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Power relationships and schedule flexibility: case studies on two supply chain modules

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Abstract: This paper presents the results of six case studies in two modules, one in the automotive industry and the other in the laptop computer industry. Each module contains a company and two of its suppliers. The objective of the study is to find out the effect of the customer's power on the supplier's choice of scheduling practice and response strategy to unexpected schedule changes. Managers in each firm were interviewed to examine five issues: customer power, customer's purchase practice, information sharing, supplier's process flexibility, and supplier's master production schedule practice. We found that supply chain power relationship is a significant, albeit latent factor in the formulation of master production schedule. Supplier's process flexibility attenuates the influence of customer power, while the customer's extent of information sharing and commitment to the purchase quantity do not necessarily depends on power. We develop some propositions as a result of this study, which may pave the way for large-scale, theory-testing field studies.

Keywords: power, supply chain management, case study, process flexibility, master production schedule, purchasing, logistics scheduling

1. Introduction

Matching supply with demand is a constant challenge for many organizations. For manufacturing industries, significant resources are often spent on coordinating demand, supply, and logistics activities within a company and across company boundaries in the supply chain. One place where the "rubber meets the road" is the practice of a firm's master production schedule (MPS). The MPS details how many end items will be produced within a specified period of time. It is a major input to the resource planning system, including capacity, material, purchasing, and logistics (Jacobs et al., 2010) To develop a feasible MPS, one needs to consider a host of factors, such as capacity, order

due date, material availability, and lead times of purchasing, production and logistics. A good MPS must strike the balance between flexibility and stability. On the one hand, an MPS is a result of cross-functional agreement between the production quantity and timing of a product. Many planning and implementation activities, such as placing orders to suppliers or scheduling logistics deliveries to customers, hinge on the MPS decision. Changing the MPS triggers a wave of changes to all linked decisions, thus throwing operations out of sync. Such disturbance comes with many costs—not only the direct costs of expediting orders, extra time and efforts of further coordination but also waste of "hidden factory." On the other hand, customers today expect a high level of flexibility from suppliers, so supplier firms try their best to accommodate customers' demand changes. To a supplier, the design of an MPS must reflect the degree of flexibility that its internal operational constraints can handle. In summary, MPS is a critical joint at which supply chain integration and coordination takes place.

There is a plethora of research in operations management literature focused on the development of MPS within the boundary of a firm (e.g., Sridharan et al., 1987; Lin and Krajewski, 1992). Many studies investigate how key parameters of the MPS affect various performance metrics. Only a few papers study MPS by considering the interactions between a customer and a supplier (e.g., Krajewski and Wei, 2001; Robinson et al., 2008). Still, their foci are on tangible operational factors such as process flexibility and demand characteristics. However, as one re-examine the development of MPS from the lens of a supply chain dyad that involves a firm and its customer, the power relationship between the two firms appears to play an important role. Power can affect the way the customer places the order as well as the extent for which the customer firm shares information with the supplier. These factors may in turn affect the stability of the supplier's MPS, yet to our knowledge there is no research of supply chain power relationship on MPS development. Thus, in this study we attempt to address this research question: How does power affect schedule flexibility in a supply chain dyad?

Since there is no existing research that directly addresses our research question, case study is a suitable approach to the problem. Case studies are often used for developing new theories or for examining unfamiliar situations (Yin, 1984; McCutcheon and Meredith, 1993). We conducted case studies in two modules, each consisting of a firm and two of its suppliers. We define the unit of study as the dyadic relationship between a customer and a supplier. One module is in the automotive industry while the other in the laptop computer

industry. Within each company, we used a structured instrument to interview managers in different functions--collecting information on five dimensions: customer power, customer's purchase practice, Information sharing, supplier's process flexibility, and supplier's master production schedule practice. We first conduct a within-case analysis for each dyad and follow with a cross-case analysis to compare and contrast the commonalities and differences of the findings.

Our results indicate that power appears to influence schedule flexibility, either directly or indirectly. Supplier's process flexibility attenuates the influence of customer power, while the customer's extent of information sharing and commitment to the purchase quantity do not necessarily depends on power. We develop six propositions that summarize our findings.

2. Theoretical Background

Each of the five dimensions in our plant visit interviews are founded upon theoretical and empirical literature support. We briefly review the literature in this section.

2.1 Power

Power may be defined as the ability of one firm to influence the intention and actions of another firm (Emerson, 1962). French and Raven (1959) developed a classification for the bases or sources of power that include mediated type. Empirical marketing literature indicates a mixed picture of the benefits of the use of mediated power (e.g, Dwyer and Walker, 1981; Frazier et al., 1989; Brown et al., 1995). Another way to measure power is to ask the supplier questions regarding its dependence on the customer's business and whether there are alternative customers for the same product (Frazier and Cody, 1991).

In manufacturing supply chain literature, Maloni and Benton (2000) found that coercive power and legal legitimate power have significant negative effect upon buyer-supplier relationship, while expert power and referent power have significant positive effects. Recent studies show further evidence against the use of coercive power (Benton and Maloni, 2005; Zhao et al., 2008).

2.2 Master Production Schedule

To develop a useful MPS, a scheduler must be mindful of various internal and external requirements that often need tradeoffs and conflict resolution. Management defines different Time Fences (boundaries between different periods) as a policy or guideline to allow different degrees of change to the MPS. The most common time fence is to specify a "frozen" segment in the

most imminent future periods that only an act of God or top management override can change the MPS.

In operations management literature, designing a MPS typically considers some or all four design parameters: the planning horizon, the replanning period (or equivalently the frequency of schedule update), the frozen interval, and the freezing method used which can be order-based or period-based (Sridharan et al., 1987). Under demand uncertainty, a higher freezing proportion often results in a higher cost and lower service level, but increases schedule stability. Only a handful of studies explicitly consider supply chain relationships (Krajewski and Wei, 2001; Robinson et al., 2008).

2.3 Purchase Practice

One major driver to a supplier firm's MPS is customer demand, which often depends on the purchasing practice of the customer. In this study, we focus on three aspects of purchasing: (1) whether the customer collaborates with the supplier to jointly develop the net requirements; (2) Whether the customer authorize the supplier to automatically replenish the inventory; and (3) Whether the customer makes a (binding) commitment to the purchased items.

In the degree of increasing flexibility, customer's order commitment takes three generic forms: (a) periodic commitment, which specifies a certain quantity each period over the life of the purchase contract; (b) total minimum quantity over the life of the contract. This is commonly called a "blanket order;" and (c) No commitment (Tsay and Lovejoy, 1999).

2.4 Process Flexibility

To cope with uncertainty, firms seek flexibility in both their internal and supply chain processes. Many measures of flexibility have been reported in literature (Gupta and Somers, 1992; Koste and Malhotra, 1999). However, since our cases focus on specific products and their production processes, we are most concerned with process flexibility.

2.5 Information Sharing

Timely information sharing helps speed up decision-making and often results in shorter lead times and smaller batch sizes (Cachon and Fisher, 2000). A buyer firm can provide demand forecasts to suppliers so that they have more visibility to plan for capacity and material requirements (Lee et al., 1997; Frohlich and Westbrook, 2001). Furthermore, sharing master production schedules with suppliers reduces forecast uncertainty and enables more detailed determination of production quantity and timing (Lancioni et al., 2000, Krajewski and Wei, 2001).

3. Methodology

We conducted case studies in two industries, each involving a three–firm module that consisted of a firm and two of its suppliers. We selected the customer firm through personal contact. Following the concept of "theoretical sampling" (Eisenhardt, 1989), we asked the top managers to select two suppliers that are quite different in size, sales revenue, product value and complexity. The automotive module consists of firms A1 and suppliers A2 and A3. The laptop computer module consists of firms C1 and suppliers C2 and C3. The unit of analysis is a specific buyer-supplier dyad. Each dyad is a case in and of itself.

4. Analysis and Propositions

4.1 The Automotive Module

A1 is a small firm that uses a molding and intrusion process to produce "plastic cushions." Such cushions are used in the air-springs of trailer truck suspension systems. A2 is a global firm that supplies plastic items and polymers used in producing A1's cushions. A3 is a machining shop that supplies a customized shaft that goes into the plastic cushions.

4.1.1 Case A1 and Its Customer

In terms of revenue and number of employees, A1 is much smaller than its customer, a manufacturer of a truck suspension system. However, the plastic cushion is sole-sourced to A1, though many other firms can produce it. The sales revenue from this customer, including the plastic cushions, accounts for about 20% of A1's annual income. The customer gives A1 three months of estimated weekly requirements and an annual total volume estimate, but it does not bind commitment on order quantity. Barring machine break down, A1 has high process flexibility because the manufacturing process is relatively fast and simple within its manufacturing cells; its short-term capacity can easily be expanded via overtime. A1's MPS is updated weekly without a formal frozen period. When the customer requests a sudden demand change (i.e., short notice within normal production and delivery lead times), A1 uses a responsive approach by adjusting its MPS. To A1, customer volume change is the leading cause of unexpected MPS change.

4.1.2 Case A1 and A2

A2 is a well-known global chemical company that supplies engineering polymer pellets to A1. A1 buys polymers solely from A2 and uses these raw materials in various product lines. A1 provides sales forecasts to A2 and has no formal commitment on order quantity. However, A1 built two storage silos next to its

plant and has set up a vendor-managed inventory system with A2—allowing A2 to determine when to replenish stock. The production of polymers is planned months ahead to optimize the utilization of bottleneck equipment in the manufacturing process. Due to high capital investment and changeover costs, A2's MPS is updated monthly and has a 4-week frozen period. Management considers the manufacturing process to be of low flexibility, mainly because capacity expansion is very expensive and process downtime is costly. The utilization of the critical machines was cited as the top reason for unexpected schedule changes. To cope with such changes, A2 predominantly uses finished goods inventory (FGI) as a buffer strategy because changing schedule is regarded as a last resort measure.

4.1.3 Case A1 and A3

Company A3 is the sole supplier of a metal shaft to A1. The size and revenue of A3 are just a bit larger than those of A1, and the shaft does not account for a high percentage of revenues to A3. A1 only gives future shipping schedules to A3, but it makes a commitment to the orders it has authorized A3 to produce. Changing the committed order quantity is subject to extra charge and has rarely happened to A1. The shaft is highly customized and takes four weeks to produce a typical batch in a job shop. One bottleneck machine could take up to more than ten hours to set up. It is costly for the manufacturing process to switch production from one product to another or to expedite a pre-emptive batch. The MPS at A3 for this shaft has a frozen interval of four weeks, and A3 also uses FGI to cope with unexpected schedule changes.

4.2 The Laptop Computer Module

In this module, C1 is a large computer "contract manufacturer" that produces a specific model of laptop computers for a global computer firm. However, C1 does not sell its own brand of computers. Supplier C2 produces fans and other devices to reduce heat generated when the computer is in use. Supplier C3 makes the external mental case of the laptop computer. Both C2 and C3 are much smaller than their customer C1 in terms of revenue.

4.2.1 Case C1 and Its Customer

Company C1 is one of the top five laptop producers in the world, and its customer is also one of the top global brands in the industry. Thirty percent of C1's annual revenues are attributed to this customer. The customer shares future production schedules and sales forecasts with C1 and does make a periodic commitment to the order quantity (as defined earlier in Section 2.3). The manufacturing lead time is 3 days per typical batch of laptop computer shipments. The management at C1 regards the firm's process flexibility as

"moderate" in terms of expanding capacity, changing over to another product, expediting a batch, and coping with changes without using FGI. C1's MPS features a 1-week frozen interval and weekly update. To C1, customer imposed volume change is the top reason that triggers unexpected schedule changes. Nevertheless, C1 is able to limit customer-induced changes; the magnitude cannot exceed 30% and the customer has to pay extra if the revised quantity is lower than the committed volume. C1 uses work-in-process (WIP) inventory to cope with schedule changes in short notice.

4.2.2 Case C1 and C2

Thirty percentage of C2's annual revenue is attributed to customer C1. Although C2 is much smaller than C1, C1 still shares information with C2 in future production schedules, sales forecasts, and inventory levels. C1 also makes a periodic commitment to the orders placed to C2. The manufacturing lead time for producing a batch of fans is two days. C2's manufacturing process has a high level of flexibility. Its MPS has a 2-week frozen interval and is updated every two days. Engineering modification is the top reason for MPS changes, and C2 also uses WIP inventory to respond to unexpected schedule changes. According to the managers at C2, customer C1 only occasionally requests volume changes and is subject to magnitude and frequency limitations.

4.2.3 Case C1 and C3

Like C2, company C3 is much smaller than C1 but still receives the same types of information sharing from C1. However, we note C3's distinctively more-powerful position, in comparison to C2's relationship with C1. First off, C3 is one of two firms capable of producing the metal cases for C1, whereas C2 faces more competitors in the supplier pool. In addition, C1's demand only accounts for 20% of C3's sales revenues. The metal cases not only need a 2-week manufacturing lead time but also play a critical role in a laptop's quality, since customers can see and touch the exterior case before they even turn on the computer. Therefore, C3 appears to enjoy more power leverage even though it is also a small supplier.

Besides making a periodic commitment, C1 also provides a total minimum commitment to C3. C3 uses an MPS with a 4-week frozen interval and a weekly re-planning interval. The manufacturing flexibility is only moderate because a high cost of switching from one type of case to another, due to size, color, and metal properties. Engineering modifications are cited as the top reasons for schedule changes, although customer C1 also frequently injects volume changes. If C1 wants to change the quantity of the committed orders, C3 allows only a 10% magnitude change and would charge C1 for doing that.

Nevertheless, C3 would rather adjust its MPS to accommodate unexpected schedule changes than build WIP or FGI inventory.

4.3 Cross-Module Analysis and Propositions

In the automotive module, the most distinct element about power is that the customer accounts for (over all products made) 20% of A1's annual revenues. None of the companies in this module give a formal quantity commitment on their purchasing contract, although A1 does honour the A3 order that is committed 4 weeks in advance. Good will and future contract opportunities are the main rewards for suppliers working under this type of purchasing practice. Concerning information sharing in this module, only A1 shares its inventory and sales forecast with A3. A1 allows its customer to change their committed delivery quantity, while both A2 and A3 will charge A1 if the volume change incurs extra costs, such as ordering less than a full truck load or additional production requires extra setups. This could be explained by the lack of power of A1 over both its customer and two suppliers. Both A2 and A3 have a frozen interval of four weeks in their MPS. However, this identical interval appears to be a coincidence because A2's polymer production needs to consider many other customers in addition to A1, while A3's MPS is dedicated to the sole-sourced shaft.

In the laptop computer module, it appears that sharing information with suppliers and making purchasing commitments are the norm--acting independently of the power relationship. Suppliers are more likely to set limitations or additional charges to customers who deviate from their committed order quantity. Compared to C2, C3 is a more powerful supplier because of the complexity and higher value of its components. However, suppliers C2 and C3 each choose a schedule change strategy that works best for their interests.

From the cross-case analysis, we develop the following propositions:

- Power may dictate the arrangement of MPS and pre-empt an established schedule, even encroaching on the frozen portion of the MPS. To a supplier, this means bearing the costs of incurred schedule changes in order to please an important customer.
- The customer's power and the supplier's frozen interval in MPS have an inverse relationship. On the other hand, the re-planning frequency of an MPS is not affected by information sharing or customer power.
- Power and dedicated asset have an interesting relationship. Commonly seen in a sole-sourcing situation, dedicated asset, such as the vendor-managed inventory between A1 and A2, is regarded as a "two-edged sword." It creates a stronger bond and commitment in the dyad relationship, and tends increase

schedule stability. However, in special circumstances, the supplier is willing to change schedules to accommodate customer needs. By absorbing such change costs, suppliers hope to be compensated through other means.

- Suppliers' process flexibility may attenuate or neutralize the influence of customer power. High process flexibility mitigates the impact of schedule changes and hence reduces the need to maintain a stable MPS.
- In general, customer power dictates purchasing collaboration and commitment; more powerful customers give less binding commitment. However, the norm of a particular supply chain, such as the laptop module in this study, may override this power.
- Information sharing can improve MPS stability and reduce the length of an MPS' frozen section. Nevertheless, power does not appear to affect the intensity of information sharing. That is, a less powerful customer does not necessarily increase or decrease the intensity of sharing its sales forecast, MPS, or inventory status with suppliers.

5. Conclusion

We used six case studies to explore how supply-chain power relationships affect master production schedule flexibility. We found that power appears to influence schedule flexibility, either directly or indirectly. Supplier's process flexibility attenuates the influence of customer power, while the customer's extent of information sharing and commitment to the purchase quantity do not necessarily depends on power.

We recognize that with six case studies we cannot generalize the findings to other cases or other industries. Nevertheless, this study brings forth some interesting observations and sheds light on the complex interactions between power, MPS, and others factors. We hope that this study will call for future studies, such as more cases or large sample surveys, to further explore this new subject.

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