The Value of Supply Chain Disruption Duration Information

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Firms face a dilemma when managing disruptions in their supply chains. On one hand, disruptions occur frequently and often without consequence. On the other hand, information on the true duration of a disruption can be prone to uncertainty. Disruptions that are initially perceived to be short can wind up being materially longer and materially more costly to downstream customers. Given the uncertainty about the true duration of disruptions, it is unclear how aggressively firms pursue additional information when they become aware of a disruption. In light of this dilemma, our research seeks to answer three questions. First, under what conditions is it worthless for the firm to gather and act on more information about the duration of a supply chain disruption? Second, when it is valuable to secure more information about the duration of a disruption, what influences the magnitude of this value? Finally, if perfect information about the duration of a disruption is unattainable, under what circumstances can intermediate levels of information provide value? In answering these questions, we seek to improve managerial decision making on the deployment of information gathering resources in the aftermath or in anticipation of a disruption.

Our work complements existing research regarding the benefit of information sharing in supply chains. Much of the focus of this research is on the value generated when the buying organization shares more information about its demand and / or inventory with a supplier, but some work also focuses on the value generated when the supplier shares more information about its inventory position with the buying organization. Our work examines an unstudied form of information sharing – the value generated when the supplier shares more information (or the buyer otherwise gathers more information) about the duration of a supply chain disruption.

Supply chain disruptions can occur without advance notice and have an uncertain duration. We model the end of the disruption using discrete integer probability distributions measured in weeks. We consider 56 different distributions consisting of uniform, left-peaked, center-peaked, and right-peaked probability distributions using all of the possible 3-week and 5-week intervals between 1 and 10 weeks. We examine five common forms of information concerning the duration of disruptions – naive point estimates, ranges, probability distributions, probability distributions with delayed updating to perfect information, and probability distributions with immediate updating to perfect
information. We label these forms of information from level 1 (naive point estimates) to level 5 (probability distributions with immediate updating to perfect information) in ascending order generally based on the amount of information that is captured.

We develop several mixed-integer programming models, some using stochastic discrete optimization and some using robust discrete optimization depending on the different forms of uncertainty in the analysis. These models allow managers to identify which disruptions will be materially more damaging if the duration information is incomplete. We measure the damage of a disruption in terms of its impact on the firm’s gross margins. Other objective measures (revenue, units sold, net income, lifetime value, etc.) are trivial to implement. We conduct our analysis using detailed operational and supply chain data from our research partner, a division of a Fortune 500 diversified manufacturing firm. This division manufactures tools and equipment primarily for large retailers who then sell the product to consumers. We examine the impact of a disruption to each of the 524 unique supplier-part pairs in the firm’s tier-1 supply chain.

Our research yields three main results. First, we show that additional information on the duration of a disruption is often worthless. Across the 29,344 disruptions that we analyze (524 unique supplier-part pairs multiplied by 56 different duration distributions), the expected value of information is zero 79% of the time (or 23,172 out of 29,344 disruptions). Knowing what drives incremental information to be worthless is useful in a practical setting because it helps managers identify situations in which it is not worthwhile to seek additional information about the duration of a disruption. We find that if any one of several factors is present in a disruption scenario, then the value of additional disruption duration information has no value. First, there is sufficient buffer (part inventory, finished goods inventory, work-in-process inventory, and alternative sources of supply) to fully meet demand over all possible duration outcomes. If sufficient buffer exists, then the impact of the disruption is zero, and therefore the impact of additional information about the disruption will be zero. Second, there is only one product (after accounting for finished goods inventory) that requires an allocation of the disrupted part during the longest possible disruption duration. In such a case, the firm does not need to make an informed choice about which products will receive an allocation of the disrupted part. Instead, all available quantities of the part will be allocated to the single dependent product. Third, there isn’t any part inventory, work-in-process inventory, or parts available through an alternative source of supply for the disrupted part. In this circumstance, the firm does not need to make an informed choice about how to allocate the disrupted part because there is nothing available to allocate. Fourth, the gross margin on a per part basis for the disrupted part is the same across all products that require an allocation of the disrupted part. In this case, the impact of the disruption on the firm’s gross margin will be the same regardless of which products receive an allocation of the parts.
If none of the aforementioned factors is present, then the disruption duration information will have some value, but the expected value of this information can vary substantially across different disruptions. Across the 6,172 disruptions for which information has some value, this expected value can range from less than $1 to more than $345,000 (or less than 0.1% to 100% of the expected cost of the disruption under level 1 information). There are 375 disruptions for which the value of information exceeds $100,000. For these disruptions, the value of information represents a weighted average savings of 30.7% of the expected cost of the disruption under level 1 information. It is advantageous for managers to know what factors lead to a higher value of information in a disruption because it helps them identify (1) when it is most beneficial to secure such information and (2) how to reduce the company’s exposure in settings under which they are unlikely to receive robust disruption duration information. To assist practitioners with this, our second result is to identify those factors that influence the magnitude of the value of information. Among our findings are that the value of information is concave with the number of products that are dependent on the disrupted part, the ratio of buffer to demand for the disrupted part, and the disruption duration (we use the maximum duration for each the distribution in our tests). The value of information has a mostly convex relationship with the range in gross margin over the products that are dependent on the disrupted part.

In many cases, it is not feasible for the firm to obtain perfect information about the duration of a disruption. To address this, our third result is to identify the relative value of intermediate levels of information and describe under what circumstances these levels of information are more or less valuable. While a higher level of information is generally more valuable than a lower level of information, this is not always true. We show that under common objective functions, level 2 (duration range) information can destroy value in some cases by increasing the expected cost of a disruption relative to its expected cost under level 1 (naive point estimate) information. The value of different levels of information can also differ widely. For instance, for some disruptions, level 2 or level 3 (probability distribution) information is sufficient to capture most or even all of the benefit the firm could achieve under perfect information. We show that the factors that are related to the value of perfect information are also related to the value of less complete levels of information.

The value of duration information varies considerably across disrupted parts, and it is often not clear to managers which disruptions are sensitive to improved duration information. Gathering complete duration information for all disruptions is infeasible, however. Such an effort can require considerable effort and expense, including conducting supplier site audits, developing actuarial models, and enlisting independent experts. Identifying the disruptions whose impact is sensitive to the level of duration information allows managers to make informed decisions about when it is worthwhile to invest in gathering such information.