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Bracing for demand shocks: An experimental investigation

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ABSTRACT

We investigate inventory ordering decisions when decision makers anticipated a demand shock. Decision makers anticipating an event have been shown to brace for an uncertain negative outcome by overestimating the likelihood of that event. Decision makers faced with a spike in demand may incur increased holding costs because they may brace, exhibiting a judgment bias, and consequently a decision bias by over-ordering inventory. Three studies span conditions of uncertainty regarding the timing and magnitude of a demand shock: Employing three between-subjects experiments, Study 1 investigates behavior when decision makers were faced with uncertainty in timing and in magnitude of demand at the most elemental level, manipulating holding and stock out costs. The three experimental tasks feature uncertainty about the magnitude of demand (Experiment 1.1), uncertainty about the timing of demand (Experiment 1.2), and uncertainty about both the magnitude and timing of demand (Experiment 1.3). Study 2 uses a dynamic, multi-period replenishment task and a between-subjects manipulation regarding the uncertainty of timing and magnitude of a demand shock. Study 3 also employs a multi-period decision environment, but compares behavior under a demand shock condition with that in a condition featuring only random variability. The collective results from the three studies identify a bias toward over-ordering in response to a demand shock, relative to the optimal orders. The between-subjects manipulations in Study 2 points toward a possible remedy as we found that providing information concerning the timing and magnitude of a shock ameliorated the bias. The primary revelation was that decision makers had more difficulty dealing with uncertain timing than with uncertain magnitude of demand. One implication is that it is particularly critical for retailers to carefully plan and manage how they share information with upstream supply chain partners regarding *when* they plan to introduce store-level promotions.

1. Introduction

In recent years, behavioral operations researchers have developed a robust literature investigating inventory ordering decisions under a variety of conditions, including stationary and non-stationary demand. However, one lingering question remains: how do inventory decision makers anticipate and react to *demand shocks*, sudden and temporary increases in a product's demand? As we will discuss, previous explanations for biases demonstrated in the literature are not sufficient to explain behavior in this context.

Promotions (e.g., price discounts, bundling with complementary product, product placement in an end cap display), and competitive events (e.g., competitor stock-outs) are pervasive causes for demand shocks.[1] While the normative literature considers the joint promotion-inventory management problem (Cheng and Sethi, 1999) as well as the joint promotion-production decision (Sogomonian and Tang, 1993), inventory ordering *behavior* in the face of demand shocks has not been previously studied.

The nature of such event-based spikes has unique behavioral implications for the decision processes of inventory managers, different from the standard processes such managers face with standard demand processes (Schweitzer and Cachon, 2000). Being unprepared for a spike in demand is undesirable due to the increased probability of demand not being filled from on-hand inventory and of the resulting consequence of a stock-out. Thus, while a salesperson may view a surge in demand positively, an inventory manager may view a demand shock negatively because it may result in stock-outs. Therefore, the decision maker is likely to take action to cope with the anticipated, if uncertain, event.

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[1] Negative demand shocks due to events such as catastrophic events, natural disasters, and competitor promotions are also pervasive but the current research confines its scope to decision behavior with positive demand shocks.

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Specifically, under such conditions, decision makers will *brace* for the possible occurrence of the event. This means that their judgment of the probability of experiencing the negative event may become pessimistic (Taylor and Shepperd, 1998). In this circumstance the pessimistic bias can be detrimental to efficient decision-making.

Bracing can take multiple forms (Shepperd et al., 2005), including decisions to avoid the possible negative outcome (Norem and Cantor, 1986). Because many inventory ordering decisions still use human judgment processes in some form (Sanders and Manrodt, 2003) and the response to these event-based shocks are the least likely to be automated in inventory control systems, it is imperative to understand this decision-making behavior, identify any judgment bias, and ameliorate the subsequent effects which lead to sub-optimal inventory control performance.

When facing inventory ordering decisions, decision makers rarely have complete demand information and, in particular, may lack certainty of information regarding upcoming demand shocks. This research examines two types of uncertainty about demand shocks: magnitude uncertainty and timing uncertainty. *Magnitude uncertainty* refers to the uncertainty regarding the number of units to which demand will increase due to the shock. *Timing uncertainty* refers to the uncertainty regarding the period in which the demand shock will occur.

Croson and Donohue (2003, 2006) found that providing certain types information to decision makers in a serial supply chain led to improved decisions and reduced occurrence of a disruptive supply chain phenomenon (i.e. the bullwhip effect). In this research, we posit that providing decision makers with information about a demand shock, particularly timing and magnitude information, may reduce observed bracing behavior. However, obtaining such information likely relies on more than the will of an individual firm; buyers and sellers must share information in order for such knowledge to be acquired. The extant operations management literature is replete with studies that examine the decision-making effects of shared information. This literature has shown that effective information sharing significantly enhances supply chain practice (e.g., Sahin and Robinson, 2005; Zhou and Benton, 2007). One explanation, based on information processing theory, is that information visibility reduces uncertainty which, in turn, improves task performance (Bendoly and Swink, 2007). Some uncertainty regarding demand shocks could be reduced if agents in the supply chain would share information both upstream and downstream. However, Bendoly and Swink (2007) demonstrate that information also plays a role as a moderator of behavioral relationships, and that the benefits of information in organizations can be subtle and nuanced. Understanding the different, and sometimes unexpected, ways in which information and uncertainty can affect decision behavior is integral to designing effective supply chain processes. The objective of this research, therefore, is to first identify empirical regularities (Smith, 1994) so that we understand the biases that may infiltrate the decision-making process. There are examples of biases that result from role of information; specifically, Osadchiy and Bendoly (2010) find that the presence or absence of information influences over and underestimation of risk in purchasing settings. Once these biases are well understood, we can then seek to identify means to ameliorate their effects or to eliminate the biases.

Sweeny and Shepperd (2007) show that in the face of uncertainty, it has been shown decision makers will *brace for a loss* in anticipation of an event that could have a negative outcome. Bracing is judging that *an undesirable outcome is more likely to occur* than the objective evidence would suggest, in order to prepare for possible negative outcomes. Some may view bracing as an adaptive goal state-of-readiness (Carroll et al., 2006) to respond to uncertain outcomes. The evidence for bracing is replete throughout the literature in a variety of contexts. Decision makers tend to brace based on judgments of the likelihood of events such as the revelation of academic test scores, financial outcomes, and medical tests (Sweeny and Shepperd, 2007).

This research suggests that decision makers brace when faced with the uncertainty of a demand shock. While in some cases this readiness can be functional (as it can result in heightened alertness and consequently better preparation to cope), we argue that in the case of inventory ordering, it may lead to sub-optimal decision-making.

Optimal ordering decisions are derived from properly balancing inventory holding costs with stock-out costs. However, any behavioral tendency that creates a judgment bias in a given period may create a decision bias where the decision maker will not make optimal ordering decisions. This results in the ordering of too much or too little inventory as the decision maker overestimates or underestimates demand in that period. In this research, we study the conditions – magnitude and timing uncertainty – under which bracing for a demand shock leads to suboptimal inventory ordering decisions. As a first step, Study 1 combines three experiments designed to examine ordering behavior in the face of the most elemental components of demand uncertainty: the magnitude, the timing, and both magnitude and timing of demand. Study 2 uses a dynamic multi-period task to study demand shocks in which the experimental design is 2(magnitude known/uncertain) × 2(timing known/uncertain). Finally, Study 3 compares decision-making between a demand shock condition and a condition of only random demand uncertainty.

We seek to first understand the behavior of inventory decision makers in the face of demand shocks, and to identify and document biases. Specifically, we ask whether decision makers will display a judgment bias when faced with event-based uncertainty of demand. We also ask whether knowing the timing and/or the magnitude of a demand shock will ameliorate a bias. Finally we ask whether behavior in response to event-based uncertainty is different from behavior in response to random uncertainty. In pursuit of these objectives, the paper is organized as follows: Section 2 presents a brief review of literature relevant to motivating the current research and developing hypotheses. Section 3 describes the three studies used to test our hypotheses and reports their results. Section 4 presents conclusions from the findings of the studies, relates these conclusions to decisions faced by supply chain managers, and presents opportunities for future research.

2. Background and hypotheses

2.1. Inventory decision-making

A body of behavioral inventory decision-making literature focused on judgment and decision biases and resulting inefficiencies has recently emerged (Bolton and Katok, 2008; Cantor and Macdonald, 2009; Croson and Donohue, 2003, 2006; Niranjan et al., 2011; Schweitzer and Cachon, 2000; Steckel et al., 2004; Sterman, 1989; Wu and Katok, 2006). The majority of these studies have used unknown demand (e.g., Steckel et al., 2004; Sterman, 1989), or stationary and known demand, specifically a uniform distribution (e.g., Croson and Donohue, 2003, 2006). Additional research has directly compared different patterns of demand in inventory decision-making; Benzion et al. (2008) manipulate a known demand distribution testing both uniform and normal demand distributions. Benzion et al. (2010) compare performance when the demand distribution is known versus unknown. Motivating their study is the reality that many practitioners in the field will not have information about the distribution of demand. They find no significant difference between uncertainty conditions (known and unknown demand) with regard to profits or the difference between