

Manufacturing Mobility in Global Operations¹

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The globalization trend inevitably affects the organization of manufacturing by enterprises. It offers opportunities to examine manufacturing from a global perspective and consequently to produce where it is most appropriate. However, globalization has also led to an increase in competitive pressures, as companies have to look wider for opportunities to increase their competitive advantages. One source of competitive advantage arises from manufacturing mobility, which is the timely transfer of technology among manufacturing sites. This paper elaborates on the important determinants of manufacturing mobility, and provides a basis for additional research in this area.

(International manufacturing; manufacturing strategy; plant networks)

1. Introduction

It is already a decade since Mowery stated: “Markets, sources of components, and increasingly, sources of technology and R&D, are now truly global. This has contributed to increased transnational collaboration in product development, manufacture, and marketing in high and low technology industries” (Mowery 1990). This increasing globalization offers both advantages and disadvantages for manufacturing companies. The advantages of this globalization process are that companies have more, and better, access to markets. The disadvantages are that a company faces new and better

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competitors. As a consequence, manufacturing companies have to re-evaluate their strategic positions using a much wider perspective. This includes how and where to compete and, related to this, where should goods be produced and by whom. Although international aspects of operations management have received increasing attention (Prasad and Babbar 2000), there is a need for more work in this area (Chakravarty et al. 1997), especially since the process is complex and diverse, and during the last decade has intensified.

Research on international operations has identified international manufacturing networks as a primary area for research. Related to this are supply chain management and technology transfer. Studies on international manufacturing networks have focused primarily on configuration and coordination. Porter identified both as key dimensions in how a firm competes internationally (Porter 1986). The configuration of a firm's activities refers to the locations where the various activities in the value chain are performed. Configuration options range from concentrated, i.e. performing all activities in one location and serving the world from one place; to dispersed, i.e. performing an activity in many countries. Coordination refers to how similar or linked activities, performed in different countries, are coordinated with each other, ranging from none to many. Most of the studies on international manufacturing networks have focused on either configuration, e.g. (DuBois et al. 1993; Brush et al. 1999), or coordination, e.g. (Flaherty 1986; Fleury and Fleury 1999). However, some authors have integrated these concepts, e.g. (Meijboom and Vos 1997; Er and MacCarthy 2001).

Theories on international manufacturing networks are crucial to the design of effective supply chains. Extending globalization in manufacturing increases the availability of suppliers. As a result, increased international sourcing of components has taken place; see for example (Kotabe and Murray 1990; Bozarth et al. 1998). The roles of factories within a supply chain (Ferdows 1989; Ferdows 1997; Vereecke and Dierdonck 1997; Khurana and Talbot 1998), and the relationships between factories have been investigated. Shi and Gregory (Shi and Gregory 1998) highlighted the trend towards an increased number of global configurations with the specific purpose of increasing competitive capabilities. Global configurations in this sense are defined as worldwide manufacturing operations that are globally coordinated in terms of global product

development, geo-integrated value-adding chain, and managerial expertise sharing systems.

Technology transfer is another aspect of international manufacturing networks. Some of the literature on international technology transfer has focused on the transfer of production technologies. “Corporate decisions about what, where, and how much to produce are shaped by politically influenced economic factors, including the degree of market openness, market size and location, and who participates in the market” (Golich 1992, p. 900). Grant and Gregory (Grant 1997; Grant and Gregory 1997) provide a detailed insight into how technologies are transferred between manufacturing locations.

Stalk (Stalk 1988) identified time as becoming increasingly important as a competitive weapon of companies. Bozarth and Chapman (Bozarth and Chapman 1996) identified the importance of time-based competition for manufacturers. Stock and Tatikonda (Stock and Tatikonda 2000), in connecting timing with technology transfer, confirmed the importance of time-based competition and identified time as one of the key elements of technology transfer effectiveness. Upton (Upton 1995) focused on the importance of flexibility for manufacturing plants. He identified mobility, a plant’s ability to change nimbly from making one product to making another, as an important dimension of flexibility. Although the above observations about the importance of time were based either on an individual company or at the individual plant level, this concept can be extended to international manufacturing networks. Steele, Grant, Gregory and Buckley (Steele et al. 1995) and Shi and Gregory (Shi and Gregory 1998) identified manufacturing mobility, in this context, as a key capability for successful international manufacturing networks, defining it as the ability to swiftly and reliably move production between manufacturing sites.

The issue of reliably moving production between manufacturing sites has been addressed in several studies on international technology transfer, e.g. (Baranson 1971; Behrman and Wallender 1976; Teece 1976; Heston and Pack 1981; Rosenberg and Frischtak 1985; Robinson 1988; Agmon and Glinow 1991; Legg 1991; Grant 1997; North 1997; Saldivar-Sali 1997). The issue of timing, however, has received little attention. Although manufacturing mobility has been identified as being important for global competition, there is hardly anything known about what determines mobility and

how mobility can be measured. This study will address these issues and make specific recommendations for further investigations on this topic.

2. Timing in Manufacturing Mobility

The timing aspects of manufacturing mobility can be divided into two separate issues. Firstly, the time that it takes to transfer production activities across borders, i.e. the time that is required from the decision to transfer production to the first item being produced. The production of the first item provides proof that the destination company is able to produce the product, in other words, the production technology has been effectively transferred. The second issue is the length of time required for the destination company to reach an acceptable production rate.

Technology transfer timing

The time required to transfer production technologies depends on two factors: preparatory activities and first unit production.

Preparatory activities include the shipment of documentation and the ‘building up’ of the technology at the destination company (Steenhuis and de Bruijn 2001). The time required for shipping documentation depends on the amount of documentation that needs to be shipped, the means by which the documentation is to be shipped, e.g. truck, ship or aircraft, and the distance that the documentation has to be shipped. The time required to establish the technology at the destination site depends on technological characteristics and environmental conditions. The technological characteristics include technology size, technology complexity, and information accuracy (Steenhuis 2000). Environmental conditions include custom’s regulations that affect the time that it takes to import the parts and/or materials required for the production process.

The time required to produce the first unit can be determined by using the learning curve approach.

The general formula for a learning curve is: $Y = aX^b$;

where Y is number of production hours for the X^{th} unit, a is the number of hours for the first unit, and b the learning rate. In practice, engineers use the learning curve rate rather

than the learning rate (b). The relationship between the learning rate (b) and the learning curve rate is as follows:

$$b = \frac{\log \text{ learning curve rate}}{\log 2}$$

Although in practice it is common to speak of the learning curve rate as a percentage (e.g. “an 85% curve”), in the formula above it has a numerical value between zero and one (e.g. 0.85). In practice (a) is determined by using a prediction for the number of production hours required once production has stabilized. For example, in the aircraft industry stabilized production is typically assumed after 100 (Y_{100}) or 200 (Y_{200}) units are produced. In other words the value for (a), i.e. the time required for first unit production, is determined by assuming $X=100$ (or 200), estimating a value for Y_{100} (or Y_{200}), and applying a learning curve rate which is frequently based on previous experience. However, if a technology is being transferred to an industrially developing country then research shows that the learning curve rate will be different to that based on performance in industrialized countries (Steenhuis and de Bruijn 2002).

Production ramp-up time

The time that is required to ramp-up production is primarily dependent on how long it takes to produce a product and how many products can be produced simultaneously. Although environmental conditions do play a role, these can be largely anticipated. For example, if it is known that it takes several months to clear parts and/or materials through customs, then action can be taken so that the parts arrive in good time at customs, and are cleared before they are needed on the shop floor. The time required for production is not only determined by the learning curve but also by cultural characteristics. For example, employees in industrially developing countries typically have a lower productivity rate (Ven and Laarhoven 1997).

3. Issues to be addressed

The basic concepts of the time element of manufacturing mobility have been outlined. To improve understanding and to aid management in determining and possibly increasing their company’s manufacturing mobility requires research focused on two

issues. The first issue is the time required to transfer production activities in an international manufacturing network. There is a need for data that connect timing issues with both the factors that influence the timing, such as environmental factors, and also with appropriate learning curves for different international settings. In order for such data to be meaningful, they need to distinguish between different international settings.

The second issue is the time that it takes to ramp-up production in a different location in an international manufacturing network. Data on the learning curve in international settings, as well as on productivity comparisons, preferably with equivalent technologies, between countries need to be collected. A relevant distinction is between destination companies that are already familiar with the production processes and those who are not. For example, when production is outsourced to a new supplier based on a 'build to print' contract, i.e. the supplier has to produce according to the methods and processes stipulated by the buyer, the new supplier will have to learn these processes and this will obviously take time. If, several years later, the production of a product requiring similar processes is outsourced to the same supplier, it is reasonable to expect that this will take less time because the supplier will already be familiar with the technology.

4. Conclusion

Manufacturing mobility is of increasing importance in international manufacturing networks. Although the reliability of production technology transfer has already been widely addressed in research, the timing issue has received relatively little attention. By conceptually establishing the most important factors in determining the timing issues associated with international production technology transfer, a better insight into the critical issues can be obtained. Timing issues are seen as being related to the actual transfer as well as to ramping-up production. Further research is needed to identify and quantify the relationships between the time required and the factors that influence it.

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