STRATEGIC CAPACITY MANAGEMENT: BALANCING TECHNOLOGICAL DEMANDS AND PERFORMANCE CRITERIA

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ABSTRACT

Although manufacturing determines mostly the current performance of companies, few companies deal with the issues related to strategic capacity management. Besides decisions on outsourcing, this involves triggering process development and improving performance by adapting organisational structures. Action Research in companies reveals the importance of capacity management at a strategic level.

The methods as proposed in this paper provide industrial companies with a tool for implementing their manufacturing strategy. Through matching product configurations with product-market strategies and product development, the methods point areas of improvement. These improvements lead to decisions on investments for resources, resource utilisation and development of processes, including initiation of manufacturing technologies.

Keywords: Manufacturing strategy, Outsourcing, Process innovation, Organisational structures, Manufacturing technology.

INTRODUCTION

The market and competition drives industrial companies to improve the way they run their overall operations. This concerns the total primary process of these companies, innovation and product development as well as the manufacturing operation. For the manufacturing operation it involves issues as:
• How shall we manage capacity from a strategic point of view?
• When should we develop new processes?
• Which processes should we develop?
• Which quantities of which processes do we need for the manufacturing operation?
• Do we acquire these processes, develop our own processes or decide for outsourcing?
• How do we manage the value chain and how do we link resources for achieving optimal performance?

When companies fail to initiate timely development of new processes, the non-availability of these processes might result in higher overall costs and increased lead-times. Action Research in two companies in particular revealed that the actual manufacturing costs might exceed up to 30% of original estimates and the overrun on lead-time might amount to 50%. This applies especially to companies who do develop and manufacture their products on customer demands.

To implement effective strategic capacity management, a method has been developed to support decision-making on a strategic basis, consisting of process mapping, an evaluation framework and a master plan for technology acquisition and resource management. It derives capacity links from the product structure to manage manufacturing
resources. This way long-term production planning is enabled as well as support during the development and engineering processes. The method combines both technological demands as well as performance criteria for strategic management.

During case studies, elements of this method have been implemented, particularly strategic capacity management and management of outsourcing. These case studies result from initiatives by industrial companies on graduate thesis assignments, thus connecting theory and practice. They show that the implementation of a proper manufacturing strategy depends on three major issues:

- Concentration on competencies and the implementation of an outsourcing policy.
- Process development to enhance manufacturing technology.
- Organisational structures to meet demands on business performance.

Although these issues as such require adequate attention of management, both their interrelations and their connections to an adequate product-market-strategy present challenges in decision-making by manufacturing managers.

Manufacturing as part of primary process

The management of industrial companies faces these challenges when defining their strategy, few methods are available for managing capacity at a strategic level and the initiation of process development (e.g. manufacturing technologies or improvements). Manufacturing is part of the total primary process of companies as depicted in Figure 1. Manufacturing provides the market place with products by being a subsystem on its own as well as that it connects product development and engineering to the market. So whenever talking about manufacturing and developing strategies we should address the link with product development and engineering. Driven by a case study into sequential and simultaneous approaches to engineering RIEDEL & PAWAR (1998) highlight that the concepts of design and manufacturing are not linked in literature and that the interaction of product design and manufacturing strategy is under-researched. The case study resulting from our own Action Research demonstrates this notion.

Case Study Vision Systems

The company produces dedicated vision systems for specific applications for a wide variety of customers having their own requirements. The total lead-times for specific orders
(product development and manufacturing) amounted to five years. Manufacturing costs accounted for 65-70% of the sales per order.

The Manufacturing Department encountered more problems to produce within budget and schedule for specific orders. Investigations showed that most problems were caused by not taking manufacturing aspects into account during product development. Typically, an old design concept included one main sensor per system for receiving signals, a new concept introduced a hundred-fold of smaller sensors. The consequences for manufacturing were not considered. This resulted in a relatively high cost-price and above all manufacturing lead-times increased with a factor 3.

Also, the Manufacturing Department did not succeed in following a strategy. First of all, because of the lead-times of product development they could not set out an adequate strategy. During product development the Engineering Department determined mostly manufacturing aspects without considering the consequences, as shown above. Secondly, the Manufacturing Department did not translate objectives into programs for improvement and did not anticipate changes for the business. This was mainly due to having insights only at a total level of load on capacity, which did not trigger decisions on capacity investments, process technology improvement and structures to meet performance requirements. (SPOELSTRA, 1998)

MANUFACTURING STRATEGY

Since manufacturing is part of the total process, the strategy is too. Figure 2 represents this thought, showing the breakdown of the overall strategy in its components: marketing strategy, product development strategy and manufacturing strategy. Although each strategy will generate more details, these strategies should have a strong common link. The case shows that particularly the execution of strategies diverges during execution, thus reducing the total efficacy from strategy formulation and implementation.

Manufacturing management is confronted with increasing overall performance and reducing costs. The issues, with which management struggles, relate to the set-up of the primary process and control mechanisms, leading to increased competitiveness in today’s global market. Key issues for capacity management in industrial manufacturing companies focus on:

- On which activities should we focus and allocate our resources to?
- How to maintain competitive leads through outsourcing, adapting the concept of the value chain and using partnerships? In which aspect of business do we excel and which ones do we want to enhance?
- How to reduce cost-prices and still meeting customer needs in terms of variety and quality of products and performance?
- How do we match capacity with forecasts and product development?

PFEIFER E.A. (1994) refer to this matter when mentioning: In view of the variety and complexity of changing boundary conditions, the question presents itself as to what methods can be best employed to sustain the competitiveness of a company. Achieving and sustaining competitiveness means paying attention to all aspects and processes within the company, according to their view. This points to major issues within the manufacturing strategy: capabilities in relation to outsourcing and process innovation plus their
implications for capacity management. Furthermore, the overall strategy and the manufacturing strategy will set performance requirements.

Although we mentioned that the strategy should eventually define performance requirements, we need to examine the components of strategy. IN ’T VELD (1998) describes strategy as the choice between alternative ways and resources to achieve a set goal. In addition, BURGELMAN E.A. (1995) distinguish the product-market strategy and the resource-based strategy (see Figure 3). The product-market view of strategy concerns itself with how a firm competes with its products and services. The resource-based strategy describes how an organisation secures the factors needed to create the base of capabilities for establishing and sustaining competitive advantage. In other words, strategy has two components: the exploitation of the competitive advantage and the utilisation plus acquisition of resources to create that advantage.

Therefor, strategy is inherently a function of the quality and the quantity of a firm’s capabilities. Strategy without capabilities has no force and equally capabilities without strategy remain aimless. In this respect, how do competencies and capabilities support the creation and the sustaining of competitive advantage? Hence, strategy articulates the ways in which the opportunities that result from the capabilities will be exploited. Thereto we should connect manufacturing to the overall primary process, improve the overall performance of resources and structure the utilisation of resources. Explicit decision-making on outsourcing provides an opportunity to enhance the capabilities and adapt to the changing market demands imposed on industrial firms.

**Outsourcing and Core Competencies**

Under influence from developments in data- and telecommunication, in information technology and diminishing of trade barriers, globalisation effects views on operations management of manufacturing, esp. outsourcing. An individual company deploying a concept for global manufacturing faces the question which activities to outsource and which ones to operate. The possibilities of communication enable to control activities at great physical distance without the necessity of meeting or travelling around the world. Recent examples are the announcements of automotive companies for joining forces in purchasing part through Internet. Thus, outsourcing raises the question, which areas of production are needed to maintain the value-added chain and in which key areas a company excels. PRAHALAD & HAMEL (1990) have introduced the concept of core competencies, further referred to as competencies. They subtly expand the view of technology from a broadly described feature whose importance is determined by its support of the corporate mission, to a specific source of corporate uniqueness. Competencies represent in their view the collective learning of the organisation, especially how to co-ordinate diverse production skills and integrate multiple streams of technology. However, the application of this theory does not lead directly to a clearly defined manufacturing strategy for global manufacturing and outsourcing.

To strategic capacity management, outsourcing provides the opportunity for levelling capacity over a horizon of two years or more and also for acquiring manufacturing technologies to expand capabilities. Thus, outsourcing evolves from both technological demands and performance requirements. The recognition of competencies creates insight in
the load on resources and the remaining capacity of resources is available for optimising
performance of manufacturing through in- and outsourcing.

**Decision-making on outsourcing**

Decision-making on outsourcing takes place at strategic, tactical and operational
levels within a company. Distinguishing these three levels will help assign specific
frameworks and requirements for each of these three processes. BURT (1989) stresses also
the two procurement functions: support during engineering and management of the value
chain as part of the manufacturing process. Action Research in the presented case and three
other cases revealed that industrial companies do not always manage the outsourcing in an
effective and efficient way. This reflected on strategic decision making as well as on
operations management. Decisions with regard to outsourcing came about during the phase
of production planning or suppliers only fulfilled a buffer function with regard to over flow
in capacity. During the early stages of development, neither practical availability of
suppliers and alliances was taken into account nor any other standard than strictly technical
and commercial aspects. Therefore, Manufacturing could not manage the total
manufacturing process at a strategic and tactical level while operational management of
outsourcing concentrates on fire-fighting.

Through the Action Research at a Food Equipment Manufacturer (VORSTERMANS,
1997) and some literature surveys (e.g. VAN DER VELDE, 1999) a new model for the
processes and the decision-making on outsourcing has been developed and implemented.
This model includes decision-making on outsourcing during the first stages of product
development. Decisions differ in each stage of product development; during pre-design it
concerns mostly subsystems of equipment and during later stages it turns to detailed
production planning. It requires close co-operation between engineering and manufacturing,
including procurement, to implement this model.

![Diagram of decision-model for outsourcing](image)

The model (see Figure 4) ranges from early supplier involvement during the design
and engineering phases to operational decisions during manufacturing. As a side effect of
such decision-making, the company at the end of a value chain will concentrate on its own
competencies as well as the capabilities of the suppliers to the company. Hence, there will
be a strong need to identify but also to maintain these competencies. Exploitation of the
decision model in this case and later cases led to a considerable reduction of costs and
improvement of total operations. All companies presently investigated applied the principle of Engineering-to-Order with lead-times in excess of one year, which makes it particularly difficult to determine which improvements do contribute to overall performance. However, the companies involved reported that staff on outsourcing did not increase although the number of outsourcing orders raised to levels of 150% or more of the original volume. Furthermore, outsourcing was not viewed anymore as a bottleneck for logistic management.

**PROCESS DEVELOPMENT**

Although outsourcing provides opportunities for the challenges management of operations faces, integral process innovation needs attention for meeting current and future business demands. The emphasis on process innovation shifts during the product life-cycle as well as the increasing demand for varieties of a product. KERKHOF (1993) shows us that during a product life-cycle that process innovation follows product innovation (see Figure 5). Though, during later stages of the life-cycle the development of process improvements exceeds the efforts on product innovation (UTTERBACK, 1994). This stresses the importance of manufacturing technology as contributing factor to process innovation. BESSANT (1997) points out recent experiences, which suggest that, the oscillation between product innovation and process innovation acts as a source of increasing competitiveness.

**MEYER & UTTERBACK** (1993) show the need for companies to deploy the concept of product families for product innovation. This means that performance of manufacturing should shift during the product life cycle, of a product family, towards product flexibility. A modular design of products combines product flexibility while maintaining overall performance in product development and manufacturing (BIKKER & DEKKERS, 1994).

**Initiation of Process Development**

The need for process development arises during product development and from meeting performance criteria. Product development, whether initiated during execution of specific orders from clients or independent product development, experiences a strong emphasis on product design and engineering. However, during operations including manufacturing the company will meet the business demands. Combined efforts and close co-operation by Development and Manufacturing will ensure meeting business demands imposed by the environment on the long-term.

**Product Development and Engineering**

Concurrent Engineering and other concepts, like Project Management, Quality Function Deployment, Integrated Product Development, have become accepted approaches for multidisciplinary product development and integrating aspects. They emphasise the communication between research, development, engineering and manufacturing (DEKKERS, 1997). Action Research in a number of cases revealed that a strong project orientation for product development leads to decision making based on sub-optimisation. The
A manufacturing organisation has mostly a strong functional structure meeting requirements on flexibility. This restrains effective feedback on manufacturing aspects during design and development. However, decision making during these phases should allow development engineers to take manufacturing aspects into account.

In order to balance between product development and manufacturing, the process development should provide information to both areas as to how implicit choices for the manufacturing area influence technological demands and performance criteria for the total operation (e.g., WUPPING, 1998). Process development should therefore translate processes in terms of products and vice versa. Since, Stage/Gate methodologies prove of importance for managing product development, at each gate assessment of manufacturing aspects should allow for linking to manufacturing strategy to product development (see Figure 1 and Figure 4). The decision-making should allow direct comparison on product level to include directly manufacturing aspects, at which product development aims. These manufacturing aspects should include: outsourcing, technological criteria, performance requirements and should initiate process development if necessary. Process development refers in this respect to improving the existing manufacturing methods, the sourcing of new processes and the assessment and acquisition of new manufacturing technologies.

The method consists out of two steps. First, product descriptions are translated into processes with technological criteria and performance criteria (see Figure 6). Secondly, if either of the two sets of criteria don't fit then alternative process are developed. These developments might lead to new processes and manufacturing technology. Mapping the processes leads also to decisions on outsourcing following the manufacturing strategy (competencies and performance requirements). These two steps are performed during each stage of product development and at each review, part of the gate, and vary only in level of detail during the process of product development. During the first stage, decision-making concentrates on product family level (if applicable), product level and assembly level. At later stages, for example manufacturing engineering, the attention shifts to the level of components and parts (see BIKKERS & DEKKERS (1994), WUPPING, (1998)).

During the case studies, relating the manufacturing strategy with the overall strategy of industrial companies, esp. the new product strategy, had the attention of both product development managers as well as manufacturing managers. The method supported the understanding between these fields within companies. It contributed to aligning manufacturing with business, at strategic levels, tactical levels and operational levels, thus aiming for an active role of manufacturing during product development.

**Meeting Performance Criteria**

Process development might also be initiated at strategic and tactical levels when execution of processes might not lead to meeting performance requirements. The identification of areas for improvement follows the same pattern as the method applied during product development and engineering, evaluation of processes against technological demands and performance criteria. Management should set out initiatives for process development from a strategic point of view.

Figure 6: Process mapping
Decisions, in view of meeting performance criteria, lead to independent process development. The decisions have a link with the products the company manufactures, they lack the connection to direct orders by customers. Both technological manufacturing development as process improvement might result from these initiatives (see also DAVENPORT, 1993).

**Technological developments**

Another source for process development is the technological development as such. By analysing the current performance against objectives set by the manufacturing strategy, management sets goals for further improvement by applying appropriate manufacturing technologies. This will enable to review potential benefits of manufacturing technologies.

The next step of this assessment would be the analysis of the available technologies to meet the suggested improvements. This matches the strategic technology analysis, literature surveys proved that few methods assist management of manufacturing technology and that most emphasis is found on product technology. According to VAN WYK (1997), tools of strategic technology analysis consist of six frameworks:

- a format for describing the essential features of a given technology;
- a system for classification of technologies;
- a model for tracking technological trends;
- a matrix for reviewing technological interactions;
- a chart of potential technological break-through zones;
- a profile of social preferences with respect to technology.

The latest framework does not directly comply with the goals of a method for scanning and assessing manufacturing technology.

The four-step scanning process as suggested by VAN WYK (1997) does not directly apply to the scan for manufacturing technology. The scanning process relates more to the explorative search for products and materials technology rather than manufacturing technology. The four steps are:

- preparation: defining the landscape that has to be scanned and setting up an agenda;
- observation: exploring the technological frontier;
- interpretation: identifying landmark technologies that serve as indicators of the main thrust of technological advance;
- evaluation: using the list of landmark technologies to identify technological potential and re-examining the company’s own technological base.

The pre-design of the method for technology scanning and implementation is depicted in Figure 7. It contains the basic elements as described above. As the figure shows, the selection of appropriate technologies takes place after defining the current performance and the identification of the competencies. The evaluation of selected technologies consists of determining the consequences of the technology for the lay-out of the processes, the changes in the performance of the manufacturing operation and impact on the organisation. Furthermore, this evaluation should reveal constraints for the application of the choices. This step will mean an integration of methods and tools, already present in today’s literature on this subject.
Hamilton points out that the portfolio of manufacturing technology should meet business demands when presenting a classification of these:

- **Base technologies**, essential to business, but they do not lead to any identifiable competitive advantage. In fact, these base technologies yield a wide availability through manufacturing equipment and suppliers.
- **Key technologies**, which provide an identifiable advantage over one or more competitors. They might link to the competencies of the firm, ensuring current competitive advantage.
- **Pacing technologies**, incipient technologies with the potential to become key technologies.

According to Hamilton (1997) firms expecting to build or sustain competitive advantage from technology should include pacing technologies in their technology portfolio. Therefore, the agenda of operations management should contain the selection of pacing manufacturing technologies to contribute to the overall health of a company. Bessant (1997) stresses connecting technological capabilities to a strategic framework.

**Successful Process Innovation**

Research directed at the situation of the U.S.A. shows that the appropriate manufacturing technology of a business depends critically on the circumstances of that business with regard to its strategic goals, its resources, the resource availability within its regional and national economy, and the characteristics of its product-market environment (Grant et al., 1991). The critical requirement for sustainable competitive advantage is that manufacturing seeks for continuous optimisation. Because of the resource profile of the U.S.A. economy, U.S.A. firms are likely to find the most attractive opportunities for improving manufacturing performance in business systems and organisational aspects of manufacturing technology rather than in the adoption of advanced capital equipment.

**Partnering Process Innovation and Outsourcing**

Jonash (1997) refers to the research report entitled *Leveraging Technology in the Global Company* published in 1993 when noting that most companies believe that close to 50% or more of their technological competitiveness will be derived from external technology sourcing and partnering during the 90's. He emphasizes the need for connecting technology to the corporate strategy and the need for integration of technology management in terms of collaboration with partners. The overall corporate strategy should address then the technology needs of corporations for the next 5-10 years and define the technologies that the company will develop and husband internally and those it will satisfy through external collaborations.
LINKING RESOURCES

Aside from resource acquisition, resource management also invokes structuring process among resources to create and manufacture products meeting business demands. Industrial companies achieve so by managing the total value chain and creating proper organisational structures.

Managing the value chain

Within a value chain companies face the choice of either specialisation of differentiation. Both choices provide opportunities for cost-reduction, improving lead-time and meeting customer demands. All activities needed for a product-market combination should add up to achieving acceptable performance levels spanning the entire value added chain. NISHIGUCHI (1994) classifies three networks for the value-added chain, mostly aimed at control of the manufacturing processes. Vertical integration points to the position in which a company owns mostly its own network of suppliers. In the case of strategic dualism, the firm retains key areas of production but outsources components. Through clustered control, an assembler deals with a first tier of suppliers who, in turn, manage the second tier. BAXTER E.A. (1996) remark that companies shift away from the vertical integration to strategic dualism and clustered control.

The shift to managing the value chain, sometimes indicated as the virtual organisation, means the implementation of proper logistic control. Concepts for the control are still under development (see WÜTHRICH & PHILIPP, 1998). WIENDAHL E.A. (1997) conclude that especially logistic control and management in value chains, they refer to these as Variable Production Networks, require further investigation.

Organisational Structures

Organisational structures within a company should meet the challenges of managing the value chain and they should also align the internal structure with business demands. Through developing proper structures, companies might reduce costs with 10% or more. WÜPPING, (1998). Although structuring a company as such does not contribute to sustained overall competitiveness on the long-term (WIGMAN, 2000), it is necessary to create a continuous flow of resources. WIGMAN claims that product innovation strategies do serve as base for creating continuous growth. Additionally though, structuring creates short-term competitive advantages, necessary for creating space for future growth. That is when management pays sufficient attention to product development as keystone for future growth. Thereto, interventions in the organisational structure do not behold unless they connect to the product-market strategy.

Hence, strategic capacity management has a strong link to the product-market strategy. However, manufacturing needs to develop its own organisational structures for meeting today's and tomorrow's business demands. Restructuring meeting benchmarks on yesterday's performance constitute a fragile base for (business) growth (FRIEDRICH AND HINTERHUBER, 1998). Companies tend to seek improvement within their existing system without questioning the system as such, a prerequisite for implementing business change.

BESSERT (1997) demonstrates this notion when introducing three cases of
organisational redesign by evolving manufacturing capability, through stage-wise change. Linking utilisation of resources to external opportunities and shifting demands is necessary for creating overall value. The integration between technology and the organisation, including appropriate information structures, is a keystone for developing strategic health.

CONCLUSIONS

Strategic capacity management thrives on the integration of technology and organisation to meet business demands. Manufacturing technology along with creating competencies as a base for managing the value chain, implementation of an effective outsourcing policy, and organisational structuring. The integration should result in transparent decisions on capacity bottle-necks and process development, mainly appropriate manufacturing technology, and the integration should define suitable business organisational structures for adapting to shifting market demands.

To achieve the integration, manufacturing management should participate actively in product development (DEKKERS, 1999). The method as described, provides both management and engineers during development a tool for reviewing manufacturing aspects: manufacturing strategy, meeting technological as well as performance requirements, core competencies and outsourcing. This leads to including manufacturing strategy in decision-making during stages and reviews of product development.

Following the framework, sketched in this paper, manufacturing management should take the lead and not await external developments. A continuous evaluation of technological developments against performance requirements and product-market developments serves a source for continuous improvement. These interrelations depend on product structures and process mapping to allow evaluation. Through a well-defined process of strategy development and implementation, manufacturing might anticipate better on market developments and product development. That enables manufacturing to create sufficient sources for their own resources as well as initiate process development. A prerequisite is a strong link to the product development strategy and the market development strategy.

REFERENCES


