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Abstract

Purpose – Demand-supply balancing (DSB) strategies and approaches are becoming increasingly important for manufacturing and operations. The purpose of this paper is to analyze practices of manufacturing companies and how they balance demand/supply in operations.

Design/methodology/approach – Questionnaire-based interview has been conducted at 20 largest companies having manufacturing/operations in Finland.

Findings – Supply chain structure, flexibility, demand management, capacity management, inventory management and revenue management are perceived as key practices for DSB.

Research limitations/implications – The results show importance of supply chain-related parameters such as supply chain flexibility and inventory management in addition to production planning and control. The study is delimited to Finland companies but it gives an idea how decision making in operations generally can be perceived.

Practical implications – DSB actions should be connected to operations strategy and long-term planning of the company.

Originality/value – DSB is a strategic-level operations question which has an impact on several functions of supply chain.

Keywords Manufacturing, Capacity management, Demand-supply balancing

Paper type Research paper

1. Introduction

Demand-supply balancing (DSB) is an important topic for any company specializing in operations. Drastic changes in demand in terms of volume, product mix or product life cycle are challenging decision makers in all levels. Globalization of manufacturing is an important driver – companies are able to make manufacturing footprint decisions on a global scale. This paper analyses the how the concept of DSB has been perceived by international manufacturing companies having headquarters in Finland. The interviews outline a picture of methods used and how the problem has been tackled by decision makers.

The theoretical framework used in this paper is based on perspectives of strategic sales and operations planning (S&OP), capacity management, operations footprint management, demand shaping including yield and revenue management, operational flexibility and capital budgeting. In everyday operations management, these issues are often interrelated The covered topics have been divided based on whether they impact either the internal (supply-side) workings of a company or if they can alternatively be used to effect the (demand-side) market environment.

2. Literature review

2.1 Demand management

The analyzing and managing the market side of the supply chain is starting point for operations strategy. Olhager *et al.* (2001) suggest an approach of taking actions to modify demand and use up most of the excess supply, and according to an Accenture (2009)

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study of supply chain mastery the companies which clearly outperformed their competition were significantly more adept at managing demand through anticipating customer needs.

2.1.1 Demand shaping. Before demand can be shaped, it is necessary to understand what its current shape is to begin with. An example of these economic demand curves is presented by the authors Docters *et al.* (2008) who suggest "strategic responses to actual and potential competition" that can raise a company from merely reacting tactically (promotion campaigns, price cuts) to proactively gaining more market share and outdoing competition. These methods of demand shaping are roughly divided into two categories, product development and competitive analysis. Product development in this case refers to actions such as new product introductions, adjusting modular variations in functionality, or re-aiming the price-point for products to cover more customers. Competitive analysis on the other hand is the identification and addressing of the market, its tiers and volumes, alternative products and other competitors working in the field. The company can immediately gain edge on the competition by analyzing the environment well enough to segment the markets. By adjusting their offering the existing customer base is not disturbed but previously untapped potential can be served instead of just providing "one size fits all" solutions (Docters *et al.*, 2008).

2.1.2 Revenue optimization. Phillips (2003) defines pricing and revenue optimization (PRO) as "the formulation and solution of tactical pricing decisions using constrained optimization" to "maximize operating contribution by opening and closing fare classes." Defregger and Kuhn (2007) discuss this same influencing of external demand by changing prices or quoted due dates as dynamic pricing. Regardless of the method or technique of revenue management used, variable (dynamic) prices always lead to segmentation of the customer base, and in most cases also their sensitivity to time and price (Phillips, 2003).

Using PRO will assist in decision making related to "prices or allocations of different products or services to different customers through different channels," and PRO can also give more visibility into the impact of constrained capacity, opportunity costs, customer response, demand uncertainty and market segmentation (Phillips, 2003). PRO's foundations are the economics of customer price response and customer segmentation which are supplemented by tactical pricing decisions: revenue management, markdown management, customized pricing, promotions pricing, as well as peak-load pricing, dynamic list pricing and auctions. Revenue management is about managing constrained, perishable inventory using availability controls where customer willingness-to-pay increases when approaching deadline. Markdown management is clearing excess perishable inventory by lowering prices when the customers' willingness-to-pay tends to decrease over time. Customized pricing offers unique prices to each buyer, and its target is to maximize the expected net contribution as a function of price essentially by price discrimination. Promotions pricing is giving rebates on the actual prices or related services such as annual percentage rates, and then managing that portfolio of promotions to maximize expected profitability. Peak-load pricing varies the price of constrained and perishable capacity to reflect imbalances between supply and demand, but it does not effectively require advance bookings or market segmentation. Dynamic list pricing is varying list prices over time in response to changing market and supply conditions and managing the velocity by which the pricing is adjusted. And auctions are sales situations where more than one buyer sequentially bids for an item.

Spengler *et al.* (2007) present a revenue management based order acceptance method to maximize the order-specific differences between revenue and variable costs (VC) (contribution margin) in manufacturing. Their study found linear programming techniques un-applicable to this problem due to their complexity but by using a more straight-forward algorithm that weights order attributes, a 5.3 percent increase in the contribution margin of short-term order selection was achieved. Defregger and Kuhn (2007) also review the same setting of make-to-order (MTO) manufacturing, order acceptance/rejection and order-specific profit margins.

A central but broad question that determines success in revenue optimization is that of pricing fairness, because even logical pricing tactics can evoke negative responses from customers if they feel that they are being taken advantage of or if the raised margins are caused by a weakening of the customer's position (Phillips, 2003). Adding to this, Chase *et al.* (2007, p. 576) argues that the fairness of the system can be implied by rate fences which are either physical (e.g. bigger accommodation) or non-physical (free helpdesk service). A valid example of a generally acceptable rate fence could be a price premium for orders with shorter lead times (Defregger and Kuhn, 2007).

2.1.3 Yield management (YM). YM is "to sell the right inventory, to the right customer, at the right time, and at the right price" (Modarres and Nazemi, 2005) through managing customer demand by promotional activities, price cutting and introduction of complementary products to face cyclical demand fluctuations (Chase *et al.*, 2007). YM also touches on the allocation of scarce resources to competing classes of demand, otherwise known as perishable asset revenue management. (Modarres and Nazemi, 2005) Also, due to the ambiguity and cross-usage of the term, it is necessary to specify the definition of the yield in the context of this study. In this paper yield refers to the financial profit gained instead of the material output of perfect quality items gained from a process. In manufacturing industries these two are very often connected to each other, but as witnessed during the writing of this literature review they are not synonymous.

Actual production planning strategies for YM are (Chase *et al.*, 2007) the chase strategy of hiring and laying off staff according to the momentary labor requirements, the stable workforce and variable work hours strategy where the headcount is stable but people are over- or under-employed from time to time, and the level strategy where demand fluctuations are matched by a fluctuating inventory buffer. This managing of demand can also be done by changing prices as a function of forecast demand, which works best when demand can be segmented by customer, fixed costs are high and VC are low, inventory is perishable, the products can be sold in advance and demand is highly variable. (Chase *et al.*, 2007) In practice this means price reductions to stimulate off-peak demand and offering deals for nonpeak orders and establishing formalized decision rules needed to enforce these price classes.

Modarres and Nazemi (2005) also introduce a model for applying YM practices into manufacturing industries in the form of a mathematical capacity-price-tradeoff problem. As their model is independent from stochastic demand (Modarres and Nazemi, 2005, p. 2), issues related to forecasting are not relevant here. Their problem can be divided into three main subjects: Sales patterns and market channels impact, demand patterns by market segment and the effects of price changes on customer decisions (Modarres and Nazemi, 2005).

2.1.4 Collaborative planning, forecasting and replenishment (CPFR). CPFR, as introduced by Crum and Palmatier (2004), is an extension of the demand-management process that goes beyond simple forecasting. The following arguments for the

necessity of sharing and communicating demand information throughout the entire supply chain:

- low commitment and lack of trust between supply chain partners;
- traditionally slow pace of DSB actions;
- insufficient usage of demand information from customers; and
- low integration between demand management and supply management.

In the course of this collaboration, useful information content that can possibly be gained from customers usually includes sales history, aggregate long-term demand (and the assumptions it's based on) forecasts, plans for promotions or pricing changes as well as the current and targeted inventory levels by location. When these are put together into a composite picture of demand, and evaluated in the proper business context, correlations between consumer point-of-sale data and the supplier's sales history can reveal irregularities that are caused by shop floor-level rushing to reach periodical targets. Describing this issue the authors claim that "loading and price-discounting practices are the antithesis of effective demand management" which "consume capital needlessly" and require premature investments (Crum and Palmatier, 2004, p. 205).

2.2 Supply management

2.2.1 Capacity management. A general definition by van Mieghem (2003, p. 269) is that "Capacity is a measure of processing abilities and limitations" and due to the effects of factors such as resource scarcity and uncertainty it "can be interpreted as some upper bounds on processing quantities." Adding to this, Chase *et al.* (2007, p. 430) defines capacity as the "amount of output that a system is capable of achieving over a specific period of time" that can be measured from resource (e.g. labor force) inputs and product outputs. Capacity can also be viewed as relative to time periods (long-, intermediate- and short-range) and different organization role perspectives. Capacity can also be linked directly to operating profits with "general higher-level models […] [that] capture the impact of capacity by a direct functional dependence of operating profits on the capacity stock" (van Mieghem, 2003, p. 275).

Whereas S&OP is about defining the external environment and internal levels required in meeting them, capacity management is about the deciding the specific details and implementing them (Olhager *et al.*, 2001). Inputs for the capacity management are the sales plan as well as the manufacturing strategy. In capacity management it is important to recognize the timing of capacity changes, which can lead, lag or track the changes in demand level (Olhager *et al.*, 2001; van Mieghem, 2003). It should also be noted that the magnitude and timing of capacity adjustments are also interdependent; many small adjustments need to be done more often whereas few large adjustments less frequently (van Mieghem, 2003, p. 289). Also, when increasing or decreasing capacity, there are three things to consider: the size, type and timing of the adjustment (Luss, 1982).

In capacity-leading scenarios the capacity increase comes first, or prior to expected changes in demand, and in capacity-leading scenarios the capacity is only acquired when a corresponding level of demand has already been acknowledged. However, it is usually not the case that a pure lead- or lag-strategy should be sought due to the extreme discrete investments. Instead a mix of these in the form of a track-scenario, where the demand is tracked as closely as possible and the size of the step changes is reduced, would be most feasible (Olhager *et al.*, 2001).

Altogether the essential difference between lagging or leading with capacity is about capacity investment costs compared to inventory holding costs, i.e. the costs of underage vs overage. The maturity of the product's life cycle can also be decisive in this; new introductions always require capacity-leading, but cautious lagging is usually sought with established products (van Mieghem, 2003).

The focus of CM from an S&OP point of view is the rate of production relative to sales, which can be level (production constantly attempts to equal sales), chase (aggregate demand for a period is satisfied periodically with a single production run) or a mix of these (Olhager *et al.*, 2001). If the first two are sometimes used in their pure form it is probably because of the industry requirements, but usually a combination of these is applied.

2.2.2 Operations footprint. According to Schuh *et al.* (2008, p. 333), examining a company's operations footprint is an "approach to measure and evaluate the strategic value of a specific configuration of a production network with respect to the network's business environment" by comparing the degree of correspondence of this network to procurement and sales markets, and the global footprint is its distribution of production capacities. Measuring a company's operations footprint is relevant to the topic of DSB because it defines the volume and complexity of the organizations structure, which can be both possibilities as well as burdens when adjusting to changing markets.

The historical setting for footprint management has risen from companies' need to decrease overall production costs and want to gain access to emerging markets. This however has led to notable technology transfers, and nowadays a more critical aspect is to tackle new competition from parties that used to be sub-contractors (Zurru, 2008, p. 148).

The strategic drivers for footprint size are usually attributable to the company's customers and/or clients. Companies can also take a multi-focal approach, where they leverage economies of scale for just a few main parts of their value chain such as raw material procurement or engineering (Zurru, 2008).

Another approach to the subject is coined by Pfitzmann and Mueller (2005), who in their article identify five distinct manufacturing footprint models: integrated, regional/feeder plant, hub and spoke, integrated hub and spoke and finally global. All titles refer to the topographical layout of the network, where, for example integrated refers to a prime product facility setup in which a single plant is responsible for manufacturing and/or assembly of a single product. Regional/feeder plant is an extension of this where the prime product facility is supported by a more advantageous facility relatively nearby. These alternative models have general trade-offs between production scale, logistics cost and time, and more explicitly they consider issues such as wage levels, capital spending intensity, sensitivity to demand fluctuation, utilization of production processes (Shorten *et al.*, 2005).

2.2.3 Operational flexibility. Because of economies of scope, meaning that "multiple products can be produced at a lower cost in combination than they can separately" (Chase *et al.*, 2007), companies are usually very tempted to optimize all production and processes to serve this objective. But what happens when the product life cycle comes to an end and the manufacturing scheme needs to be altered? This is one of the founding issues behind the need for operational flexibility.

Sethi and Sethi's (1990, p. 290) article gives a long-term and comprehensive view toward capital investments while highlighting the effects that increased flexibility (to respond to changes in consumer demands and competitive threats) and versatility (in meeting diversified market demands) can have on manufacturing systems. They divide flexibility into 11 different types of measures (p. 296): machine flexibility; flexibility of a material handling; operation flexibility process flexibility; product

flexibility; routing flexibility; volume flexibility; expansion; program flexibility; production flexibility; market flexibility.

2.2.4 S&OP in DSB. S&OP is "a cross-functional planning process that sets the overall level of manufacturing output to best satisfy the currently planned levels of sales, while meeting general business objectives of profitability and productivity" on a tactical level (Dilger 2009, p. 24). Boyer (2009, p. 4) sees it as "top management's handle on business" where demand and supply are balanced on a regular and formal basis to enable fact-based proactive resource decisions. The function of Sales and Operations Process within a business is to enable the Sales and Marketing functions to achieve their targets while mitigating risks connected to net working capital growth in supply chain costs (Gallucci, 2008). A formalized S&OP process will create value in business by improving forecast accuracy, customer service and portfolio management as well as reducing obsolescence and inventory levels altogether (Bower, 2006). Also, as any formalized process, it also creates measurability into the business and gives accountability for all involved stakeholders (Bower, 2006). According to Dilger (2009), combined good performance in the areas of revenue, inventory and factory utilization speaks of an aligned S&OP process.

2.3 Literature analysis

Number of various approaches on DSB has been presented in the operations literature. There are several attempts to improve the supply chain performance by utilizing market information, combining operational performance aspects with flexibility and cost analyses. However, many of these approaches are separate tools and the linkage between both sales and delivery is not always very obvious. Operations strategy of a company should probably connect these items into higher level objectives Figure 1. illustrates a summary of the approaches related to DSB. This summary from the literature is used in empirical research when developing the questionnaire instrument conducted to a sample population of Finland-based manufacturing companies.

3. Research method

In order to analyze how manufacturing companies are dealing with DSB, a survey instrument was developed. The starting point of selecting suitable survey candidates was the TE500 list of top 500 companies in Finland (*Talouselämä*, 2010). From this list

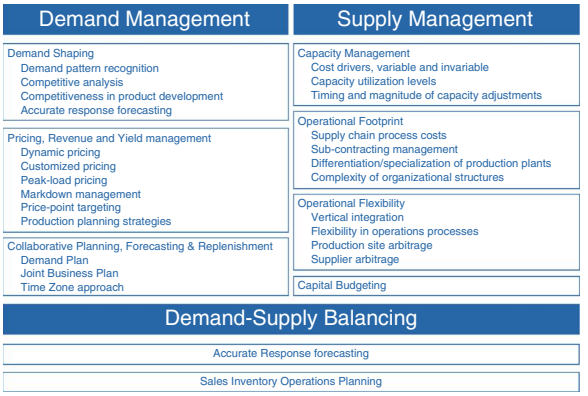

Figure 1.
Summary of approaches defining demand-supply balancing

manufacturing industries with presence in Finland and internationally were chosen. Other sources such as national business newspapers Kauppalehti, Tekniikka and Talous and other domestic business publications were also used to compliment the survey group. Companies in distinctly process-based industries such as pulp and paper were excluded, as well as companies that only had sales offices in Finland because they would have little to none insight into the manufacturing operations covered.

The set of 22 different types of industries to choose from are directly derived from the "C Manufacturing"-section of the Standard Industrial Classification TOL 2008 and thus also correspond to international classification systems such as Eurostat's NACE Rev. 2 – CPA 2008 (Statistics Finland, 2008). A total number of 47 companies were contacted by telephone and e-mail to ask for their participation in the survey, of which 40 (85 percent) favorably agreed to partake. Of the 40 companies that received invitations into the survey, ultimately 20 completed the online survey (four began but did not complete and 16 did not even begin) which solidifies the final response rate to 43 percent. Albeit reasonably small number of companies, this target group covers more than 50 percent of the Finnish manufacturing output. The perspective of these companies should give a good overview on a national level of such companies and their operations strategy. Based on the responses also the distribution of industries and size of the companies, are supporting this.

Table AI shows a summary of the questions presented to the managers of the companies. The questions were analyzed by using basic descriptive statistics, such as average, median and standard deviation.

4. Results

The general demographic parameters were quite harmonious, as the respondent population consisted dominantly of top management (80 percent), and the most common industries represented were the manufacture of fabricated metal products, electrical equipment and machinery (Figure 2). The "other" category in industry sector (15 percent) represents companies in the business of manufacturing medical equipment and reagents, sports equipment and laboratory instruments. It should be noted that in addition to the differences in executive responsibilities depending on company size that the job titles might also be subjective as these terms were not pre-defined, but nevertheless these figures verify that the survey did reach the topmost operations management of 20 companies.

The companies studied operated on an average turnover of nearly 200 MEUR and held an average of over 800 employees, but since the equivalent median figures were approximately 120 MEUR and just close to 600 employees the top few companies were clearly larger than the rest of the population (Figure 3).

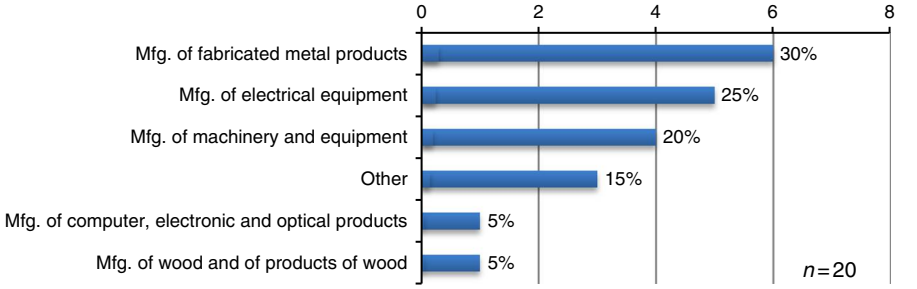

Figure 2.
Distribution of industries in survey sample

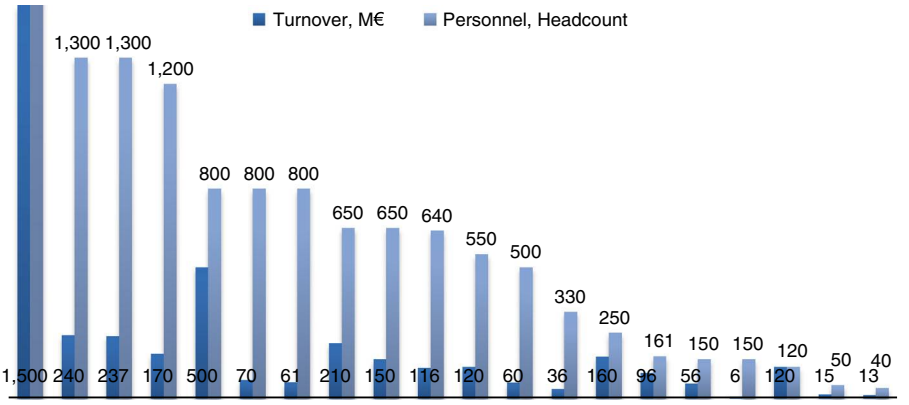

Figure 3.
Turnovers and personnel of surveyed companies

4.1 Supply chain structure

Questions regarding the physical supply chain structure revealed significant differences between the operational footprints of different companies. As shown in Figure 4, the largest company could supply their products from one factory and through 50 distribution centers while the smallest 35 percent of companies did not have their own DCs. All of them did operate on a significant scale and should have the same operations management requirements and capabilities. The similarities in structure and differences in scope were also revealed by the free-form answers given by the respondents when asked to describe their supply chain structure on a general level. More than half of the companies reported to be operating in business-to-business markets such as the manufacture of industrial goods, where their products were delivered straight to customers and perhaps with assistance from an external logistics partner but anyhow without their own fixed distribution center or network. Interesting aberrations were the subsidiaries of international corporations, where the Finnish branch depended on but also benefited heavily from the global logistics.

And as seen in Figure 5, a majority of respondents saw themselves that all or most of their production as completely multipurpose, while only a quarter of companies reported that each of their operations sites focus on a single product or product group.

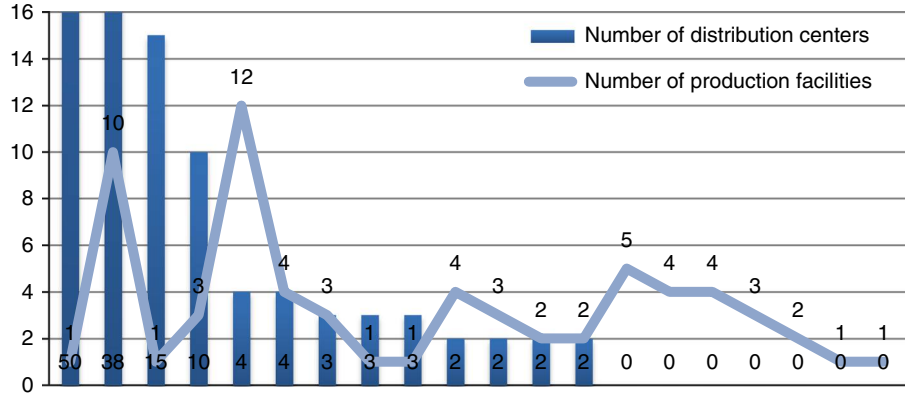

Figure 4.
Numbers and relationships of production facilities and distribution centers

4.2 Supply chain flexibility

On supply chain flexibility, the respondents felt that on average 68 percent of the components they use could be sourced from several providers (Figure 6). This gives companies real opportunities in supplier selection, however, it should be noticed that the notable dispersion (standard deviation 25 percent) included in this figure means the actual levels will vary quite much. But be it as may, most companies rely on a single supplier to a significant extent of their component deliveries which is dubious not merely from a risk management point-of-view, but if the suppliers are aware of this then they will know to hike up their prices in an unchallenged environment.

The reason for asking this question related to component commonality in two parts was to discover the exactly this correlation that is illustrated in Figure 7, where the differences between aspirations and reality are obvious. Especially the deviation in the topmost section tells that 30 percent of companies think that this commonality is highly important but for one reason or another have not themselves reached that level. Elaborating even more, it should be noted that even though the "notable" and "somewhat" – categories are in fair balance the respondents who answered that they have achieved "little" commonality do in fact give it higher value. Despite the subjectivity of the answering options, the survey proves that component commonality is an issue worth consideration. So pursuing that track, a noteworthy follow-up question could be to study how much tradeoff to added (development or ramp-up) costs the participants would have been ready to endure as a tradeoff for increased commonality.

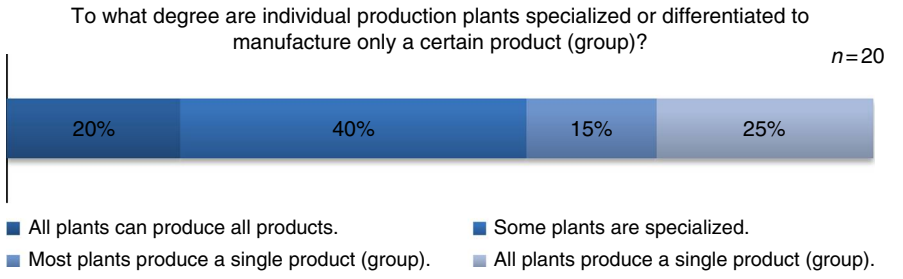

Figure 5.
The level of production plant differentiation

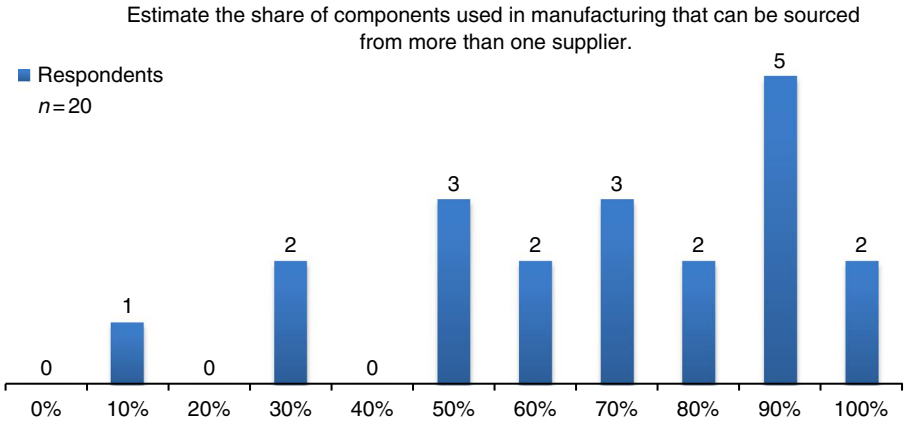

Figure 6.
The relative share of components sourced from more than one supplier

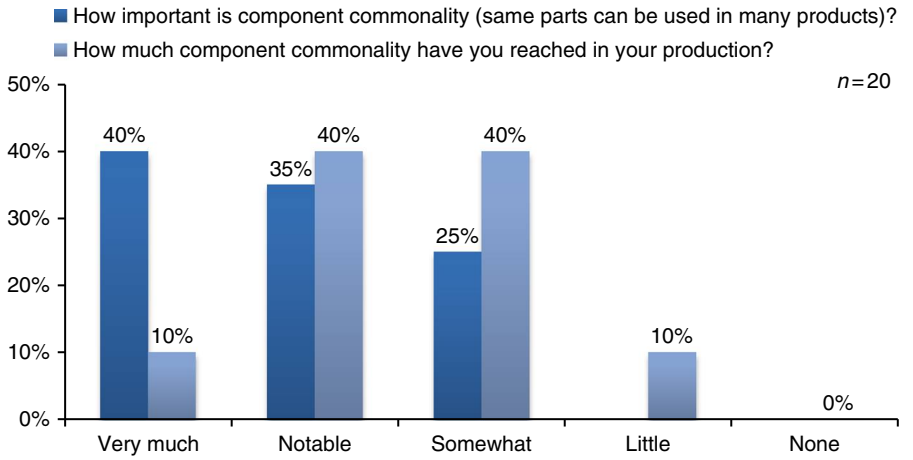

Figure 7. Comparison of the significance of commonality in manufacturing

The opinions of postponement (Figure 8) also reflect the interviewed executives' attitudes on postponing. They are also very much related to the question regarding the segmentation of products by the predictability of their demand, which will be brought up later in the demand management section.

4.3 Demand management

In light of these survey results the overall situation of the companies' state of demand management leaves much to hope for, but also identifies specific areas of improvement and reveals that interest in the subject is widespread. A startling discovery was the fact that a 70 percent majority of these companies do not account for the cost of lost sales. The clear point is that seven of ten have no visibility and cannot quantify the potential gains they could achieve by tapping onto un-activated markets, so in fact their whole market strategy could be misguided.

The two most uplifting results to come out of the survey were related to the discovery of latent demand management capabilities. About 80 percent of the companies reported being capable of distinguishing their products by the predictability of their demand in order to phasing the production. Second, just as proposed regarding CPFR, nearly all of the companies shared their internal demand forecasts with their external suppliers (35 percent completely and 60 percent to some degree) which, considering that the question was not to only bound primary or strategic partners, is quite a high figure. It is quite reasonable to draw the conclusion that the general supply chain prerequisites for CPFR, operational postponing and accurate response forecasting in are in place with most respondent companies.

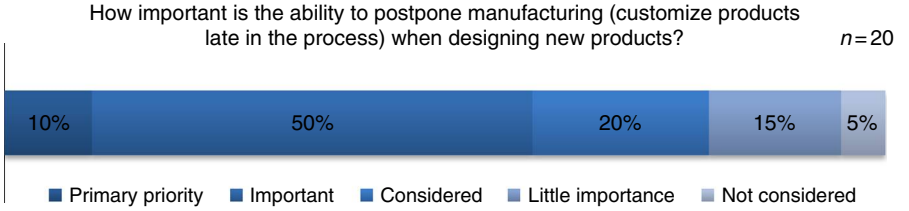

Figure 8. Importance of postponement possibilities in new product design

4.4 Capacity management

Enquiring about the cost drivers of operations differed from the previous questions in the sense that the answers could be given in free form instead of multiple choices. The question was also divided into two parts (variable and invariable) but especially the personnel costs overlapped both categories, most likely due to the use of flexible (temporary) workforce solutions vs fixed labor working under steady-term employment. Unfortunately the response rate was not as high as hoped because the question was not mandatory to answer, so only 65 percent of participants answered regarding their VC and 50 percent gave input of their invariable costs. But despite this the results were clear: the main variable cost drivers reported were materials and components (92 percent) and labor (15 percent), and the most common invariable ones personnel (50 percent), general overhead (38 percent) and real estate-related (25 percent) costs such as rent. The combination of free form and voluntary answering caused the fact that there is only coherent outcome from this question: industrial manufacturing companies' most significant operations cost drivers are materials and components, which far surpass the importance of labor (Figure 9).

There is no clear consensus as to a minimum percentage level of production capacity utilization since the answers range from 0 to 70 percent, and even though a calculated average of 36 percent can be derived from the results this cannot be considered all that reliable as the volatility (standard deviation divided by the mean average grade) (Brealey *et al.*, 2009, pp. 319-321) used to measure the level of dispersion rises up to 61 percent (22.10/36 percent). The only sensible answer that could be passed of here is that half of the companies can temporarily scale back their production output to as low as to 30 percent of their capacity without suffering major impacts, but only four of them can run it to a complete halt. On the other hand, the situation is much more conclusive when looking at the maximum capacity targets where the average is 88 percent but the volatility of the answers is far less at only 18.2 percent (16.09/88 percent) (Figure 10). Conclusion on these figures it would be safe to say that only under half of the companies can effectively utilize all of their existing production capacity while 55 percent have the need to keep 10-20 percent slack capacity. One must doubt whether the cost structures of these companies are optimal or even sound if they constantly need to keep 10-20 percent of their capabilities out of use. On the other hand, a more

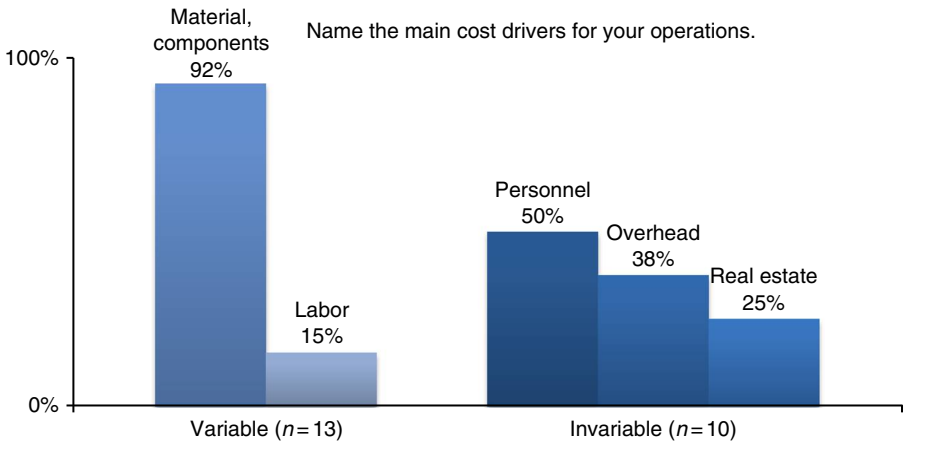

Figure 9.
The most common operational cost drivers by category

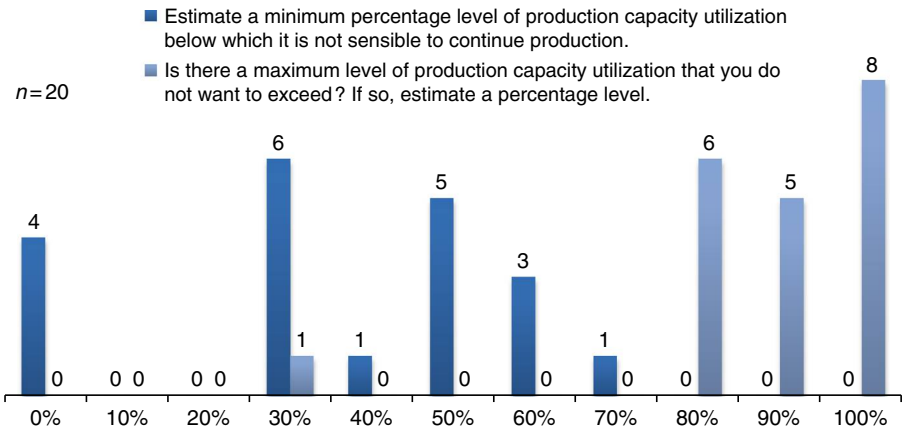

Figure 10.
Upper and lower boundaries of production capacity utilization

positive conclusion could be that most of these companies have done well by acquiring surplus capacity that is at their disposal during momentary demand peaks. Whatever the case may be, this slack capacity is another example of unexamined business elements that should be quantified and valuated.

The capacity-adjustment models of leading, lagging and tracking introduced by Olhager and van Mieghem were understood by respondents, as all participants identified a theoretical model that resembled their own operational model. A 45 percent majority of respondents claimed to adjust their production capacity continuously, and the rest of the group was quite evenly split between following behind or anticipating before demand changes with capacity investments (Figure 11).

4.5 Inventory management

The responses regarding inventory management generally confirmed a pre-existent assumption: inventory levels, related practices and especially the capital tied into it are very much on the top of every operations officer's agenda. The relatively high response rates in the free-form answers of this section gave much insight to how and with what tools these companies balance their in-house supply, but also highlighted a few improvement areas such as the high average level of excess inventory.

With a response rate of 75 percent, the answers illustrated in Figure 12 show that nearly all companies follow the value of their inventory, and the next most common reported KPIs were inventory turnaround time and days of supply (measure of product availability, also known as days on hand). Three companies each also told that they paid close attention to inventory aging, write-offs and the relative share of slow-moving inventory.

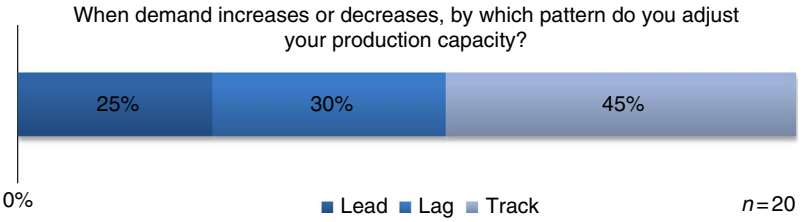

Figure 11.
Breakdown of capacity-adjustment behavior

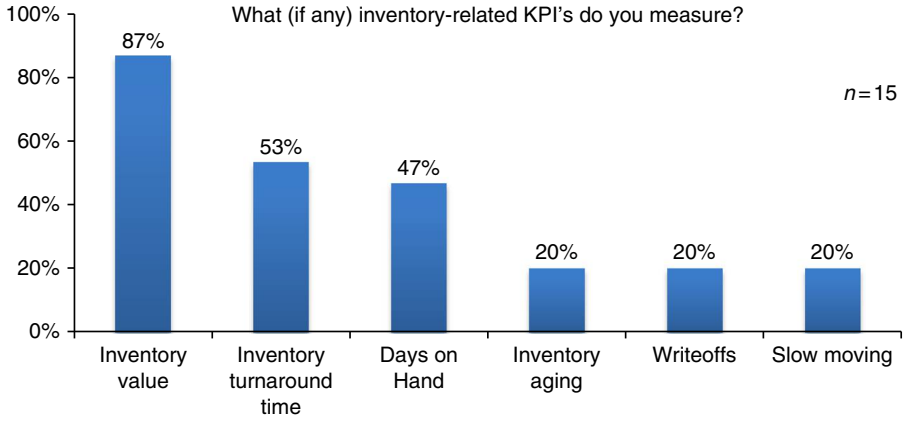

Figure 12.
The most commonly reported inventory performance indicators

To get an estimate of the level of slack companies subsume within their supply chain, they were queried of whether they held needless stock. It was to be expected that not all participants wanted to respond to this sensitive question, but the achieved 85 percent coverage is statistically sufficient. But what is not acceptable however are the startling results: over 40 percent of respondents admit that on average 1/3 of their inventory is excessive (Figure 13). Just picking up any of the companies' balance sheet and dividing the working capital tied into inventory by three would give a number to quiet down any board room meeting, but besides the financial effects such as cost of capital, etc. these surplus inventories must also cause some down-writings by aging and damage, and real warehouse space taken. Some of this might be safety stock or arbitrage from low spot commodity prices.

Moving on, it was also important to ask whether the surveyed companies have (or recognize that they have) operational controls to prevent the overlapping (redundant production) and aging of inventory. Since these questions were also voluntary and could be answered in free form, some respondents probably skipped this part to save time and the response rate fell to only 40 percent (overlapping) and 50 percent (aging) which means the given answers have less statistical relevance. Since the most

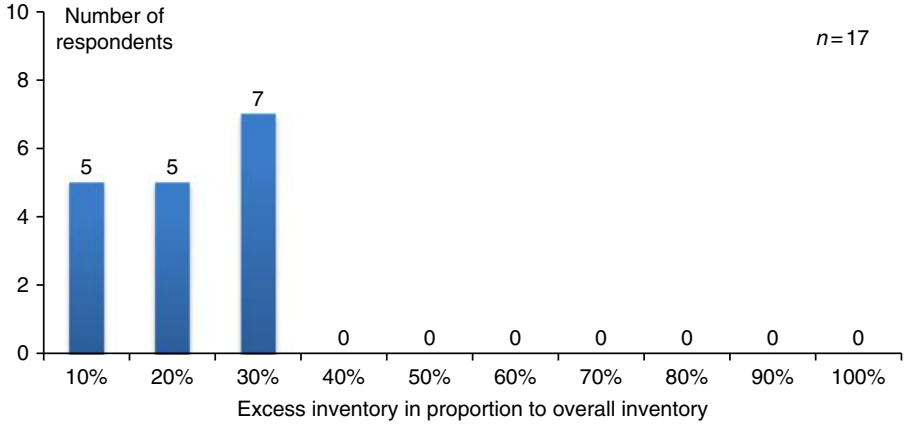

Figure 13.
Share of excess inventory reported by respondents

commonly mentioned controls for avoiding overlapping are MTO and pull production approaches which are not really that high-end, it would be reasonable to assume that some or even most of the participants that did not respond also utilize these and just do not realize this effect they have. For preventing the aging of stock the most mentioned control was first in first out where materials are utilized in the same order that they have been received which most likely works fine with a limited number of categories but might prove to be difficult to manage with a wider range of items. Follow-up lists for slow-moving goods were also favored for this purpose, but only one company actually said admitted to not having any controls at all for aging.

The single-largest group of companies (40 percent of respondents) used VMI in only 10 percent of their sourced materials which is very low, so considerable efficiency improvements could be reached if this number were to go up. It seems that some low-hanging fruits of holding cost savings could be reclaimed by comparing the average levels of excess inventory (21.18 percent) and share of VMI (23.50 percent) in each company, and considering if a reduction in the foremost could be transferred to the latter in a way which would not overly strain the supplier but improve efficiency at both ends.

4.6 Pricing, revenue and YM

The figures for Pricing, Revenue and YM show that most companies review their central pricing policies on an annual level and a third examine them quarterly. The "other" category represents business models where the pricing is continuously adjusted or based on unique project deliveries. As with Figure 14, the cadence at which pricing is altered also speaks in volumes about the organizational maturity and capabilities of the company because the knowledge and resource-requirements for re-pricing more often increase very steeply.

Eleven of the respondents adjusted their pricing rarely or never to accommodate for even sharp peaks in demand. Understandably the nature of business in industrial goods means that pricing decisions cannot be made overnight and the customers necessitate stability in this respect to effectively finance the deals, but if the main pricelists remain static through the whole time period then the pricing could keep directing demand toward unfavorable products during that whole term.

Figure 15 explains the industry executives' views on how they react to demand changes with their own production planning strategies, and some overlapping occurred as they were given the option of choosing multiple answers at once. The "other" option chosen by two respondents includes the models of "banking" peak-load work time and applying standard overtime-work arrangements. Overall the results indicate that about 2/3 of companies balance their production levels by varying the personnel work hours, but nearly a half (9) also reported being prepared to lay off and hire people to conform to momentary demand settings. Approximately, the same amount of companies (8) also admitted to matching demand fluctuations with a dynamic inventory buffer, or in other words by accumulating excess inventory in weaker times and then reducing that when times pick up.

5. Conclusions

The results of the survey give further understanding on supply-demand balancing practices actually used by the companies. The most common ways in which Finnish industrial manufacturing companies today balance their demand and supply are

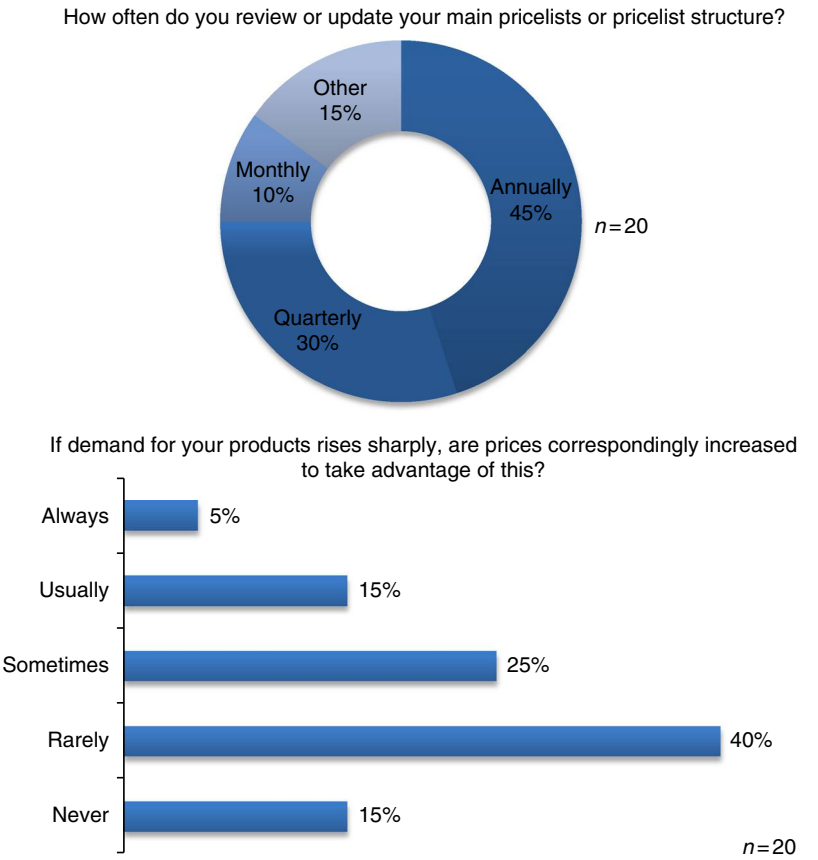

Figure 14.
The cadence of pricing structure reviews

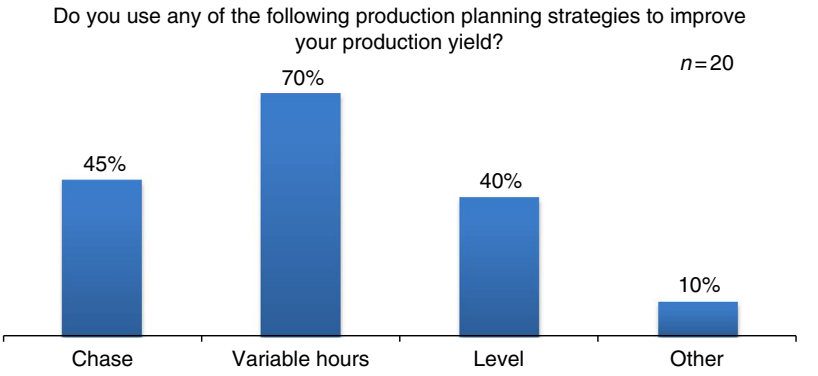

Figure 15.
Production planning strategies used to improve production yield

utilizing the existing potential to a small extent. There is much interest in matters related to advanced supply chain management solutions, established processes and significant maturity could rapidly be achieved by implementing the practices introduced here.

For operations strategy development and practical implication, there are some items. Based on the survey results it is not possible to outline a typical sequence of development steps. However, it seems that there are certain maturity levels in the process. Generally, the managerial implications of the result show a list of important areas of improvement for these companies:

(1) Outlining supply chain Structure – regardless of size a clear majority suffers from organizational complexity. Manufacturing footprint strategy and sourcing decisions combined should consider the potential from DSB (Zurru, 2008).

(2) Enhancing supply chain flexibility – despite the significant dependence on single suppliers, one of the highest positive correlations (74 percent) of the whole survey was between the companies that have choice in suppliers and are aligned with their supply chain partners. All parties are more likely to be aligned for reaching the same goal if a transparent business relationship of open competition exists. The significance of commonality and postponing capabilities were comprehensively recognized by respondents and warrants further research.

(3) Use of analytics in demand management for pricing and YM – the surveyed companies showed quite rigid pricing behavior, which seems to indicate that they either cannot or do not know how to influence demand through dynamic pricing. Most also appear to counterproductively fail in not taking advantage of possibilities to reduce inventories by lowering profitability. Though companies reported being quite adept in understanding market behavior and analyzing customers and competitors, they failed to operationally act upon this intelligence since the principal observation was that hardly any of them account for the cost of lost sales.

(4) Flexibility from capacity and inventory management – The most important cost drivers were sourced materials and components, which underlines the importance of functional supplier-relations management. Under half of companies could take full advantage of their production capabilities, and even fewer could down-scale their operations to a standstill if necessary. Regarding the timing of acquiring additional capacity or cropping excess, a quarter of companies have chosen to lead in anticipation of the market while a third lags behind. Inventory management KPI's should be connected to these.

When developing the DSB related to delivery processes, the required actions may vary between companies. Figure 16 aims to propose an outline for managing demand-supply related initiatives. Market demand changes in terms of demand, product mix, completion in cost or other features of delivery need to be analyzed frequently. Then operations strategy level should decide actions to respond on each of these challenges. Global footprint update, introduction of S&OP procedures or developing dynamic pricing could be examples of actions. Key performance measurement should be connected to the actions and monitoring the impact of actions.

The contribution of this paper is show that companies have potential on improving their operations network in various aspects. This paper has given some insight how companies are currently managing demand-supply processes. The data set is limited to a single country and reasonably small number of respondents. It gives some insights where typical international companies operating are in terms of DSB and what type of

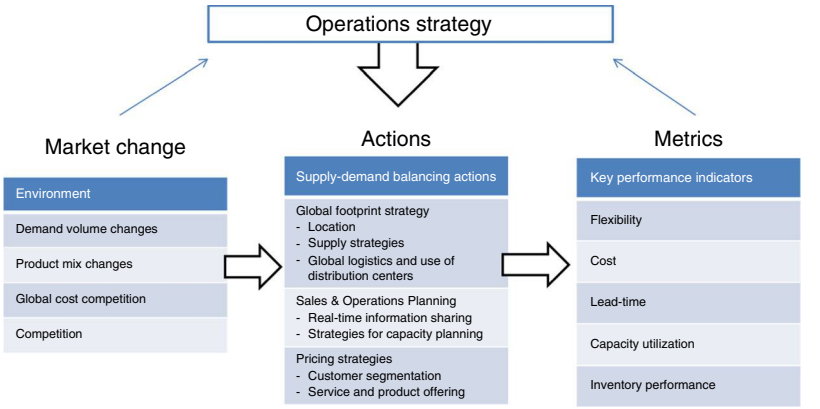

Figure 16.
Connecting operations strategy to demand-supply related decisions

actions are being used. Further research is needed on maturity steps of developments and based on empirical examples to propose what could be typical maturity levels on the DSB roadmap.

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(The Appendix follows overleaf.)

Appendix

Question identifier	Average	Median	SD
A. General information			
1. Time taken in answering (minutes)	47:37	18:42.5	101:07
2. What is your company's main type of industry?	17.75	18	3.43
3. What is your position within this company?	1.2	1	0.41
4. What was your annual turnover (M€) from the last full fiscal year	196.8	118.0	326.78
5. What was the average number of employees you held during the last full fiscal year	822.05	595	1283.35
B. Supply chain structure			
7. How many production facilities does your company have?	3.35	3	2.92
8. How many distribution centers does the company currently have within its network?	6.9	2	13.36
9. To what degree are individual production plants specialized or differentiated to manufacture only a certain product?	3.25	3	1.41
10. Is your operational performance limited by complexity in organizational structures (multiple reporting lines, geographical dispersion, etc.)?	3.3	3	0.92
C. Supply chain flexibility			
13. Estimate the share of components used in manufacturing that can be sourced from more than one supplier. (0-100%)	68%	70%	25%
14. How important is component commonality (same parts can be used in many products)?	4.15	4	0.81
15. How much component commonality have you reached in your production?	3.5	3.5	0.83
16. How important is the ability to postpone manufacturing (customize products late in the process) when designing new products?	2.55	2	1.05
17. How often are new supply chain partners tendered or requests for proposal sent out?	2.2	2	0.89
18. Do your supply chain partners share the same targets, incentives and agendas as you?	2	2	0.56
19. How much do you think macroeconomic developments (e.g. changes in unemployment, inflation or consumption trends) affect your business?	2.65	2.5	0.88
20. How much attention do you pay to these macroeconomic developments?	2.55	2.5	1.00
D. Demand management			
22. Do you measure the cost of lost sales (profit that could have been gained if a missed order had been fulfilled)?(1 = Yes, 2 = No)	1.7	2	0.47
23. How many of your customers in the market do you analyze and segment?	1.95	2	0.83
24. How many of your competitors in the market do you analyze and segment?	2.15	2	0.75
25. How deeply does your company identify the demand behavior patterns of sales channels and/or customers?	2.2	2	0.52
26. Can you separate your products from each other depending on how predictable their demand is? (1 = Yes, 2 = No)	1.2	1	0.41
27. Do you share your demand forecasts with your suppliers?	1.7	2	0.57

Table AI.
Survey questions summary

(*continued*)

Question identifier	Average	Median	SD
E. Capacity management			
30. Estimate a minimum level of production capacity utilization below which it is not sensible to continue production. (0-100%)	36%	35%	22.10%
31. Is there a maximum level of production capacity utilization that you do not want to exceed? (0-100%)	88%	90%	16.09%
32. When demand increases or decreases, by which pattern do you adjust your production capacity? (1 = Lead, 2 = Lag, 3 = Track)	2.2	2	0.83
F. Inventory management			
35. If you tend to hold excess inventory, please estimate its size in proportion to overall inventory. (0-100%)	21.18%	20.00%	8.57%
38. Please estimate the volume of your materials/components sourced through Vendor-Managed Inventory. (0-100%)	23.50%	15.00%	23.90%
G. Pricing, Revenue and Yield management			
40. How often do you review or update your main pricelists or pricelist structure?	3.65	4	0.88
41. If demand for your products rises sharply, are prices correspondingly increased to take advantage of this?	3.45	4	1.10
42. When adjusting your pricing, do you consider the effects it may have on your capacity utilization?	3.25	3	1.16
43. How important are price discounts when attempting to reduce inventory?	3.65	4	1.09
44. Do you use any of the following production planning strategies to improve your production yield?	3.05	3	1.43
H. Survey Feedback			
46. Did this survey address the demand-supply Balancing capabilities of your supply chain in enough detail?	50.4	50	8.77
47. Did this survey address the demand-supply balancing capabilities of your supply chain in enough scope?	48.4	50	9.01

Table AI.

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