Production plants within global production networks: Synergies and redundancies

Farhad Norouzilame (farhad.norouzilame@mdh.se)
Department of Product Realization, Mälardalen University, Sweden

Jessica Bruch
Department of Product Realization, Mälardalen University, Sweden

Monica Bellgran
Department of Product Realization, Mälardalen University, Sweden

Abstract

Management of production plants on global scale adds diverse challenges to those normally faced within national borders. A constant challenge is to achieve the most efficient network configuration via robust design of production systems. A case study is conducted where commonalities among production plants of a global manufacturing company have been studied in regard to the design of production system within global production networks. The results show three synergetic areas through the global production network. Standardization levels of production system constituents have been also discussed.

Keywords: Global production network, Global operation management, Synergy

Introduction

Globalization, as an inevitable phenomenon, has brought a new era into the world of manufacturing. Corporations in global markets have faced increasing pressures to internationalize their manufacturing (Colotla et al., 2003). Most middle sized and large companies are now creating an international market and have to build and/or manage an international network of operations, either through M&A activities or via their actual organic growth (De Meyer and Vereecke, 2000). Access to low-cost production, access to skills and knowledge and proximity to market are the major motives behind globalization of production along with many other reasons such as the control and amortization of technological assets, pre-emption of competitors, incentives from local governments, and reducing transportation costs (Ferdows, 1997; Yip, 2001).

International manufacturing networks are new manufacturing systems in terms of mission, structure, infrastructure, capability, and design process, which needs more detailed observation and theory building (Shi and Gregory, 1998). Due to the critical importance, the area of international operation management needs more empirical theories to help managers better design and operate global production networks (Prasad and Babbar, 2000). Some strategic choices in the global network such as (1) the ideal number of plants, (2) the geographical dispersion of the plants, (3) the strategic role of the plants, (4) the level of competence for each plants, and (5) products produced in each plant (Vereecke and Van Dierdonck, 2002). A lot of research has been conducted on the mentioned topics (e.g. Feldmann and Olhager, 2013; Gourevitch et al., 2000; Kodali and Routroy, 2006); nevertheless, the design of production systems within global production network has not been sufficiently addressed within the literature and there is a need for a multi-perspective framework for such purpose. The current study introduces synergies, redundancies and standardization level among different plants of a global production network as an important input to the design of production systems within global production networks.

The paper begins with some introduction followed by a synopsis of literature about the research area. Later, research methodology including explanations on the case and data collection methods has been presented. Finally results have been stated followed by discussions and suggestions on future research streams.

Frame of reference

Global production and plants role

The trend of internationalization of production has grown considerably faster than international trade since the mid-1980s (UNCTAD, 1996). Some have also witnessed a trend within the research from a factory focus toward a corporate international factory network (Shi and Gregory, 1998). Also discussions regarding relationships within networks have been shifted from a focus on the one-to-one headquarter-subsidiaries relationships toward the problem of managing a network of foreign subsidiaries (Vereecke and Van Dierdonck, 2002) which justifies the global managers' desire to use the maximum potential out of the "networked" structure. Some questions regarding the design of production systems within global production networks are:

- What should be common and what should be different among plants within a global production network?"
- What potentials lie within the existing commonalities in the network?
- How could the differences of plants create a unique profile (core competence) for the respective plant?

It seems that the network trend is progressively gaining in importance since its very early mentions dating back to mid 1960s where the challenges of American companies within international environment have been addressed (Skinner, 1965). The "networked" structure of manufacturing companies maintains to be important as mentioned in a recent report (McKinsey&Company, 2012, p.1): *"The new era of manufacturing will be marked by highly agile, networked enterprises that use information and analytics as skillfully as they employ talent and machinery to deliver products and services to diverse global markets".*

An initial step for realizing a global production network is to map its structure. Different models regarding the classification of plants within global production network have been developed. Using the network methodology to analyze the role of each factories of eight international companies and considering a number of characteristics of the plants such as age, autonomy, size, relationships with suppliers, level of investment and capabilities developed in the plant and performance in terms of quality, cost and speed, De Meyer and Vereecke (2000) have clustered factories into four types as shown in table 1.

Table 1 – Classification of production plants within global production network

Plant type	Specification
Isolated plants	Isolated position in the network, few innovations reach this plant, few innovations are transferred to from this plant, , little strategy autonomy, serving a limited geographical market
Blue print plants	Receiving lots of innovations but return hardly any, carry on innovations based on a blueprint they receive, low level of capabilities
Host plants	Essential role in the knowledge network, frequent exchange of innovations, receiving many visitors, not many visitors made to other plants, serving a broad market, central nodes in the network, real information exchanges
True innovators (Glue providers)	Innovation exchange, sending out people, receiving less visitors than hosts, younger than host, high autonomy, a lot of process investment

From strategic point of view and based on two dimensions of *location advantage* and *site competence*, six generic plant roles have been identified for the production plants within global production networks i.e. offshore, outpost, server, source, contributor, and lead plant (Ferdows, 1997). Despite some concerns regarding Ferdows's model (Meijboom and Vos, 2004), it has been widely recognized by several authors as a suitable basis for further research. (Feldmann and Olhager, 2013; Maritan et al., 2004; Meijboom and Vos, 2004; Vereecke and Van Dierdonck, 2002). However, the network focus is not sufficiently addressed while there has been much attention to role of individual plants within the network.

Synergies, Redundancies and Standardization level

Finding and using synergies to derive competitive edges from the networked type of organizations is of great importance for the managers of global manufacturing companies. The concept of employing commonality among plants has been mentioned already in mid 1980's pointing out the benefit from the synergy among the plants within a coordinated manufacturing network (Flaherty, 1986). Colotla *et al.* (2003) name three mechanisms for gaining advantage from co-ordination of multi-plant network: *Thriftiness*, *mobility*, and *learning*.

Standardization has been defined as reducing, simplifying and organizing matters which are apt to become diversified, complicated, and chaotic if left uncontrolled (JISC, 2005) providing advantages such as (1) predictable, robust processes, (2) enhance speed, flexibility and reproducibility while saving costs, (3) identify best way for core processes, and (4) streamline comparable real activities (Pfeiffer et al., 2010).

Prior to identification of synergetic points among production plants within a network and considering them as inputs to the process of production system design within global production networks, it is essential to provide a clear picture of some terms used in this study i.e. *production system*, *production system design*, and *global production network*. Production System is defined differently within the literature based on different perspectives. Despite being used interchangeably in literature, there is a difference between manufacturing and production. Some authors assume production as a subsystem within the greater category of manufacturing system (see Bellgran and Säfsten, 2010 for example) while others put manufacturing inside production system (e.g. Groover, 2007). In this study, it is preferred to use production system defined as the arrangement and operation of machines, tools, material, people and information to produce a value-added physical, informational or service product (Cochran et al., 2002). The main building blocks of production systems are generally put under four main categories i.e. human resources, technology, information, and organization which are in close interaction (Jacobsen et al., 2002). Considering holistic view for production system implies a need to extend the activities of production system design process beyond those of production equipment, plant layout and job design (Love, 1996).

The process of production system design supports manufacturing companies in their attempt to achieve faster time to market, smoother production ramp-up, enhanced customer acceptance of new products, and/or a stronger proprietary position. Design of production system is a multidisciplinary process which requires the integration of several specialized functions (Bruch, 2012). This makes it hard to coordinate the design process and work in a systematic way (Bellgran and Säfsten, 2010).

Global production networks are defined as networks consisting of wholly owned factories, i.e. belonging to the same company which makes a difference to supply chain management (Feldmann and Olhager, 2013). Designing production systems which are part of global production networks, adds additional dimensions both from internal (decisions within the production system) and external aspects (requirements placed by the global environment).

Methodology

This paper is a result of a case study with the aim of studying production systems within a global production network in order to identify commonalities among the plants. The case study approach was chosen since it allows an in-depth study of a contemporary phenomenon in its real-world context plus it is suitable for answering *how* and *why* questions (Yin, 2009). Unconstrained by the rigid limits of questionnaires and models, it can lead to new and creative insights, development of new theory, and have high validity with practitioners, the ultimate user of research (Voss et al., 2002). The unit of the analysis was global production network including the constituent production systems which were the lowest level (unit) of analysis.

The case company was a global manufacturing company headquartered in Sweden with total number employees of approximately 1250 with eleven production sites in six different countries and presence in all BRIC countries. The core business of the company was production of mechanical and electromechanical solutions for commercial vehicles, construction and mining industries, and general industry.

Data was gathered through document studies, passive and participant observations, and interviews. The documents include the organizational structure of the company, the configuration of the global network, and details of each plant such as products, layout, processes and etc. The observations include participating in some project meetings and workshops plus frequent presence of the main author at the company over a span of one year plus visit to six subsidiary plants which provided deeper understanding than what would have been achieved with just one or a few visits.

Hence, the study was affected by action research defined as working toward practical outcomes, and also creating new forms of understanding. Action without reflection and understanding is blind, just as theory without action is meaningless. (Reason and Bradbury, 2001). The stakeholders were involved both in the questioning and sense-making that informed research in contrast to traditional research where members of the system are object of the study (Coughlan and Coghlan, 2002). Yet, particular care was taken to avoid academic independence.

In total, ten semi-structured interviews were conducted (table 2) during the period between autumn 2013 to spring 2014. After interviews were recorded and transcribed, and then analyzed based the guidelines by Saunders et al. (2011).

Table 2 – Semi-structured interviews

Respondent position	No. Of interviews	Total Duration (hours)
Chief Executive Officer	3	4.5
Chief Operating Officer	2	3
Production Manager	2	2.5
Key account manager	1	1.5
Supplier Manager	1	1.5
Executive Supplier Quality Manager	1	2

After interviews were transcribed, ‘data cleaning’ process was performed to make sure that the transcription is accurate by correcting any transcription error. Then the interview data were documented and summarized. Finally, a reflective diary including self-memos was created to keep track of the data. Due to high amount of data regarding the products and processes, the telecommunication sector and respective products have been excluded. Instead, the focus was on the automotive and general industry sector.

Empirical Findings

The case company is a contract manufacturer which implies that they must be able to produce the customers’ products in a more effective way than they could do themselves. As a consequence, they must come up with production solutions that could produce the customers’ products with acceptable quality and reasonable price which actually amplifies the importance of production system for the company.

The company had continuous growth since its establishment about 30 years ago except the year in 2009 because of the global economic crisis. During the recent years the company experienced a rapid expansion phase which intensified the importance of global production facing multiple production system design projects. Some production plants (e.g. the subsidiary plant in Brazil) were developed from the scratch as a part of the organic growth following a global customer. Others plants however (for instance the plant in Germany) were added to the network via M&A activities due to the maturity of the production in the country with motivation of entering new markets. Each plant within the global network produces a set of products. Certain plants have developed in specific areas and have become global core competence center for that specific area.

Considering the company’s long-term vision which is to become the most preferred supplier by customers, the design of production system in global scale gains a special significance which in turn motivates the use of commonalities within the network. That being said, during the process of production systems, the commonalities are not considered sufficiently. Decisions regarding production system are rather formed gradually and are mostly affected by two key factors specified in the contract i.e. required capacity and the offered price.

Synergies and redundancies

Analyzing the global production network of the case company and relations among plants three main categories have been identified as major drivers to achieve synergies:

- *Product group* produced at different production plants
- *Production process* used at different production plants
- *Complementary competences* at each site which complement production processes

Each category can be further divided into subcategories in order to identify current synergies among the production plants. A few examples of each category have been provided along with four production plants referred to as Plan S, B, L, and G for confidentiality reasons.

Table 3 – Examples of the identified categories

Product group	**Sub-products**	**Plant**
Shaft	Drive shaft	Plant S, B
	Input shaft	Plant S
	Transmission shaft	Plant L
Bearing	Outer rings with grooves	Plant L
	Outer rings with grooves and holes	Plant L
	Inner conical rings	Plant L
gear	Planetary	Plant S, G
	Helical	Plant G
	Worm gear	Plant G
Production process	**Sub-processes**	**Plant**
Turning	Facing	Plant S, L
	Grooving	Plant S, L
	Threading	Plant S
Milling	End milling	Plant S, L
	Spline milling	Plant S, L
	Key slot milling	Plant S
Hardening	Case hardening	Plant S, L
	Induction hardening	Plant S. L
Complementary Competence	**Function**	**Plant**
Measurement	Quality control	Plant S, L, B , G
Calibration	Tool calibration	Plant S, G
Project management	PM based on project model	Plant S, L, B, G

Synergy in this context refers to the cooperation among different plants on one or more specific areas which produce an overall better result than if each plant were working separately. The better results can be simply better understanding of a challenge, or ideally providing more innovative and advantageous solutions compared to the ones achieved individually.

Redundancy is defined here as the duplication (or multiplication) of processes throughout the global production network which allows the operation to continue either in case of failure in a plant or customers' increased demand by using the redundant capacity of the network. This provides a certain degree of flexibility mentioned as flexibility on network level of manufacturing systems (Norouzilame et al., 2013) by using the global redundancy and balancing the production capacity over certain plants of the network. This enables the company to send specific parts from Sweden to Brazil and the other way around if required.

Level of standardization

Another perspective is to look at different standardization level of production system constituents of the production plants within the global production network. Results on standardization of different components of production system refer to diverse standardization levels (Table 4). Three levels of standardization have been considered which are defined as: (1) not standardized: no similarity or commonality regarding the respective aspect among the different plants; completely different structure, methods, and standards (2) fairly standardized: partial similarities between two plants concerning a certain aspect which triggers cooperation to a certain degree, (3) fully standardized: having entirely the same structure all through the network.

Table 4 – Standardization of production system constituents within global production network

Standardization level	Production processes	Production equipment	Equipment suppliers	Material suppliers	Material standard- specification	Inbound logistics	Outbound logistics	Organization structure	ERP system	Project model	XPS	Quality systems (ISO/TS)	Environmental systems	Building and premises	Control System (Balanced Scorecard)	Human resource (competence)
Fully standardized	⊙	○	○	○	●	○	○	⊙	●	●	●	●	○	○	●	○
Fairly standardized	●	●	○	●	○	●	●	●	○	○	○	○	●	●	○	●
Not standardized	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○

In general, the results of the study illustrate that all plants within the global production network ought to gain some general capabilities to a certain level (see Figure 1). Besides, they should develop core competence i.e. unique capabilities tailored to their strategic role. One reason for such decision is the high cost of developing specific processes. Simply put, it is not affordable produce "everything everywhere". For instance it is not cost-effective to develop several heat treatment centers within the global production network due to the high cost of equipment and resources needed.

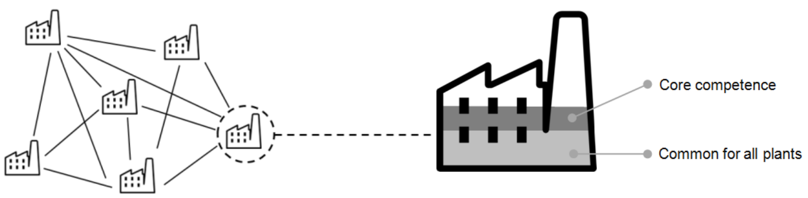

Figure 1 – Commonalities and core competence of plants within global production network

Analysis

To identify the potential synergetic points among plants within a global production network, they should be initially listed under different categories. Then common areas must be thoroughly analyzed to find the best way to proceed. Ideally, best-practice related to each synergetic area should be identified and then get spread to the other plants. This could be achieved via building cross-factory groups i.e. teams consisting of experts or engineers working together on a specific synergetic area.

Following three categories provided earlier and classifying the examples taken from the collected data, potential synergetic areas could be observed as shown in figure 2. For instance, from the product perspective, both plants S and B produce drive shaft as a sub-product within Shaft product group which can trigger further cooperation regarding that specific component. Same applies to the production process where both plants S and L posses heat treatment as a common production process which could be used as a potential synergetic point. Regarding the complementary competences, calibration process is used for example for calibrating machine tools could be mentioned which is common for both plants S and G. Those commonalities have been shown in figure 2. Each arc in the circles shows which plant owns what product, production process or complementary process ordered from outer circle toward center representing plant S, L, B, and G respectively.

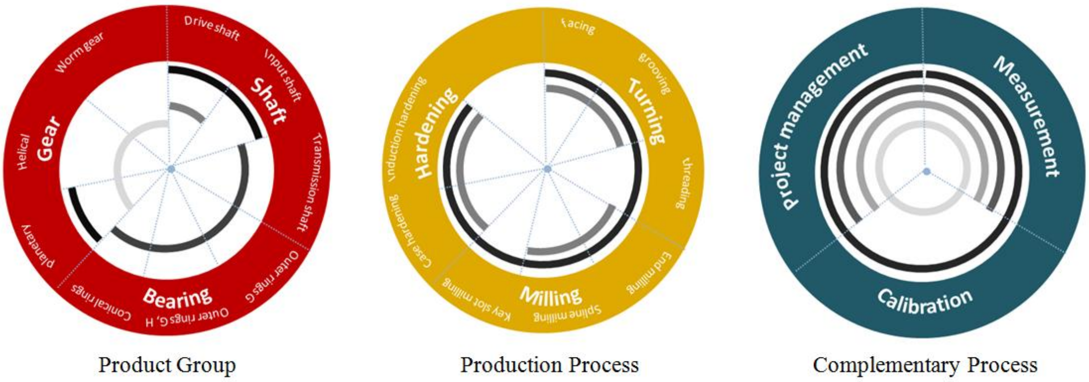

Figure 2 – Synergy drivers within plants of global production networks

Concerning the standardization level of production system constituents, more divergence in opinion was observed on few aspects of production system whereas for most of other aspects, there was consensus over the level of standardization. The more debated aspects were production processes, material suppliers, and organizational structure. Some differences arise from different roles and backgrounds of the people involved, Interestingly, the more the role of the respondents get closer to the top management, the more standardized they believe those aspects must be. Conversely, people working directly with the respective aspects were more reluctant to consider fully standardization.

Some debate aroused from the reality versus ambition (shown as ●/⦿ respectively in table 4). In other words, despite the tendency to fully standardize certain components of production system, the constraints in real-life hinder achieving that. For example, regulations and legislation set by different governments could greatly influence the standardization level of production equipment, equipment suppliers, and environmental system.

Regarding the organizational structure, lack of competent resources in some factories or adaptation to local culture might cause the organization to deviate from its standard structure. This also concerns the human resource factor which is very difficult to standardized due to intrinsic contrasts among people resulted from different background, education, culture, etc. The company's strategy regarding equipment purchase could affect the standardization of production equipment. The company in this case strategically purchases used machineries which makes it difficult to have standardized production equipment. Regarding the suppliers, the company has an ambition of having limited numbers of suppliers and establish deeper relations with them while still having eyes on other potential suppliers around.

XPS refers to the company-specific production system tailored to its structure and which is different from the definition of production system provided earlier in this study. This factor is extremely important to be standardized through all plants which will in turn result in a standardized control system (balanced scorecard).

Conclusion

Synergetic and redundancies are positive attributes for global production networks which are resulted from utilizing the existing commonalities among network plants. By deploying synergies, global manufacturing companies could be able to create economy of scale (thriftiness) and learning abilities, while having redundancy in the network provides manufacturing mobility advantage. It is concluded that global manufacturing companies can benefit from improved decision making support and understanding the implications of synergy and redundancy on their production system design within their global production network. This study complements earlier theories by presenting real-life examples within industrial context which could provide insight to understanding the significance of considering synergy and redundancy in early phases of production system design within global production networks.

Furthermore, standardization level for different components of production plants within global production networks has been can be used as guidelines for practitioners within similar context. Some suggestions for further research are:

- To involve more cases within the same or at least similar context to compare and generalize the results. The categories provided here are a set of critical components of a production system for the case company studied which might need to be adapted or developed further depending on the context
- Examine the theories on a wider range and test them further in heterogeneous context by using the current case as a pilot case and starting point of multiple-case study (cross-case analysis)
- Embed the synergies and redundancies as guidelines in wider context of design of production system within global production networks
- To consider other perspectives along with synergy and redundancy as factors affecting the process of production system design within global production network to provide a comprehensive framework

As for limitation of this study, it must be mentioned that the result of this study has been drawn from a case study in a multinational manufacturer of discrete components within the mentioned sectors (in contrast to process industries) which experiences a rapid expansion. Consequently, results and theories are based on the empirical case study data collected via the multi-plant network of the case. Hence, categories provided as synergetic areas and level of standardization might be affected by the context and needs of the case company. Generalizing results demand studying more cases on different context.

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