HISTORICALLY INCOHERENT ESTIMATES OF THE VALUE OF LEAD TIME RELIABILITY

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ABSTRACT

Current theory holds that the distribution of demand during lead-time and the required in-stock service levels can explain the incoherent value of reliability (VOR) estimates published in the transport economics literature over the past 25 years. We argue that these two elements, alone, are inadequate to explain inconsistent VOR estimates and present other important factors.

INTRODUCTION

Knowledgeable shippers have struggled to evaluate the economic value of lead-time reliability (VOR) accurately, as evidenced by the incoherent shipper perceptions reported in the transport economics literature over several decades [10]. Meanwhile, research has shown that it is not only theoretically possible for *improvements* in lead-time reliability to paradoxically *increase* reorder points and safety stock [21] [22], but likely [10]. Dullaert and Zamparini [10] recently proposed that this paradox could offer a novel explanation for the difficulty that shippers have in accurately estimating the benefits of decreasing lead time variability, as measured by the standard deviation of lead time, to inventory and total costs. They conducted an analysis based on specific real-life data in [27] to demonstrate "how the distribution of demand during lead-time and the required service level can explain the wide variety of VOR estimates (including negative estimates) obtained in the transport economics literature" [p. 199]. This paper explains why the aforementioned paradoxical phenomenon is inadequate to explain the VOR incoherence.

DISCUSSION

The incoherent VOR estimates found in the transport economic literature are a direct consequence of three problem elements: (1) the use of different methodologies, (2) the theoretical limitations of inventory models, and (3) the difficulties in applying them.

Different Methods

Researchers have used different methods to estimate the value lead-time reliability, which range from a narrow focus on safety inventory to a broad total landed cost perspective. For example, Chopra et al. [4] consider only safety inventory, Chaharsooghi and Heydari [3] consider safety inventory and stock out costs, Song et al. [21] consider ordering, safety inventory, cycle inventory and shortage costs, Tyworth and Zeng [26] consider total logistics costs (including pipeline and transportation costs), and Tyworth and O'Neill [25] consider total landed cost (including product cost).

Meanwhile, different service metrics have exacerbated the problem of getting a clear assessment of VOR. Dullaert et al. [7, p. 276] list the numerous service metrics used by researchers and correctly note that safety inventory based on the cycle service level ("S1") metric does not consider the order quantity—and thus the order frequency—that influences the accuracy of the true service realized. This finding undermines the current theory proposed by Dullaert and Zamparini [9] [10], because they only consider reorder points based on cycle service levels and safety stocks. Since the economic benefit of lead-time reliability is either an increase in product availability with the same safety stock or a decrease in safety stock to achieve the same availability target, the assessment of VOR must consider the two key drivers of availability (fill rates): shortages and order quantities.

The use of different statistical forms to evaluate out-of-stock exposure and expected units short is another source of potential confusion. For example, the exponential and Poisson distributions conflate the effects of speed and reliability into a single parameter [13].

Finally, stylistic assumptions not grounded by industry benchmarks either for analytical tractability or for lack of real data may add little, if any, clarity in the eyes of a practitioner despite claims of useful general insights. Examples include constant demand [12], zero lead-time [22] [28], zero order or setup cost [3], and ungrounded distributional forms to model demand over lead-time [13].

Theoretical and Practical Limitations

Inventory theory provides answers to how and when to order based on long-run expected costs given static cost and service conditions. Shippers, however, face a dynamic business environment. Although seasonal demand is handled easily in theory and practice, lead-time fluctuations have received relatively little attention. Yet, Saldanha et al. [18] demonstrate the significant seasonal fluctuations in lead-time over several high traffic trade lanes. Additionally, carrier practices can amplify such variability. On one hand, slow-steaming practices either to reduce capacity in the presence of weak global economic growth or to save fuel in off-peak periods [11] exacerbate ocean lead-time seasonality. On the other, practices such as "bumping," "skipping" and "cut and run" prevent containers from making the scheduled voyage, thereby increasing lead-time and lead-time variability during peak periods [2]. Since these practices occur mostly in the Pacific lanes, seasonal variations are likely to differ by lane. The operational complications resulting from these practices affect not only the theoretical researchers that struggle to model them but also the managers that try to cope with them.

Implementation Issues

Firms confront important implementation issues when trying to evaluate their out-of-stock exposure risk. Although theoretical and empirical evidence indicates that the risk period should encompass door-to-door lanes [19], anecdotal evidence indicates that shippers often focus on segments, such as port-to-door and port-to-port and use a variety of metrics to measure lead-time performance, including comparing actual transit time to contract, schedule, and average transit time [2].

A directly related implementation challenge is collecting the lead-time data required to characterize the distribution of demand over the out-of-stock exposure period (X) accurately. There is no publicly available evidence that companies collect direct observations of X. Instead, they gather data on demand and lead-time separately with various levels of sophistication. Even when such data are collected, the majority of shippers "[U]se manual or spreadsheet based processes for import operations" [1, p. 6]. In the rare cases when such data are available, the ERP systems are not capable of modeling their distributions accurately [6].

One of the most significant barriers to practitioners' understanding of VOR is, perhaps, what Caplice alludes to as the "disconnects between the procurement staff negotiating the contracts with carriers and the operations team that must execute them" [23]. Caplice goes on to note that ocean contracts are "simply thrown over the wall" between procurement and operations. The fracturing of strategic and operational responsibilities may remove incentives to monitor and measure lead-time performance even if the systems were available to do so.

CONCLUSIONS

Future research on the value of lead-time reliability should address methods, limitations, and implementation issues to clarify methods and metrics for consistent applications. Using input parameters and service metrics based on industry benchmarks together with a door-to-door setting and a total landed cost criterion would certainly enhance clarity. When modeling out-of-stock risk, research on carrier schedule unreliability, individual segment lead-times, lead-time fluctuations, and correlations between segments would add important insights to the importance of accurately characterizing that risk in practice. Such a research agenda would contribute to providing effective guidelines on when to use relatively simple methods to assess out-of-stock risk exposure and when more involved methods are necessary.

Finally, the functional fragmentation of operational processes into multiple strategic and operational tasks presents an important research opportunity. Cyert and March [5] first characterized this as a problem of local rationality which is "[T]he tendency for the individual subunits to deal with a limited set of problems and a limited set of goals" (p. 165). Future research could explain the factors such as bounded rationality leading to greater local rationality among larger firms by synthesizing transaction cost, resource-based and real options theories [16], and demonstrating the adverse effects of inter-departmental competition driven by incentive misalignment [24]. The lenses of information processing and structural contingency and configurational theories could be used to develop organizational governance mechanisms that integrate the strategic and operational processes across operational processes [17].

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