with special-purpose machines in a line flow system.	High level. General-purpose machinery and skilled operators.	
Operator-paced line flow	High level of delivery. Short through put time.	More specialized equipment and operators. Low cost.	See cost.	Lower due to more specialized equipment and operators.	
Equipment-paced line flow	Specialized machines. Steady, fast production. Fast, reliable delivery.	High volumes of a few products. Equipment, operators specialized. Low cost and high-quality products.		Equipment, operators specialized. Low flexibility and innovativeness, since changing is expensive and requires long shutdowns.	
Continuous flow	Fastest possible. Requires maintenance and reliable suppliers.	Lowest possible (for large volumes of one or a few products).	Highest possible quality (see cost)	Difficult to provide at high levels. Fixed speed of machinery. Expensive changes. Long shutdown.	

Figure 5 Support from the different production processes to the competitive priorities (Miltenburg, 1995)

Step 5 Identify possible and suitable changes

With the results from the previous four steps a picture is given with a match or a mismatch between current and preferred situation. If there is a match, it can be concluded that the current production system is supportive for the manufacturing strategy. On the other hand, if there is a mismatch, it must be investigated whether it is the production system or the manufacturing strategy that is failing. The case can be that the production system has evolved without formal support in a changed manufacturing strategy. A manufacturing strategy essentially has to be dynamic and take into account changed circumstances concerning products, markets and competitors. When the problem is identified, possible and suitable changes can be sought within the decision areas. Outgoing from the manufacturing capability analysis performed in Step 1, those areas with the largest potential for improvement can be identified.

4 Company A

Company A designs, manufactures and sells equipment for the building industry. The company is part of a larger company. The visited division is one of four divisions of a unit. The division of this study has 600 employees. The portion of the invoicing delivered to Sweden is 30% and the rest is exported, mainly within Europe. The manufacturing is entirely based upon customer orders and production does not start prior to order. Their customers are retailers and sales companies. Some of the subcontractors are involved in the customer orders production and deliver components specified individually for each order. The company is divided into three product lines. The base organisation is process oriented. The major part of the production is assembly, which takes place along operator paced assembly lines. Most of the equipment is general purpose. The delivery precision, the product performance, and quality are considered to be qualifiers. They win orders on flexibility, brand name, and price.

Results and conclusions

The framework turned out to be a good tool when evaluating the congruence between the present manufacturing strategy and the production system. It was also a guide for detection of areas where further actions are necessary when changing the production system, if a mismatch is identified between manufacturing strategy and production system. This part of the analysis was, however, perceived as the trickiest one. The company representatives found the analysis valuable and the output from the analysis corresponded with their view of the current situation. However, the respondents perceived that the matrixes in the original analysis model were quite complex, and they might require some time to be understood.

Input from the Company A case to the developed analysis model

The number of steps in the analysis model was increased from three to five. The reason for this was that, during the first analysis, it was perceived that it was too much to comprehend within each step. The analysis of the current manufacturing capabilities had been extended to comprise two additional areas in addition to the original suggested six areas. The main reason was that the missing areas, according to areas traditionally mentioned in manufacturing strategy theory, were considered as important to give a good overall description of the manufacturing function.

In order to simplify the interpretation of the analysis model some modification were made concerning the link between the manufacturing capability and the competitive analysis. Furthermore, the product/process matrix was modified. Originally, Flexible Manufacturing Systems (FMS) and Just-In-Time (JIT) were described as two separate production systems below the traditional diagonal. This was, however, believed to be somewhat misleading, since neither FMS nor JIT can be described as production systems, but rather as subsystem and as control principles respectively.

5 Company B

Company B is a supplier specialising in sheet metal processing. They assemble electronic equipment. The company produces cabinets, assembles the electronics, checks and delivers the finished product. They are part of a larger group of companies, but this unit has a total of 500 employees. The company has one major national customer, representing almost 100% of the invoicing. They offer full responsibility for complete system solutions, including product design, prototype manufacture, as well as development of production tools and methods. There are a few big domestic competitors, but for some products they are the only manufacturer in the country.

They assemble on suborder calls and deliver three times a day to the customer. The company works on focusing production, thus making it possible to assemble only a few main products in higher volumes. The assembly is flow oriented. In the assembly line with the highest volumes, assembly takes place along an operator-paced line. To be considered as supplier, delivery and quality are qualifying criteria. Flexibility and cost are the order winning criteria.

Results and conclusions

Today’s production system supports the requirements on delivery, cost, quality and flexibility. Focus is on flexibility. Quite a good level of flexibility is, however, described by the respondent. To keep this level of flexibility it is essential to work with activities within the decision areas supporting flexibility e.g. education and to use general-purpose equipment.

The present production system was found to be most supportive, with respect to the present competitive situation. Thus, no change of the system was suggested, but in order to be even more competitive, some of the manufacturing levers could be improved. The aim should be to try to make these factors equally supportive, so that no individual factor is an obstruction to a good result.

Input from the Company B case to the developed analysis model

After the modifications from the first case study, the number of steps and their extent seemed suitable. The levels of manufacturing deliverables, see the lower right-hand square of Figure 1, were reduced from a number of non-supportive and supportive levels to two supportive levels.

In that way no classification has to be done regarding the degree of a production system not being supportive to a certain manufacturing output. The most difficult part is still to identify suitable activities to enhance the congruence. It is also this part of the analysis that involves the largest effort, since a closer picture and knowledge of the specific company has to be achieved in order to be able to make the right decisions. Therefore the analysis model cannot really be considered as an easy to use tool.

6 Results and conclusion

After these two case studies, it can be concluded that the analysis model seems to give quite a good picture of the congruence between manufacturing strategy and production system. The model is usable in the senses that, if knowledge about the underlying principles in the analysis model is at hand, it is possible to investigate the congruence between manufacturing strategy and production system. The time to perform an analysis is estimated to three days, one day to collect data and two days to do the analysis. It is, however, believed that the analysis model needs some further development to be considered as an easy to use tool for e.g. the SMME production manager.

The increased competitive pressure together with the development within a number of areas as for example control principles, process technology, and information technology has somewhat altered the scene. Consequently, the relevance of the 20 years old production/process matrix can be questioned. In its original form the ability to produce a larger number of products, in different variants, customisation, is more or less excluded. The Toyota Production System (TPS) is often regarded as the ultimate solution, which makes it possible to combine the productivity of a line flow system with the demands for agility and quick changes of products (Monden, 1998). In this way the various advantages of a line flow system are combined with the possibilities involved in producing many different products in small quantities. This is the key issue when meeting the increasing demands for customized products. It is, however, not adequate to include TPS into the product/process matrix, since TPS does not imply a specific system layout. TPS is an overall philosophy, comprising much more, such as dedication of the management, operator training, continuous improvement etc. All of these are necessary actions, regardless of the layout of the production system.

7 References

Greatbanks, R., Boaden, R., Musson, S. (1998) Can SMME´s be World Class*? Proceedings of the First International SMESME Conference*, Sheffield, UK.

Hayes, R. H., Wheelwright, S. C. (1979) Link manufacturing and product life cycles, *Harvard Business Review*, January-February, pp. 133-140.

Hayes, R. H., Wheelwright, S. C. (1984) *Restoring our competitive edge: competing through manufacturing*, John Wiley & Sons, New York.

Hill, T. (1995) *Manufacturing Strategies*, MacMillan Press Ltd., Chippenham, Wiltshire, England.

Miltenburg, J. (1995) *How to formulate and implement a winning plan*, Productivity Press, Portland, Oregon.

Monden, Y. (1998) *Toyota Production Systems – An Integrated Approach to Just-In-Time*, Engineering & Management Press, Norcross, Georgia.

Slack, N., Chambers, S., Harland, C., Harrison, A., Johnston, R. (1998) *Operations Management*, 2nd edition, Financial Times, Pitman Publishing, London, UK.

Säfsten, K. (1998) *Requirements and strategic preconditions for efficient assembly - A theoretical analysis*, Linköping Studies in Science and Technology, Thesis No. 707, Linköping, Sweden.