Performance Measurement for Collaborative Manufacturing Networks – Theoretical Investigation with Focus on SME

Andreas Sandgren*
Department of Industrial Engineering and Management
Jönköping University, School of Engineering
P. O. Box 1026
SE-551 11 Jönköping, Sweden
Phone: +46 36 10 16 37
Fax: +46 36 10 05 98
E-mail: andreas.sandgren@ing.hj.se

Mats Winroth
Department of Industrial Engineering and Management
Jönköping University, School of Engineering
P. O. Box 1026
SE-551 11 Jönköping, Sweden
Phone: +46 36 10 16 40
Fax: +46 36 10 05 98
E-mail: mats.winroth@ing.hj.se

*Corresponding author

Abstract
It is suggested in different foresights that collaboration is one way to compete with other manufacturers. Traditional performance measurement techniques can be applied at collaborative settings, but they need to be redesigned. This article investigates performance measures in collaborative manufacturing networks for SMEs.

Key words: Foresights, manufacturing, SME, Network, Performance measurement
1 Introduction

Increased globalization leads to drastically changed conditions for manufacturing (Audretsch, 2003). Different roadmaps indicate possible scenarios. A German study shows that it is possible to maintain manufacturing in countries which are not low cost countries for manufacturing (Pfaeffmann & Stephan, 2001). The trend is that manufacturers go towards a more advanced manufacturing and that they often give their customers extra value by e.g. taking part in more complex systems solutions. Their ability to reach profitability and growth depends on success in developing new products and entering new markets (Azzone et al., 1995). Small and medium sized enterprises (SMEs) do, however, have limited resources to adapt to this new and more complex situation (Peklenik, 2002). One possibility is to enter collaborative settings with other companies and thus join forces. Sandgren and Winroth (2005) describe several factors that could be important for manufacturing in collaboration. The purpose of this paper is to investigate performance measurement in collaborative manufacturing networks for SMEs.

1.1 Foresight

Increased demands on efficient manufacturing from customers to reduce costs will lead to more development in the manufacturing system to reach competitiveness in manufacturing. Recent introduction of methodologies for integrated product and process designs has reduced time-to-market and put more focus on the ability to develop designs for the entire life cycle of products (VMC, 1998).

The European industrial structure is fairly dominated by SMEs (MANUFUTURE, 2003). This gives several advantages e.g. flexibility, but it could also be a weakness such as reduced export impacts (MANUFUTURE, 2003). The problem for European industry is that they have high labour costs and therefore it is very difficult to compete with low-wage countries, especially in mass-production of consumer products (MANUFUTURE, 2003).

There are several different ways to go to improve competitiveness. Since it could be hard to compete with the lowest price, other aspects of adding customer value may give competitive advantages (Christopher, 1998). It is possible to combine several opportunities to be more competitive. One way is to increase the scope of delivery and, as manufacturing in that way becomes more complex and high-tech, it will become more difficult to carry out manually (IMS, 2001). In this case, simulation could be useful in order to build a model to determine in advance how a new production system will affect the manufacturing conditions in short and long term (IMTI, 2000). This often means that the companies need competence and financial resources to be able to invest in more or less sophisticated simulation hardware and software, which may be particularly difficult for SMEs (Peklenik, 2002). An opportunity is that they collaborate in networks with other small companies and share such competence and equipment (Coviello & McAuley, 1999). Changes that affect manufacturing companies call for the following issues to be handled:

- **Production systems** that is fast and flexible and able of handling customers’ short term changes.
- **Highly skilled organisations** are required to handle the necessary speed of the production systems, which are a result of the increased competition.
Entering **cooperation and alliances** is one way to become more competitive for SME suppliers in the future and these SMEs need to find ways of collaborating in these new settings.

The focus during the last years has been to develop the supply chain and supply chain network (van Hoek, 1998). So far most companies have been optimising their own part in the supply chain. The development has however in resent time moved to optimising the whole supply chain and suppliers and distributors have taken over a larger share of the operational activities from OEMs (van Hoek, 1998), see figure 1.

![Diagram of supply chain](image)

**Figure 1 Value adding process (van Hoek, 1998)**

The development within the supply chain and increased demands on suppliers has increased the need for better control over the performance in the supply chain. Depending on the movement of activities, the control becomes even more important and also the presence of a control system.

In many cases a simple method is enough to show the performance of a company. One way to share information is through return graphs that show the product life cycle and that integrates cost and time measures (House & Price, 1991), see figure 2. The graph contains several measurements in order to show the development over time of the new product development (House & Price, 1991).
By means of a return map, showing the performance indicators, the performance for a single product is easily shown. The problem with the return map is however that not all important performance measures are included. There is also a problem to show the performance of company networks. Collaboration in networks also increases the cost for maintaining the network itself and the cost raises with the number of partners (Neely, 1999). A performance measurement system would help getting better control over activities at the different collaborating companies (Neely, 1999).

2 Differences between small and larger companies

The ongoing globalisation, which has increased during the last years, has improved the ability for distribution of products all around the world (Audretsch, 2003). This has lead to increased competition, which smaller companies often have difficulties to cope with since they do not have the same ability to improve their efficiency (Audretsch, 2003).

Larger companies normally invest more in product development (Peklenik, 2002), both in terms of financial resources and human efforts. They put more efforts into further training of personnel than smaller companies (Audretsch, 2003). Furthermore, they are more active on the international arena, involving both foreign customers and suppliers, compared with SMEs (Audretsch, 2003). The aim with international work is often to be less dependent of a few customers and/or suppliers (Audretsch, 2003). Increasing the number of customers enables larger production series and reduction of product costs, which in turn gives competitive advantages towards SMEs (Pratten, 1991). Due to that SMEs normally have fewer customers makes them more vulnerable to changes than larger companies (Hudson et al., 2001). Other negative impacts for SMEs are reactive thinking through a fire-fighting mentality for problem solving (Hudson et al., 2001).

On the positive side for SMEs is that they can have a closer customer relation, which could lead to better customization and better customers’ satisfaction (Audretsch,
Customisation gives SMEs the possibility to giving good service and being flexible and sensitive to customer needs (Storey, 1994). SMEs also normally have a flat organisation (Hudson et al., 2001), which could improve the possibility for a high flexibility (Dangayach & Deshmukh, 2001). A flat organisation enables fast decision paths (Dangayach & Deshmukh, 2001). Small companies also have benefits of personalised management, which could increase cooperation between co-workers in the organisation (Dangayach & Deshmukh, 2001).

Many problems, emanating from the small size of the company, could be overcome through collaboration (Lazerson & Lorenzoni, 1999). The possibility to find matching companies in a supply network gives several positive effects (Arend & Wisner, 2005), such as reduction of costs and increased innovativeness (Coviello & McAuley, 1999). Taking part in supply networks also enables differentiation for a single company, and still focusing on its core business (Hartley, 2000). Networks with limited resources could be helped by web based solutions, which make it possible to reach foreign markets and suppliers (Gunasekaran & Ngai, 2004). A problem is that small companies do not have the technological capability that is necessary in order to take part in a supply network (Venkataraman & Van de Ven, 1998).

## 3 Performance Measures

Traditionally, performance measures have been used by shareholders to estimate the company’s financial results (McKenzie & Shilling, 1998). Performance measures have also been used to illustrated where companies have there strengths and weaknesses. Many different performance measures are used by different companies, and in some cases a classification of performance measures could be required to receive better control over the company measures. In the literature, many different classifications of performance measures are described. A common classification is however (Neely et al., 1995; White, 1996):

- Cost
- Flexibility
- Quality
- Time

In most cases it is not obvious what to measure, concerning both financial measures and non financial measures (Neely et al., 1995), and the problem is to select the right measures for the purpose. Normally there are a couple of measures that are more relevant than others, and together best will visualise the company performance. Often an organisation chooses historical measures, such as measures for cost and productivity. The selection of measures should reflect the organisation’s long-term strategy, which unfortunately is not always the case (Neely et al., 1994). An explanation could be that organisations often select measures that they tried earlier and that they feel comfortable with. Often old measures can be self-generated, which means that the organisation select measures (White, 1996). A problem with self-generated measures is they do not take customers’ valuations into consideration (White, 1996). To avoid the problem with just taking old measures, benchmarking could be an option in order to find best practice of selecting performance measures. Benchmarking does not however guarantee that entirely objective measures are found (Nemetz, 1990), but subjective measures could also be an option as long as the right items are measured. In the selection of measures, it is important to both measure the input and the output of the processes. Sometimes it could be hard to find the precise
figures for different measures, but still they are important to measure. In some cases, the problems with inexact figures depend on the dimension of the measure. Flexibility has e.g. many dimensions and could be hard to measure with precision (Barad & Even Sapir, 2003; White, 1996). When the organisation knows exactly what to measure, there is a need for a tool or a system for linking different measures to each other so that the evaluation provides a support for improving competitiveness.

4 Performance Measurement Systems

Using a performance measurement system, and a proper organising and linking of different measures, gives important input for improvements. Bond (1999) describes three factors that a performance measurement system should be able to handle:

1. Provide an early warning detection system over what is happening
2. Diagnose reasons for the current situation
3. Indicate what radical action should be undertaken

To reach these factors there some issues that the performance measurement system should be able to handle. The performance measurement system should be (House & Price, 1991):

- Simple to understand
- Have visual impact
- Focus on improvement rather than variance
- Visible to all

There are many frameworks suggested for performance measurement. Keegan et al. (1989), see figure 3, suggested a framework with the main purpose to connecting financial measures with non financial measures.

![Performance Measurement Matrix](image)

**Figure 3** The performance measurement matrix (Keegan et al., 1989)

The strength of the framework is the connection between financial and non financial measures (Keegan et al., 1989), while the weakness is the gap between different levels within the organisation (Folan & Browne, 2005).
Another framework for performance measurement systems is the Balanced Scorecard (Kaplan & Norton, 1992). The strength of the Balanced Scorecard is the integration between financial measures and non-financial measures, internal measures, and external measures, see figure 4. The starting point for the framework is four questions, which are (Kaplan & Norton, 1992):

1. How do we look to shareholders?
2. What must we excel at?
3. How do customers see us?
4. Can we continue to improve and create value?

The aim of the Balanced Scorecard is to show, in a balanced way, the performance of the organisation and where improvement should be implemented in order to improve competitiveness.

Figure 4 The Balanced Scorecard (Kaplan & Norton, 1992)

A framework with more focus on process is present by Brown (1996). Brown (1996) has the differences between the input and the output of the process in focus. Brown uses an analogy with baking a cake to describe the framework (Brown, 1996). According to the analogy, the entire process is described, from measuring the volume of flour to handling customer satisfaction after eating the cake. Lynch and Cross (1991) developed a framework that tries to combine a hierarchic base with the process focus, which also is the strength of the framework. By means of this combination it is possible to combine the advantages of both the hierarchic view and the process approach (Lynch & Cross, 1991).

4.1 Performance Measurement Systems for Networks

There are several frameworks of performance measurement systems developed for inter-organisations (Beamon, 1999; Brewer & Speh, 2000). Beamon (1999) suggested a framework for performance measurement in supply chains. The framework has three classes of measures (Beamon, 1999):
• **Resources** – Resources measures include: level of stock, workforce requirement, and costs. Measuring resources is often done through minimal required items or through efficiency and is important for this framework (Beamon, 1999). Too few measures within the resources class could create problems for other classes of measures, such as output and flexibility, and too many measures within resources increase the difficulty to handle and interpret the performance measurement system.

• **Output** – The next class is output, which includes: customers’ awareness, quality, and number of produced products. Many measures within the class are easily presented numerically, as number of produced products, and time required in terms of production time for a single product (Beamon, 1999). There are some measures that require more effort if they are to be presented numerically, such as satisfied customers and product quality (Beamon, 1999).

• **Flexibility** – The last class of the framework is flexibility, which measures the ability for adjustment of prerequisites in terms of volume and other changes from customers that affect the number of produced products (Beamon, 1999).

A more extended framework for inter-organisations is present by Brewer and Speh (2000). They made a further development of the Balanced Scorecard in order to make it suitable for supply chains. The general goal with this perspective is to reduce waste, increase flexibility, and reduce costs. These goals are important both for internal organisations as well as external organisations. To reach the goals for the organisation, which is to create value for customers, it is important to focus on the right issues and produce products that customers demand (Brewer & Speh, 2000). To maintain the competitiveness, the organisations need to adjust for future needs. To find out the future needs and new directions, benchmarking should be carried out continuously in order to find new areas for prerequisites where improvements are necessary. The main benefit of working with the supply chain is to improve the financial result, but also to handle different functions for improvement of efficiency and productivity for functions connected to the supply chain (Brewer & Speh, 2000).

### 5 Adjustment of Performance Measurement System

Most frameworks for performance measurement systems are developed for larger and single companies. For small and medium size companies, the choice of performance measurement frameworks is limited. Performance measurement systems for networks are also limited. Further adjustment of different frameworks should be done in order to fit SMEs in networks. The framework should handle measures for both financial and non financial measures (Keegan et al., 1989). The framework should also support strategy and be adjusted for the specific conditions for SMEs in network (Brewer & Speh, 2000). There is a global competition and smaller companies have in some cases not enough resources (Coviello & McAuley, 1999), thereby should resources be an important part of the framework. An adjusted framework should handle issues such as:

- Simplicity
- Easiness to measure
- Quick response
- Culture differentials
- Balance between financial and non financial measures
The Balanced Scorecard is a well-known, and often used, performance measurement system (Folan & Browne, 2005). There are also frameworks developed and adjusted for measurement of supply chains. One example of adjustment of the Balanced Scorecard is a framework presented by Brewer and Speh (2000). With this as starting point could the Balanced Scorecard be a good start for further development of a performance measurement system for SME in networks. With adjustments from Brewer and Speh (2000), and adjustments for smaller companies, the following perspective should be investigated further:

- Network Perspective
- End customer Perspective
- Resources Perspective
- Development Perspective

5.1 Network Perspective

The network perspective handles issues about strategy and how the network implementation could enable improvements at different levels of inter-organisations. The network perspective should focus on flexibility, costs, and increased competitiveness. Smaller companies often have difficulties to reach competitiveness due to less financial resources and range of knowledge (Audretsch, 2003; Coviello & McAuley, 1999; Hudson et al., 2001; Peklenik, 2002). Here a change in philosophy could be necessary so that the strategy fits the network solution, it is e.g. important to adopt flexibility to fit the entire network (Brewer & Speh, 2000).

5.2 End Customers Perspective

It is important to focus the end customers during the work in a network (Brewer & Speh, 2000). From an end customer perspective, the own company result is not in focus, instead the focus should be at the network in order to customise the network from an end customer perspective. Important parts to focus on are lead time, quality, and delivery precision. The main objective of strategy is to improve the financial results and if that is not directly possible, the strategy should be focuses on other items which improve competitiveness. A redesign of the strategy will then hopefully improve the financial results over time. The translation of the strategy should be excellent, otherwise there is a risk that focus will be on wrong items and the aim and desirable results will not be reached (Kaplan & Norton, 1992). Even if the focus is on the end customer, it is important not to forget the purpose of the network, and companies being members of the network should collectively answer to the end customers.

5.3 Resource Perspective

The resource perspective is important for small companies. The focus is here on resources that will be available for the network and that together create a critical mass of network resources. Focus is also on factors such as cycle time, quality, and level of knowledge. Small companies are in some cases dependent on a few number of employees, which leads to small companies being more vulnerable than large companies when missing important employees that work in the manufacturing system (Audretsch, 2003; Hudson et al., 2001). Even the information flow is an important issue in order to reach competitiveness in a network. To get the most out of the network, companies need to be on the same technological level for information
sharing. This is however not always the case with small companies thus creating a problem (Venkataraman & Van de Ven, 1998).

5.4 Development Perspective
The last perspective is development perspective. In this perspective, focus is on issues that will be important in the future. It is necessary with a certain level of competence of employees to progress. A certain level of knowledge could help understanding the technical development, which could assist the organisation in becoming able of higher innovations, improvements, and learning (Brewer & Speh, 2000). Also network strategy is important for the development. The strategy should give an overview of important issues that need to develop in order to create efficient inter-organisational networks.

6 Conclusions
From different foresights a couple of areas affecting the manufacturing system are identified. The manufacturing system needs to develop in order to fit future prerequisites of reaching competitiveness. Development by means of inter-organisational company network could give competitiveness faster compared with a company trying to reach competitiveness on their own. A problem with development of a network is that the performance of the network could be hard to measure and thereby it is difficult to investigate the network competitiveness. An option for investigation is to use a model for performance measurement. In most cases these models for performance measurement need an adjustment to fit the network purpose. Most models and frameworks for performance measurement are developed for larger single companies. There is however some models and frameworks adjusted for networks. A further adjustment of these models to fit SME in networks could be described as follows:

- Network perspective
- End customers perspective
- Resources perspective
- Development perspective

Further investigation is required to consider if the model could be used for SME in networks. Empirical investigations are also required to test the feasibility of the model.

7 References


