

**THE ROLE OF EMOTION IN THE NEWSVENDOR
PROBLEM**

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Abstract

The newsvendor problem is a foundational model for decision making in inventory and supply chain management. In its simplest form, the newsvendor must decide how many units to order of a perishable product that has stochastic demand. This single-period inventory problem sets the groundwork for more complex inventory decisions and has relevant applications in a diverse set of business fields such as capacity allocation, revenue management, and staffing in service industries. The optimal policy prescribing the order quantity that maximizes the expected profit is well documented. Not surprisingly, behavioral studies have found that human decision making deviates from the rational expected-profit-maximizing order. Interestingly, however, two systematic patterns arise when people make these decisions and have been replicated across multiple studies for almost two decades. First, when individuals adjust their order quantity over consecutive periods, they tend to do so in the direction of the most recent demand realization. This phenomenon is commonly referred to as *demand-chasing*. Second, when order quantities are averaged across periods, they tend to fall between mean demand and the optimal order quantity. This pattern has come to be known as the *pull-to-center effect*.

Existing literature suggests dispositional factors, like whether people tend to follow an anchoring and insufficient adjustment heuristic, may explain these patterns. However, these studies have primarily assumed an observer's perspective and have failed to identify what the cognitive mechanism that explains why people choose a particular order quantity is. Supporting this claim, a recently published literature

survey concluded that there is a lack of understanding of what the cognitive processes that drive ordering behavior are and hence, it is unclear what the underlying explanation for these effects is. This dissertation addresses these shortcomings in two essays.

The first essay focuses on demand-chasing. By considering the actor’s perspective, we show that the situation in which decisions are made in the newsvendor problem explains why people chase demand, and thus dispositional inferences are unwarranted. In an experimental setting, we test our hypotheses which are based on counterfactual thinking theory and find that decision makers experience a negative cognitive-based emotion—regret—, and this emotion predicts demand-chasing behavior. The second essay focuses on the pull-to-center effect. Having identified, in our first essay, a crucial cognitive mechanism through which ordering behavior can be explained, we develop hypotheses describing the influence such mechanism has on average order quantities being pulled-to-center. Results show that as decision makers chase demand their average order quantity is more pulled-to-center, but this effect is contingent on the level of knowledge individuals have about the newsvendor problem.

In conjunction, these essays provide a comprehensive understanding of decision making in the newsvendor problem by identifying a cognitive-based emotion resulting from situational factors and showing how it affects ordering behavior in the form of demand-chasing, which in turn affects aggregate level patterns and performance. The theoretical implications of this dissertation focus on explaining *why* people order what they do and providing a single unifying mechanism through which past findings can be interpreted and reconciled. The practical implications focus on specific managerial actions that help mitigate the deleterious effects of self-blame that occur when people regret the choice they made.

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Chapter 1

Introduction

A fundamental question in supply chain management is how much to order. When customer demand is uncertain, ordering too many results in unnecessary costs due to inventory being discarded, stored, or salvaged, while ordering too few results in lost sales and dissatisfied customers due to products being out-of-stock. This situation worsens when inventory cannot be carried from one selling period to the next because, for example, products become obsolete or outdated. Inventory managers across different industries face this problem when choosing ordering levels for fashion goods, perishables, technology devices, seasonal products, spare parts, and more. Because this situation resembles that of a newsboy who must decide how many newspapers to order in advance that will be for sale at his newsstand during the day, this problem is called the newsvendor problem. Inventory management is not the only business context in which this problem appears. When a fixed set of resources or products are to be allocated so as to minimize the expected cost or maximize the expected revenue, such as capacity allocation, staffing in service industries, and revenue management, managers face a closely related problem.

The optimal solution to the problem, which determines the order quantity that maximizes the expected profit, is well known (Arrow et al., 1951). However, behavioral studies have found that human decision making deviates from what is prescribed analytically (Schweitzer & Cachon, 2000). When averaged across periods and indi-

viduals, order quantities systematically fall between the optimal order quantity and mean demand. Because average order quantities seem as though they are pulled away from what is optimal and toward mean demand, this aggregate level pattern is known as the pull-to-center effect. Although this effect has been replicated in almost every behavioral newsvendor study and indicates decision makers often obtain much lower profits than those they could have achieved had they chosen differently, why it occurs is unclear.

To date, researchers have studied the pull-to-center effect through four different perspectives: heuristics and cognitive biases, utility functions, special modeling forms, and individual heterogeneity characteristics. These perspectives have contributed to determine which factors may be related to the pull-to-center effect and develop economic models that predict order quantities that exhibit a similar aggregate level pattern. However, they fall short of identifying the cognitive processes that take place when decision makers place orders and explaining how these processes may lead to average order quantities being pulled-to-center (Becker-Peth & Thonemann, 2019). For example, we now know that if decision makers follow an anchoring and adjustment heuristic when choosing, their average order quantity is likely to be pulled-to-center, but which individuals follow such heuristic, as well as when and why they do so is less clear.

Undisputedly, the pull-to-center effect has received most of the attention in the behavioral newsvendor literature. However, researchers also report another pattern occurring at a choice level. Decision makers tend to adjust their order quantity from one period to the next in the direction of past demand. The literature suggests three plausible explanations for why this demand-chasing behavior may occur. Individuals chase demand because they follow a specific type of anchoring and adjustment heuristic, believe that independent draws are correlated, or have low cognitive reflection. However, existing findings cast doubt on whether these reasons robustly explain why

decision makers chase demand.

Although the foregoing perspectives through which the pull-to-center effect has been studied, as well as the plausible explanations offered for demand-chasing behavior vary, they seem to emerge from a shared viewpoint—the observer’s viewpoint. Because this viewpoint lacks the awareness of situational forces that influence those who make choices—the actors—, it makes inferences about their dispositions even when the observed behavior is explained by the situation (Gilbert & Malone, 1995). Therefore, it is not surprising that existing explanations have attributed these patterns to dispositions of decision makers (e.g., their tendency to follow a heuristics).

The essays that follow propose studying the newsvendor problem from a different viewpoint—the actor’s viewpoint. In doing so, we recognize the situation in which decision makers place their orders and infer how what they experience influences the choices they make. The first essay is devoted to explaining why decision makers chase demand when placing orders, and the second essay focuses on explaining why average order quantities may be pulled-to-center. We find that decision makers behave in a way that is expected when choices are made under the influence of situational forces present in the newsvendor problem, and that what seemed, so far, to be distinct patterns, are in fact closely related and explained by the same underlying mechanism—an emotion called regret. These results evidence the critical role emotions play in human decision making, and show how pervasive emotions are even in contexts like the newsvendor problem, which are generally characterized by more rational decision processes.

Chapter 2

Essay 1: When Emotion Gets in the Way: An Experimental Analysis of Demand-Chasing in the Newsvendor Problem

2.1 Abstract

Prior research has demonstrated that when placing orders in the context of the newsvendor problem, decision makers tend to adjust their orders in the direction of recent past demand realizations. This suboptimal behavior, known as *demand-chasing*, is found in both field and experimental settings. To date, the literature suggests the dispositions of decision makers (e.g., their tendency to use heuristics) explain this behavior, but in the present study we offer a plausible alternative explanation. Specifically, we argue and find that decision makers in the newsvendor problem feel regret—a negative cognitive-based emotion—motivated by counterfactual thinking as they realize they would have fared better if they had placed a different order, and this emotion predicts demand-chasing behavior. Because the behavior is induced by the situation, dispositional inferences are likely unwarranted. In addition to identifying the key mechanism leading to the emotion, we report two conditions that can affect the extent to which decision makers experience regret and show the effects these conditions have on demand-chasing are not direct but driven solely by this emotion. So robust is the effect of regret on demand-chasing that this effect

persists no matter how much more decision makers know about the problem. These theoretical insights provide the basis for us to reinterpret mixed findings in the existing literature. The results of our study suggest that if managers wish to help decision makers avoid demand-chasing, then training them how to cope with the emotional effects of counterfactual thinking is a necessary and important first step.

2.2 Introduction

The newsvendor problem models a situation in which a newsboy must decide how many newspapers to order in the morning that will be for sale at his newsstand during the day. This single-period inventory problem is the foundation for more complex inventory problems and it applies to a variety of business domains such as capacity allocation, revenue management, staffing in service industries, R&D investment, insurance acquisition, and scheduling in project management.

Given the unit cost, selling price, salvage value, and demand distribution function, the newsvendor problem has an optimal solution that maximizes the expected profit (Arrow et al., 1951) by way of an expected-profit-maximizing (or optimal) order. Behavioral studies have found that human decision making systematically deviates from the expected-profit-maximizing order (Schweitzer & Cachon, 2000). But perhaps more surprising is the evidence presented by several of these studies of a *demand-chasing* behavior (e.g., Benzion et al., 2008; Bolton & Katok, 2008; Lurie & Swaminathan, 2009; Kremer et al., 2010; Moritz et al., 2013; Lee & Siemsen, 2017)—characterized by ordering less after a period when excess inventory had to be disposed of and ordering more after a period when profit was forgone. In practice, a notable occurrence of this behavior was observed in the famous IBM supply shortage of Aptiva PCs. The company reportedly gave up potential revenue of about US\$100 million because of sales lost to the shortage. The shortage has been attributed to the com-

pany’s caution in planning for the Aptiva launch in 1994 because of oversupplying the ValuePoint product line earlier, a mistake that left the company with an inventory worth US\$700 million in unsold PCs (Ziegler, 1994).

Why, then, do people chase demand? Is it simply because decision makers observe customers’ demands after placing orders for them and this information is readily available from memory? Or is chasing demand the result of wanting to undo and correct a situation in response to strong feelings associated with prior decisions? Although the former would imply that cognitive processes explain the behavior, the latter suggests emotional aspects are at play. In an economy in which the cost of overstocks and out-of-stocks for retailers in the United States is estimated to be 3.2% and 4.1% of revenues, or up to about US\$123.4 billion and US\$129.5 billion annually, respectively (IHL-Group, 2015), finding answers to these questions seems pertinent.

Schweitzer & Cachon (2000) were the first to show evidence of a demand-chasing behavior. Arguing that decision makers follow an anchoring and insufficient adjustment heuristic, they reported that when individuals changed their choice from one round to the next, they were more than twice as likely to adjust their order quantity in the direction of demand in the previous round (24.7%) than away from it (11.0%). In contrast, arguing that decision makers think independent draws are correlated (i.e., the gambler’s fallacy), Bolton & Katok (2008) reported that they made orders that were statistically correlated (either positively or negatively) with the previous demand realization. Estimating an overall measure of demand-chasing for each individual based on a linear regression model, other researchers found that persons low in demand-chasing score high in cognitive reflection (i.e., tendency to let System 2 processes—analytical and reflective—moderate an initial System 1 response—intuitive and rapid) when placing orders under certain conditions (Moritz et al., 2013).

To date, the literature describes an important regularity: Some people tend to chase demand more often than others (i.e., variation between individuals), but no

single person chases or refrains from chasing demand every period (i.e., variation within individuals). However, none of the explanations for demand-chasing seems sufficient to account for differences observed within individuals choosing to chase demand in one period and declining to do so in the next period. Researchers have attributed demand-chasing to dispositional factors, suggesting that certain people are predisposed to behave this way. We propose instead that, because they affect decision makers, situational factors present in the newsvendor problem can explain such behavior. To the extent that dispositional inferences are logically unwarranted when people do precisely what the environment or situation demands (Gilbert & Malone, 1995), efforts to uncover situational factors that determine how decision makers behave are necessary.

After placing an order in the newsvendor problem, demand occurs and decision makers receive this information. Consequently, they may realize they would have been better off if they had chosen a different order quantity, and they regret their decision. Regret is a negative, cognitive-based emotion we experience when we realize or imagine that our present situation would have been better had we decided differently in the past (Pieters & Zeelenberg, 2007). Although it may vary in intensity and severity, we are exposed to feeling regret every time we make a choice (Zeelenberg et al., 2001). Two preconditions, both of which are present in the context of the newsvendor problem, are necessary for people to experience regret: an element of personal agency and the realization that another choice would have been better (Zeelenberg & Pieters, 2007). Therefore, the extent to which people experience this emotion when placing orders in the newsvendor problem may vary across periods, depending on the choices they have made and the specific situation they face. Because regret produces an aversive state that people are motivated to regulate (Pieters & Zeelenberg, 2007) and has been shown to influence choice behavior in systematic ways by switching to alternate options (Zeelenberg & Beattie, 1997; Zeelenberg & Pieters, 1999; Tsiros &

Mittal, 2000), one can expect this emotion to play an important role in this problem. This leads to our first research question: (1) Do people chase demand because they regret having made a poor decision and are motivated to undo and correct the situation?

If regret plays a significant role in ordering behavior, then it is also necessary to identify its antecedents. Feedback about chosen and foregone outcomes has been shown to be essential in realizing an alternate option could have been better and thus inducing a sense of regret (Zeelenberg & Beattie, 1997; Creyer & Ross, 1999; Tsiros & Mittal, 2000). In the newsvendor problem, such feedback can arise in two situations—one in which demand for papers is known only from sales made (later we refer to this idea as censored demand) and the other in which demand for papers is known from sales made as well as unfulfilled customer orders (later we refer to this idea as uncensored demand). In addition, the types of thoughts that trigger regret become activated as discrepancies between actual and ideal goal states become apparent (Roese & Epstude, 2017). In the newsvendor problem, such discrepancies can arise from situations in which papers being sold are considered as either low- or high-profit-margin products. These situations that characterize the newsvendor problem inspire our second research question: (2) Do people experience greater regret when demand is uncensored versus censored, and when placing orders for low- versus high-profit-margin products?

People vary in the level of knowledge they have about a specific problem they face. Being knowledgeable about the newsvendor problem suggests individuals realize there is a trade-off between ordering too many versus too few product, and that the quantity they should order depends on the unit price and cost of the product (assuming no salvage value), neither of which varies across periods. To the extent that having greater knowledge about the problem facilitates decision quality, which in turn serves to reduce the effect of regret on decision making, it seems reasonable to consider the

role of knowledge level in the newsvendor problem. Hence, our third research question is: (3) Are people who know more about the newsvendor problem influenced to chase demand more than those who know less?

Given its focus, our work makes at least three important contributions to the literature. First, instead of attributing demand-chasing behavior to dispositional inferences such as following a heuristic, falling victim to a fallacy, or reacting intuitively, we considered how the situation might cause decision makers to exhibit such behavior. We are the first to propose the idea that demand-chasing behavior is induced by a situation in which people make a specific decision. People experience regret—a cognitive-based emotion—when they realize that having ordered a different quantity would have been better. We introduce and measure experienced regret, the first empirical measure of emotion to appear in the newsvendor literature, and identify relevant antecedents of the emotion that are present in newsvendor settings. Our theoretical model presents how these factors are related and how they lead to demand-chasing behavior. Revealing these relationships shows, for example, that comparing ordering behavior and performance when people order low- versus high-profit-margin products without accounting for experienced regret, something that has been done frequently in past studies, is misleading and should be avoided.

Second, our study shows counterfactual thinking occurs and is the mechanism through which regret leads to the behavior, explaining *why* people chase demand in a given period. Uncovering this cognitive mechanism that drives demand-chasing has far reaching theoretical and managerial implications. On one hand, understanding why people chase demand reconciles mixed findings in the existing literature and we cover these in detail in our discussion. For example, Lurie & Swaminathan (2009) found that decision makers exhibited greater demand-chasing when they received demand information more frequently. Because realizing that another choice would have been better is a precondition for experiencing regret (Zeelenberg & Pieters,

2007), and in the newsvendor context this occurs when decision makers obtain past demand information, those who receive more frequent feedback will experience higher levels of regret. In turn, they will chase demand to a greater degree. Also, by introducing a measure of regret that is captured *in situ* we open the possibility for future research to explore and explain additional unresolved outcomes in newsvendor decision making and the influence of this emotion in other operational contexts. On the other hand, because demand-chasing behavior is suboptimal, having identified the mechanism that is at play together with its antecedents sheds light on ways in which certain actions may or may not improve performance in practice by addressing emotion (an unexplored topic in the existing newsvendor literature).

Third, because having greater knowledge about the newsvendor problem assists people in improving the quality of their decision by recognizing the main trade-offs and the parameters that matter (which do not change across time), we report a rather surprising finding. Our results indicate that how much one knows about the newsvendor problem has no effect on how experiencing regret affects demand-chasing behavior. This is relevant because it attests to the pervasiveness of emotion and its influence on decision making in an operational setting.

2.3 Literature

The newsvendor problem is one of the fundamental inventory problems studied in operations management. Arrow et al. (1951) introduced the problem and derived, analytically, the order quantity that maximizes expected profit. Assuming the product has no salvage value, this optimal order quantity q^* depends on the demand distribution function F together with the unit cost c and selling price p , and can be expressed as:

$$q^* = F^{-1} \left(\frac{p - c}{p} \right)$$

The term in parentheses is known as the critical ratio (or fractile) and has been used to classify the type of product being ordered (Schweitzer & Cachon, 2000). A high-profit-margin product has a critical ratio with a value of 0.5 or greater. A low-profit-margin product has a critical ratio below this value. Assuming a symmetric demand distribution, it then follows that the expected-profit-maximizing order falls above mean demand for a high-profit-margin product and below mean demand for a low-profit-margin product. The first researchers to analyze how human subjects place orders in the newsvendor setting were Hoskin (1983), who was interested in how people use opportunity costs, and Schweitzer & Cachon (2000), who were concerned with why people deviate from the optimal order quantity. Schweitzer & Cachon's (2000) work has been the foundation of most subsequent behavioral studies. We do not wish to provide an exhaustive review of all behavioral newsvendor studies here. Instead, we refer interested readers to a current and comprehensive literature review by Becker-Peth & Thonemann (2019). In the sections that follow, we focus on two streams of literature that inform our research questions.

2.3.1 Demand-Chasing

Consider a situation that begins with a person who, acting on behalf of a retailer, has placed a recent order and then knows what actual customer demand is. He or she must now decide how much to order for the subsequent selling period. The person may choose the same quantity that was ordered for the previous period (i.e., a repeat choice) or a different quantity by adjusting it upward or downward. Demand-chasing describes the behavior that occurs when a person chooses to order a different quantity for the following period by adjusting the previous order in the direction of the most recent demand realization. In other words, the new order quantity reduces the difference between the initial order and the actual demand that followed it. Because the conditions of the problem that determine the optimal solution do not change across

periods, modifying what is ordered as displayed by chasing demand has generally been considered sub-optimal behavior (e.g., Schweitzer & Cachon, 2000; Bolton & Katok, 2008; de Véricourt et al., 2013; Moritz et al., 2013). Nevertheless, researchers provide ample evidence, using different types of measures and reporting various statistics, that attests to the presence of such behavior. Table 2.1 lists the existing literature related to chasing demand, summarizes the evidence each study provides with respect to this behavior, and indicates the type of measure(s) it used. The table also shows the experimental conditions that have been found to be associated with chasing demand as well as the documented plausible explanations for this behavior.

For the most part, researchers have used four measures of chasing demand: (1) comparing *changes towards versus away* from demand realization in the previous period; (2) calculating and contrasting separate *adjustment scores* (e.g., proportion of units adjusted from the previous period to the next over deviation between ordered quantity and demand realization in the previous period) for changes toward and away from demand; (3) estimating a *regression coefficient* for a term that captures the weight given to the deviation between ordered quantity and demand realization in the previous period; and (4) evaluating the *correlation* between order quantities and previous demand realizations.

Using simulated data from two different stochastic processes, one that generates ordering decisions sensitive to demand in the previous period (i.e., as displayed by chasing demand) and the other that generates them independent of demand (i.e., quantal choice), Lau & Bearden (2013) produced thousands of 31-period decision sets and compared how well each type of measure of chasing demand performed in identifying the process that produced each set. They concluded that some measures are more likely than others to report false positives and false negatives (i.e., claiming the data was produced by one process when it was in fact produced by the other). This finding is particularly useful for studies attempting to classify subjects in one

Table 2.1: Newsvendor Literature Related with Chasing Demand Behavior

Study	Evidence	Type of Measure	Experimental Condition	Plausible Explanation
Schweitzer & Cachon (2000)	Although 64.3% of decisions were characterized by repeat choice, when subjects in Experiment 1 changed their order quantity, they were more than twice as likely (24.7% versus 11.0%) to adjust it toward past demand.	Changes towards vs. away Adjustment score		Anchoring and insufficient adjustment heuristic
Ben Zion et al. (2008)	Across all treatments, participants on average changed their orders toward demand in the previous round more often than they did away from demand in the previous round.	Changes towards vs. away		
Bolton & Katok (2008)	About 30% of subjects in the low-profit-margin condition and 10% of subjects in the high-profit-margin condition were reported to have a positive correlation between their orders and previous demand.	Correlation		Gambler's fallacy (i.e., fallacious belief that independent draws are correlated)
Bostian et al. (2008)	Parameter estimates of an analytical model show that a 10-unit difference between the order quantity and demand in the previous round produce a 1.5-unit change in order quantity in the following round.	Regression coefficient		
Katok & Wu (2009)	In all treatments of the retailer game, results show a positive correlation between order quantities and demand in the previous round.	Regression coefficient		
Lurie & Swaminathan (2009)	A GLM analysis for Experiment 1 shows orders are significantly associated with deviations between previous round order quantities and demand.	Regression coefficient	Feedback frequency	
Kremer et al. (2010)	Most decisions in the operations context are characterized by repeat choices (48.28%), but when order quantities are changed, most adjustments are made in the direction of previous demand (29.21% vs. 15.99%).	Changes towards vs. away	Context (i.e., neutral lottery context vs. operations newsvendor context)	
Feng et al. (2011)	Significant positive coefficients, indicating the degree to which order quantities are related with the deviation between prior order and demand, were found for both Chinese and American subjects.	Correlation		
de Véricourt et al. (2013)	Gender differences found in demand-chasing.	Correlation		
Lau & Bearden (2013)	Although the study does not present new evidence in favor of demand-chasing behavior, the authors classify and compare the different measures used in the literature to describe the phenomenon.			
Moritz et al. (2013)	Regression coefficients of a linear model in Study 1, show a positive relationship between orders and the deviation between previous order quantities and demand. A similar result was found using a correlational measure in which 86% of subjects presented positive correlations between their orders and past demand.	Regression coefficient Correlation		Cognitive reflection
Rudi & Drake (2014)	Rather than using a measure of demand-chasing, the authors found a consistent adjustment behavior (i.e., variability in order quantities) across different experimental conditions and claimed that robustness tests show subjects tend to chase demand.	Standard deviation	Variability in what is observed	
Lee & Siemsen (2017)	One possible factor described by the authors affecting random judgment error (i.e., the notion that human judgment is inherently stochastic) is demand-chasing. Results show that the standard deviation of random judgment error in order quantity is high for both conditions, direct order and task decomposition.	Standard deviation		
Schultz et al. (2018)	A one-sided t-test on the regression coefficient shows that 49.3% of subjects chase demand. In addition, based on the number of changes moving toward vs. away from prior demand, the authors reported that 84.9% of these were consistent with chasing demand.	Regression coefficient Changes towards vs. away		

of two categories—those who chase demand versus those who do not. For example, when chasing demand is conceptualized as being the result of following an anchoring and insufficient adjustment heuristic (e.g., Schweitzer & Cachon, 2000), the interest lies in identifying those who use the heuristic versus those who do not. However, the results presented by Lau & Bearden (2013) have less meaning when, instead of classifying subjects into categories, one is concerned about describing the behavior of an individual who may choose to chase demand in one period and abstain from doing so in the next.

Rudi & Drake (2014) and Lee & Siemsen (2017) provide yet another type of measure. Theirs is based on the *standard deviation* of orders to assess the variability of these quantities across periods. Acknowledging that demand-chasing occurs in the context of the newsvendor problem (as evidenced in Table 2.1), the standard deviation can be used as an indirect measure of such behavior.

After almost two decades of behavioral research on the newsvendor problem, the literature identifies several experimental conditions associated with demand-chasing and suggests plausible explanations for its occurrence. Lurie & Swaminathan (2009) found that more frequent feedback (e.g., being informed about realized demand every period versus every three or six periods) is positively associated with chasing demand. When comparing how people make choices in a newsvendor problem (i.e., operations frame) and a lottery with identical profit distributions as the newsvendor problem (i.e., neutral frame), Kremer et al. (2010) found that the number of adjustments toward prior demand is higher when the situation is described as a newsvendor problem rather than a lottery. By manipulating the type of feedback people receive after placing an order, Rudi & Drake (2014) reported adjustments to order quantities are positively associated with variability in what individuals observe.

As described in Section 2.2, the literature offers three reasons for why people chase demand, but these reasons appear doubtful against some findings. Schweitzer

& Cachon (2000) argued that the behavior occurs because of individuals following an anchoring and insufficient adjustment heuristic. Because one would expect those using such a heuristic to adjust their order quantities every period, the authors concluded there is only some evidence of people using this heuristic, given that they chase demand in some rounds but not in all. Bolton & Katok (2008) associated the behavior with the fallacious belief that independent draws are correlated (i.e., gambler's fallacy). Although the authors showed evidence of demand-chasing behavior, they did not examine whether the mechanism underlying this belief is at play. However, people who erroneously believe that independent draws are correlated would consistently adjust their order quantities across multiple rounds. Thus, the finding from Schweitzer & Cachon (2000) appears to also cast doubt on this reason. Moritz et al. (2013) proposed that chasing demand is associated with cognitive reflection and found support for this claim when people placed orders for a medium- and high-profit-margin product, but not for a low-profit-margin product. Again, it seems that the reason offered to explain demand-chasing may be doubtful because it falls short of fully describing the results across different conditions.

Although the foregoing reasons for demand-chasing vary, they seem to arise from a common viewpoint. They are based on inferences from observers who recognize that decision makers in the newsvendor problem chase demand and then attribute the behavior to the dispositions of the decision makers. As such, this observer's viewpoint characterizes the motive for demand-chasing as a predisposition of those who display such behavior. For example, after realizing a decision maker has chased demand, an observer may infer the person behaved this way because he or she is predisposed to follow an anchoring and insufficient adjustment heuristic. Still, we do not know if the person chasing demand actually follows this heuristic because he or she was never asked. In addition, we do not know if the situation defined by the newsvendor problem motivates a person to chase demand. If we are to get beyond doubtful reasons for

demand-chasing, it is necessary to consider the experiences of decision makers and how the situation of the problem shapes these experiences. Against this background, we shall turn our attention to a defining circumstance of the newsvendor problem that pertains to how much a decision maker knows about demand before placing orders.

2.3.2 Censored and Uncensored Demand

In practice, most retailers know with certainty how much of a given product they sold, but when they run out of stock, they have trouble determining how much they could have sold. Thus, a retailer’s observations of sales are a censored representation of the full demand process (Mersereau, 2015). The literature describes this situation as censored demand (Rudi & Drake, 2014). In contrast, when retailers know, in addition to actual sales, how much they would have sold if they had not run out of stock, the literature refers to this situation as uncensored demand. Both censored and uncensored demand have been identified as conditions that affect ordering behavior to varying degrees. Although the common practice in experimental settings has been to inform individuals, once orders are placed, about uncensored demand, few studies have provided censored demand information instead (Bostian et al., 2008; Rudi & Drake, 2014).

In their research, Bostian et al. (2008) ran three experiments in which subjects, after making their ordering decisions, only observed the quantity they had actually sold. Interestingly, the authors showed demand-chasing behavior occurs to some extent even when demand is censored. Rudi & Drake (2014) also used censored demand information to study whether people who adjust order quantities are influenced by what they observe over periods. By manipulating the feedback presented to subjects (i.e., censored versus uncensored demand), findings show orders are less variable with censored demand than with uncensored demand. The authors attribute such behavior to the fact that people use available feedback when making decisions and, in the

newsvendor problem, the variability of what is observed when demand is censored versus uncensored is likely to differ (i.e., the standard deviation of actual sales is bounded above by the standard deviation of the demand distribution).

2.4 Theory

Our focus on the decision maker in the newsvendor problem compels us to consider his or her thoughts and feelings because they could be associated with choice behavior. Interest in how thinking and feeling are related can be traced back to the work of philosophers like Aristotle and St. Augustine. Although psychologists were rather late to empirically study the interface of affect and cognition, researchers now recognize that these mental faculties do not operate in isolation (Forgas, 2000). Affect influences attention, memory, thinking, associations, and judgments, while cognition is used essentially in appraisal and analysis of situations to elicit affective states (Forgas, 2000). Hence, the available evidence points to a bidirectional connection between affect and cognition.

Naturally, judgment and decision making has been one of the main disciplines in which this relationship between thinking and feeling has been studied (Schwarz, 2000). Sufficient evidence now exists in support of the idea that emotions influence how people make decisions (Lerner et al., 2015).

2.4.1 Regret

Regret is one of the emotions most closely related with decision making (Zeelenberg, 1999) and is one of the most prevalent emotions people experience (Shimanoff, 1984). We feel regret when realizing or imagining that our present situation would have been better had we decided differently in the past (Pieters & Zeelenberg, 2007).¹ It

¹Some researchers consider disappointment to be another emotion also related with decision making. Although both emotions result from comparing an obtained outcome, they differ in what

is a negative emotion of self-blame that comprises two basic components (Sugden, 1985; Pieters & Zeelenberg, 2007). Regret can be experienced from comparing the outcome of a chosen option with that of a foregone option (i.e., outcome component). For example, this occurs when the obtained outcome contrasts poorly with what might have been obtained if a different choice had been made. However, we may also experience regret from how the decision was made (i.e., process component). For example, when the decision involved an error of judgment or was made unjustifiably.

Regret may stem from decisions to act (i.e., action regret; e.g., investing in a company that went bankrupt) or from decisions not to act (i.e., inaction regret; e.g., not investing in a company that thrives) (Gilovich et al., 1998; Pieters & Zeelenberg, 2007; Patrick et al., 2009). In addition, one may feel regret from past decisions (i.e., experienced regret) or in anticipation of future decisions (i.e., anticipated regret) (Pieters & Zeelenberg, 2007). In the present study, because the interest is on decision making in the context of the newsvendor problem, we find it reasonable to focus on regret from past decisions to act (i.e., action and experienced regret). Regret that occurs from decisions to act is important because in this setting, decision makers must choose an order quantity before the approaching selling period. In addition, because decision makers receive demand information after choosing and must then decide how much to order for subsequent periods, experienced regret stemming from

the outcome is compared with (Zeelenberg et al., 1998). Regret arises when the obtained outcome is compared with a better outcome that might have occurred had a different choice been made. In contrast, disappointment arises when the obtained outcome is compared with a better outcome one had expected to occur from making the same choice. In this study, our focus is on regret. Two main reasons support this choice. First, a significant difference on the agency dimension of the appraisal patterns between both emotions indicates people perceive regret as caused by oneself and disappointment as caused by circumstances beyond the control of anyone (van Dijk & Zeelenberg, 2002). In turn, this distinction leads to different goals people want to pursue when experiencing the emotion (i.e., emotivation). Regret is associated with wanting to undo the event, but disappointment relates with a tendency to do nothing and get away from the situation (Zeelenberg et al., 1998). In the context of the newsvendor problem, evidence seems to suggest people react to past decisions (e.g., chasing demand) rather than “do nothing”. Second, because the decision maker receives information about a foregone choice that would have been better (i.e., realized demand), a clear comparison between the obtained outcome and a better outcome that would have come with a different choice easily comes to mind.

past decisions plays a central role. However, we do not rule out the possibility that individuals in the newsvendor problem may also feel regret in anticipation of future decisions.

Studies show regret has a unique appraisal combination that determines when regret gets triggered and also a specific set of response components that defines how people cope with a given situation when this emotion is felt (Roseman, 2013). Events that set the stage for regret to occur are appraised as being inconsistent with current motives, offering low control to get less of the current negative stimuli, and assessing oneself as having caused the situation (i.e., agency) (Roseman, 2013; van Dijk & Zeelenberg, 2002). Once regret is experienced, the response strategy consists of phenomenological (i.e., thinking about the mistake made, a sinking feeling, thinking about the opportunity that was lost, and feeling like kicking oneself), physiological (i.e., increased activity in the medial orbitofrontal region of the brain), expressive (i.e., eyes closed and lips stretched and pressed together), behavioral (i.e., doing over and doing differently), and emotivational—goals people want to pursue when experiencing the emotion (i.e., wanting to improve performance and wanting to undo and correct the situation)—components (Coricelli et al., 2005; Roseman et al., 1994; Roseman, 2013; Zeelenberg et al., 1998; Zeelenberg, 1999).

The literature has identified two main preconditions for people to experience regret (Zeelenberg & Pieters, 2007). First, there must be an element of personal agency. As described by its appraisal pattern, associating oneself with having caused the situation that produced the negative stimuli is essential to experiencing this emotion. Second, one must realize that another choice would have been better. Thus, researchers have found feedback about actual and foregone outcomes to be one of the main antecedents associated with regret. Zeelenberg & Beattie (1997) found that participants playing the ultimatum game as proposers experienced more regret when their offer was much higher than the minimal acceptable offer of the responder (i.e., 10 guilders versus 2

guilders). Using hypothetical scenarios in which participants acted as a salesperson having to decide on the discount to be offered to a customer in an attempt to win business over from a competitor, Creyer & Ross (1999) reported that as outcome feedback became increasingly negative (e.g., forfeiting most of the sales commission by offering a big discount when the nearest competitor had offered none), subjects reported higher regret. Tsiros & Mittal (2000) described a hypothetical situation to participants (in Study 2 and 4) in which a consumer had, after considering two options, made a purchase decision of a given product (e.g., laptop). Subjects reported the hypothetical consumer as experiencing greater regret when information on the forgone outcome (which was acquired through the experience of a friend who had purchased the alternate option) was known.

Regret causes an aversive state that people are motivated to regulate and has thus been found to influence choice behavior. In their study, Zeelenberg & Beattie (1997) also found that participants in the ultimatum game who had been informed their offer was much higher than the acceptable offer of the responder and as a result had experienced greater regret, changed their offer significantly by decreasing it when playing a subsequent round. Using a hypothetical situation described to participants in which two dissatisfied customers of the same service-provider had experienced either regret or disappointment (Study 1) and a personal service encounter recalled by participants with which they had been dissatisfied (Study 2), Zeelenberg & Pieters (1999) found that regret is associated with switching behavior in the context of unsatisfactory services (i.e., leaving the relationship with a service provider and either initiating a relationship with another provider or refraining from the service altogether). Tsiros & Mittal (2000) showed (in Study 1) that when presented with a hypothetical purchasing scenario, participants who had reported the consumer as experiencing greater regret (as a consequence of having obtained information on the forgone outcome) also reported the consumer as having lower repurchase intentions.

As a whole, these studies show that reversing or switching to an alternate option is an essential regulatory strategy when experiencing regret (Pieters & Zeelenberg, 2007).

Improving the quality of the decision has also been shown to function as a regulatory strategy in managing regret (Pieters & Zeelenberg, 2007). For example, implemented by an increased external or internal (i.e., from memory) information search, learning, or advice seeking (Zeelenberg & Pieters, 2007), this strategy prevents future regret and reduces its effects on decision making.

Given that one must realize that another choice would have been better, regret is often referred to as a cognitive-based emotion. Imagining such an alternative scenario implies thinking about how the outcome obtained from what was chosen compares with another outcome that might have been obtained if a different choice had been made (Zeelenberg, 1999). Interestingly, these types of thoughts, known as counterfactual, are not produced randomly and take a special form (Roese & Olson, 1995a).

2.4.2 Counterfactual Thinking

Counterfactual thinking is a separate but strongly related stream of research. Counterfactual thoughts are about what might have been, of how the past might have been different had some other aspect been different (Roese & Epstude, 2017). Counterfactual thinking has been studied primarily by social psychologists, but additional evidence appears in other fields, including cognitive neuroscience and developmental and clinical psychology (Roese & Epstude, 2017). Before the emergence of counterfactual thinking theories, early assertions about this construct were informed by norm theory from Kahneman & Miller (1986). Counterfactual thoughts are mental simulations that present us with alternative versions of past events (Roese, 1997). They describe a situation that did not actually happen (i.e., contrary to fact or counterfactual) and can be characterized by conditional propositions that contain an antecedent

and a consequent (i.e., if-then statement) (Roese & Epstude, 2017). A focal factual outcome is generally the point of departure to building a counterfactual. Next, some factual antecedent is altered and the consequences of that alteration are then assessed (Roese & Olson, 1995a). The literature distinguishes between two different types of counterfactuals. Episodic counterfactuals, which are the focus of our study, correspond to alternative realities of personal events experienced firsthand (we use the term counterfactual thinking to refer to this type of counterfactuals). In contrast, semantic counterfactuals are associated with alternative constructions of general events and knowledge about history, society, and the natural world.

The main principle of the functional theory of counterfactual thinking is that counterfactual thoughts are reflections of goals and have a clear connection to goal-directed cognition (Roese & Epstude, 2017). Given that they have a purpose, counterfactual thoughts are constrained and usually require small changes to actual events to provide practical alternatives (Seelau et al., 1995). Thus, counterfactual thoughts are not random but disciplined suppositions. The two key elements in determining a counterfactual thought are how it gets *activated* and its resultant *content*. Activation of spontaneous counterfactual thoughts is not arbitrary, but systematic in response to goals being blocked (Roese & Epstude, 2017). Situations in which a discrepancy occurs between actual and ideal goal states are likely to trigger counterfactual thoughts. Goal blockage may manifest and be perceived in various forms, including a sense of failure, perception of a problem, lack of goal progress, negative outcome, and disconfirmed expectancy (Roese & Epstude, 2017). In addition, the negative affect resulting from this discrepancy is relevant in the activation process of counterfactuals because it signals a problem needs attention and mobilizes action (Roese, 1997). Hence, the greater the perceived discrepancy, the greater the urge towards action aimed at reducing the divergence.

Once activated, counterfactual thoughts take a particular form determined by

their content, which is confined by how to achieve an unrealized goal (Seelau et al., 1995). Some aspect of the situation is altered in such a way as to produce an alternative outcome that bridges the gap between actual and ideal goal states. Because these mental simulations contrast two outcomes that differ only by a specific antecedent, counterfactual thoughts are considered experimental proxies containing a causal inference (Roese, 1997). This causal insight, stemming from a belief that changing a specific antecedent would have been enough to produce a desired outcome, carries informational content that facilitates a behavioral intention (Roese & Epstude, 2017). When opportunity exists, the behavioral intention aimed at reducing the difference between actual and ideal goal states gets implemented and gives rise to corresponding behavior. Although counterfactual thinking is generally functional and expected to lead to performance improvement, the actual impact on performance will depend on the accuracy of the causal inferences that are drawn (Roese & Epstude, 2017).

2.4.3 Regret and The Newsvendor Problem

Because of its choice structure, the newsvendor problem creates opportunities for a person to experience regret. First, the two main preconditions of regret are satisfied. An element of personal agency is present, given that a decision maker is responsible for choosing how much to order. Because demand becomes known after each selling period, a person realizes that another option could have been better anytime an order he or she placed deviates from actual demand.

In addition, because the problem involves a clear goal (i.e., to maximize profit), the key elements of counterfactual thinking can be predicted. Activation of counterfactual thoughts will occur in response to goal blockage. Therefore, knowing that what one ordered deviated from customer demand will be perceived as a negative outcome and trigger a counterfactual thought. Because demand is random, this is likely to happen more often than not. The content of this counterfactual thought will be about how

to achieve the unmet goal. Hence, after deviating from customer demand, an aspect of the situation will be altered in a way that is thought to bridge the gap between actual and ideal goal states. Thoughts like “if I had ordered more papers, I would have been able to sell more” or “if I had ordered fewer papers, I would have incurred fewer costs” likely come to mind.

Decision makers in the newsvendor problem receive feedback in the form of customer demand information after placing their order. However, as described in Section 2.3.2, when demand is censored, this information contains only the quantity that was sold. This implies that whenever order quantities exceed customer demand, decision makers receive the same information regardless of whether demand is censored. But the information decision makers receive will be different if demand is censored versus uncensored when order quantities fall short of customer demand. Later we use this asymmetry in information, which occurs naturally from whether demand is censored versus uncensored, as a manipulation in our experimental setting.

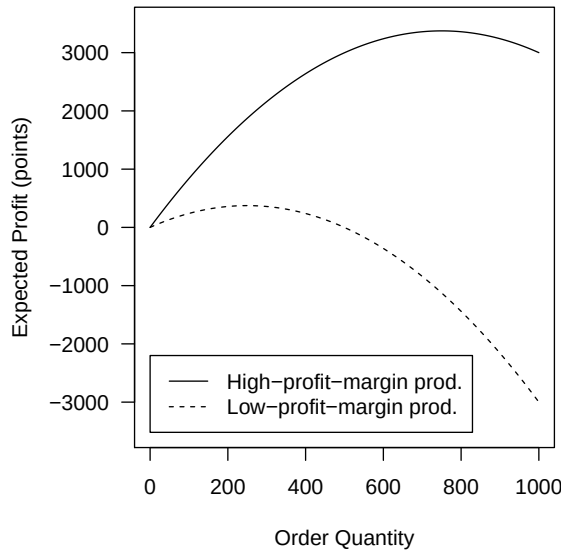
When out-of-stocks occur, people facing censored demand will know they sold everything they had ordered, but they will not know how much they could have sold if they had ordered more. In contrast, people facing uncensored demand will know what they missed out on and realize they would have been better off if they had ordered something different. Thus, receiving complete demand information plays an important role in realizing that another choice would have been better. Which is, in turn, one of the preconditions of experiencing regret (Zeelenberg & Pieters, 2007). Given that higher expected profits are obtained when ordering above mean demand for high-profit-margin products and below mean demand for low-profit-margin products, together with evidence showing that at an aggregate level, order quantities tend to fall between the optimal order quantity and mean demand (Schweitzer & Cachon, 2000), these facts suggest that overstocks are likely to occur for high-profit-margin products but out-of-stocks are more likely for low-profit-margin products. To the extent that

receiving complete demand information plays an important role in realizing that one would have been better off if a different choice had been made, we expect censored versus uncensored demand to have a significant effect on experienced regret for low-profit-margin products. In accord with the foregoing ideas, we make the following prediction.

Hypothesis 1 *For low-profit-margin products, decision makers experience greater regret as demand information becomes uncensored.*

Given the likelihood of each outcome (i.e., customer demand), the expected profit from a product can be estimated for any order quantity. The expected profit as a function of order quantity offers important differences between high- and low-profit-margin products, beyond simply showing the order quantity that maximizes profit. Orders above mean demand produce the highest expected profit for high-profit-margin products, but the lowest expected profit for low-profit-margin products. The opposite is true for orders that fall below mean demand. Most importantly, assuming similar demand characteristics for both types of products, the expected profit from high-profit-margin products is greater than or equal to that of low-profit-margin products for any given order quantity. These facts are depicted visually in Figure 2.1 by comparing the expected profit function of a low- versus high-profit-margin product.

Unless a cost for not satisfying demand or a fixed cost is considered, the expected profit from high-profit-margin products is nonnegative. In contrast, under some conditions (e.g., when the demand distribution includes low values), the expected profit of low-profit-margin products may be negative. Together, these observations show that when placing orders for products having similar demand characteristics, decision makers in the newsvendor problem are more likely to obtain lower profits from low- versus high-profit-margin products. In addition, if based on the problem parameters, it is possible for losses to occur, then decision makers are also more likely to experience losses for low- versus high-profit-margin products. To the extent that



Notes: Expected profit corresponding to a product exhibiting uniformly distributed demand between 0 and 1000, selling price of 12 points, and unit cost of 3 and 9 points for high- and low-profit-margin products, respectively.

Figure 2.1: Single Period Expected Profit as a Function of Order Quantity

counterfactual thoughts get activated as perceived discrepancies between actual and ideal goal states become greater (Roese & Epstude, 2017), we expect the type of product to have a significant effect on experienced regret. Accordingly, we make the following prediction.

Hypothesis 2 *Decision makers experience greater regret when ordering low- versus high-profit-margin products with similar demand characteristics.*

In experimental settings created to study the behavioral aspects of decision making, profit differences like those described above may produce inequitable payoffs across subjects if they are assigned to one treatment only and if their compensation is tied to performance. In the context of the newsvendor problem, some studies have accounted for this imbalance by using different exchange rates to convert from experimental to real-world currency (e.g., Chen et al., 2013) or fixed costs to modify the profit earned (e.g., Bolton & Katok, 2008) in each treatment. Because in this study

we are interested in observing the effect of this profit imbalance, we converted experimental profits to their corresponding real-world amount at the end of the session and used an exchange rate for each treatment to ensure subjects on average received similar compensation.

One of the central tenets of prospect theory (Kahneman & Tversky, 1979) is that losses loom larger than gains. If this is the case, then the perceived difficulty of obtaining greater profits should be exacerbated for low-profit-margin products, with which losses are more likely to occur, compared with high-profit-margin products. Therefore, this aspect of prospect theory should reflect how people feel about their decisions as they place orders in the newsvendor problem.

Feeling regret produces an unpleasant state that people are motivated to regulate (Pieters & Zeelenberg, 2007) and has thus been found to influence choice behavior. The literature contains evidence that switching to an alternate option is a common strategy when coping with this emotion (Zeelenberg & Beattie, 1997; Zeelenberg & Pieters, 1999; Tsiros & Mittal, 2000). In addition, the content of counterfactual thoughts that accompany regret is constrained by how to achieve an unrealized goal and provides important cues about the behavioral intention that follows (Roesse & Epstude, 2017).

To the extent that actual versus foregone profits, in the context of the newsvendor problem, differ only by whether one ordered what one did or what customers demanded, this antecedent can be inferred to be causal. Hence, modifying this aspect of the behavior is expected to lead to a better outcome. The informational content carried by these causal insights implies that if opportunity exists (e.g., a similar decision is to be made in the future), a behavioral intention of altering the order quantity to one that is closer to what customers demanded should be implemented. In conjunction, evidence of switching to an alternate option as a means of coping with regret and a behavioral intention stemming from counterfactual thoughts that

accompany the emotion, suggest that choice behavior will be influenced as decision makers in the newsvendor problem experience regret. Specifically, we expect decision makers experiencing more regret to change or switch to an alternate option that is closer to the most recent demand realization (i.e., chase demand).

Hypothesis 3A *Decision makers chase demand to a greater extent as they experience more regret.*

Hypothesis 3B *Decision makers chase demand more frequently as they experience more regret.*

Based on our theoretical framework, chasing demand occurs not because of dispositional factors (e.g., following an anchoring and insufficient adjustment heuristic, believing that independent draws are correlated, or scoring low in cognitive reflection), but because the specific situation experienced after choosing and obtaining an outcome affects how subsequent decisions are made. Therefore, an individual's display of demand-chasing behavior can vary across time and manifest in different ways. First, people can chase demand to a different extent by adjusting the order quantity to a greater or lesser degree from one period to the next. Second, chasing demand may occur more or less frequently across time periods. This distinction is important because, although the extent to which people chase demand provides evidence of how regret influences the magnitude of order adjustments, frequency shows whether the consequences of experiencing regret persist over time. Therefore, we present our hypotheses in terms of both, the extent and frequency with which decision makers chase demand.

Hypothesis 1 suggests that as demand information becomes uncensored, decision makers experience greater regret. In addition, Hypothesis 3A argues that as decision makers experience more regret, they chase demand to a greater extent. Together, these hypotheses suggest that demand information becoming uncensored increases

the extent to which decision makers chase demand indirectly through experiencing regret. Accordingly, we make the following prediction.

Hypothesis 4A *Regret mediates the relation between demand information and the extent to which decision makers chase demand.*

Similarly, Hypotheses 1 and 3B imply that demand information becoming uncensored increases the frequency with which decision makers chase demand indirectly through experiencing regret.

Hypothesis 4B *Regret mediates the relation between demand information and the frequency with which decision makers chase demand.*

To the extent that decision makers ordering low- versus high-profit-margin products experience greater regret (Hypothesis 2), we extend the above hypotheses accordingly. In particular, combining Hypotheses 2 and 3A suggests that ordering low- versus high-profit-margin products increases the extent to which decision makers chase demand indirectly through experiencing regret.

Hypothesis 5A *Regret mediates the relation between product profit margin and the extent to which decision makers chase demand.*

And Hypotheses 2 and 3B imply that ordering low- versus high-profit-margin products increases the frequency with which decision makers chase demand indirectly through experiencing regret.

Hypothesis 5B *Regret mediates the relation between product profit margin and the frequency with which decision makers chase demand.*

Improving the quality of the decision, often implemented by acquiring relevant information, acts as a regulatory strategy in preventing future regret and reducing its effect on decision making (Pieters & Zeelenberg, 2007). In the context of the

newsvendor problem, the information people read, their past experience with similar situations, and their cognitive ability with related tasks may contribute, among other factors, to varying levels of knowledge about the problem across individuals. In addition to realizing there is a trade-off between ordering too much versus too little, having greater knowledge about the newsvendor problem helps people recognize that what they should order depends on the unit cost, selling price, and demand distribution of the product (assuming no salvage value) that do not vary through time (Schweitzer & Cachon, 2000). Because having greater knowledge about the newsvendor problem facilitates decision quality, which in turn serves as a regulatory strategy by reducing the effect of regret on decision making, one would expect individuals with higher levels of knowledge to be less affected by regret and thus exhibit less demand-chasing.

Hypothesis 6A *Having greater newsvendor problem knowledge reduces the influence regret has on the extent to which decision makers chase demand.*

Hypothesis 6B *Having greater newsvendor problem knowledge reduces the influence regret has on the frequency with which decision makers chase demand.*

2.5 Experimental Design

To test our hypotheses, we conducted an experiment in which participants were asked to make multiple successive ordering decisions simulating the newsvendor problem. Our experimental design in many ways resembles those used in several previous studies (e.g., Schweitzer & Cachon, 2000; Bolton & Katok, 2008; Moritz et al., 2013; Rudi & Drake, 2014; Becker-Peth & Thonemann, 2016).

2.5.1 Subjects

Two hundred and two subjects were recruited through Amazon Mechanical Turk (MTurk). We restricted participation to workers located in the United States. To ensure data quality and respondent attentiveness (Peer et al., 2014; Hauser & Schwarz, 2016), we also restricted participation to workers with highly rated reputations who had completed a minimum of 100 tasks (in MTurk terminology, human intelligence tasks or HITs) and who had an approval rating above 95%. Using similar conditions, Lee et al. (2018) replicated the main results obtained by Bolton & Katok (2008) when they used MTurk workers—instead of students—to conduct the same newsvendor experiment. The experimental program prevented subjects from participating more than once by blocking access to the MTurk HIT for workers who had previously accepted it.

The average age of subjects was 35.7. About 5% were students and 38% were females. All participants had at least a high school degree, and approximately half of them had a bachelor’s degree. Subjects were paid a \$4.00 participation fee, plus a payoff contingent on their performance in the newsvendor task. The total payoff, including the participation fee, was \$4.68 on average, and ranged from \$4.00 to \$5.54. The experimental currency used during the newsvendor task was expressed in terms of *points*, and total profits earned by participants were converted to U.S. dollars at the end of the session. Two different exchange rates for low- and high-profit-margin products were used to compensate for profit imbalance across conditions and ensure equitable payoffs (as described in Section 2.4.3).

2.5.2 Experimental Procedures

Before making decisions in the newsvendor task, subjects received a short training session that covered the basic features of the newsvendor problem. The main objec-

tive of the training was to create a common ground across subjects about the task they were to perform, but without communicating any type of solution or method to calculate the expected-profit-maximizing order. The training was self-paced, had an average duration of 11 minutes, and included six slides describing the motivation of the problem, the trade-off between ordering too much versus too little, and insight about the effect of parameters.² This approach, as opposed to the oral presentations or lectures other behavioral newsvendor studies have used (e.g., Rudi & Drake, 2014), ensures that all participants receive the same information (regardless of the session they are in) and that the experimental design and results can be replicated. After completing the training, but before initiating the newsvendor task, each person answered nine multiple choice questions that provided a means to assess their knowledge about the problem. The questions derived from information commonly shared in the instructions for newsvendor settings (e.g., Schweitzer & Cachon, 2000; Bolton & Katok, 2008) and that buyers could be expected to acquire before placing orders to suppliers (for similar assessments, see Becker-Peth et al., 2013; Becker-Peth & Thonemann, 2016). Specifically, we measured whether subjects correctly estimated the cost of having an out-of-stock and overstock of one unit, the number of units sold, and the profit earned, and also whether they appropriately identified when an out-of-stock or overstock occurred and successfully calculated the corresponding cost (see Appendix A.1 for details).

After these preparatory steps, participants were randomly assigned to one of four treatments simulating the newsvendor task. In accordance with our research hypotheses, we used a 2×2 between-subjects experimental design that varied the type of demand information subjects received after placing an order in each round (i.e., censored versus uncensored demand) and the product profit margin condition (i.e., low- versus high-profit-margin product). Participants' demographic information by

²A transcript of the training slides is available from the authors upon request.

Table 2.2: Participant Demographic Characteristics

Treatment		Observations	Baseline Characteristic				
Demand Information	Product Profit Margin		Age	Gender	Student	Schooling	Work Experience
Censored	Low	54	34.74	0.35	0.02	4.65	13.09
Censored	High	54	36.96	0.39	0.06	4.24	15.02
Uncensored	Low	47	33.13	0.40	0.06	4.06	12.19
Uncensored	High	47	37.94	0.36	0.09	4.43	16.38
Total		202	35.70 (9.59)	0.38 (0.49)	0.05 (0.23)	4.35 (1.28)	14.16 (9.36)

Notes: Treatment and total sample means. Gender is the proportion of subjects who are females ($f = 1$). Schooling is coded using an 8-point scale: Less than HS, HS degree, Some college, Associate degree, Bachelor's degree, Master's degree, Professional degree, and Doctorate. Work experience is measured in years. Standard deviation of baseline characteristics for total sample in parentheses.

treatment group is summarized in Table 2.2.

Participants in the censored demand group (following the description in Section 2.3.2) were informed about customer demand when an overstock occurred. But when this was not the case, individuals in this group only knew how many units they had sold. In contrast, participants in the uncensored demand group received customer demand information every period regardless of whether they had run out of stock. The product profit margin was manipulated by varying the unit cost of the product. The low-profit-margin product had a unit cost of $c = 9$ points, and the high-profit-margin product had a unit cost of $c = 3$ points. Except for these differences, participants received identical instructions in preparation for the newsvendor task. The instructions described the task subjects were to perform, including the cost of each unit ordered from the supplier (depending on the treatment group), the price of each unit sold to customers ($p = 12$ points), the demand distribution (uniform between 0 and 1000), and the goal they were to accomplish. In addition, the instructions explained how to calculate profit, how ordering decisions and rounds took place, and how payoffs were estimated and paid (see Appendix A.2 for the exact transcript of the newsvendor task instructions for one treatment group).

Based on the experimental parameters, the optimal order quantities were 250 and 750 units for low- and high-profit-margin products, respectively. Participants in all treatment groups executed 30 consecutive individual inventory ordering decisions.

Each experimental round simulated a selling period in which participants chose an order quantity and were then informed about customer demand (if demand was uncensored) or sales in units (if demand was censored). Participants also received a summary of the number of units ordered and the profit earned in points. In any round, when orders were to be placed, subjects could display the complete set of instructions if necessary and were presented with summary information for all previous decisions made, including order quantity, demand (if demand was uncensored), units sold, cost, sales, profit, and cumulative profit.³ Participants in all treatment groups faced the same sequence of demand draws, which were randomly generated before the experiment.

We used a modified version of existing scales developed by Marcatto & Ferrante (2008) and Buchanan et al. (2016) to measure the extent to which subjects experienced regret for the decisions they had made. The instrument contained seven items on a 7-point Likert scale (for details about the instrument, see Appendix A.3), and responses were averaged across items to create an experienced regret index (Cronbach's $\alpha = 0.92$). To prevent order bias, measurement items were randomly ordered when presented to subjects. Experienced regret was assessed at the end of rounds 1 and 25. Upon completion of the newsvendor task, subjects received a summary of all their ordering decisions and the total profit (or loss) they had achieved in points. If a profit had been earned, it was converted to U.S. dollars and paid to participants at the end of the session. In the final section of the experiment, demographic data and individual heterogeneity measures were collected. These measures, which have appeared in the behavioral newsvendor problem literature as being related with performance outcomes, included: cognitive reflection based on the Frederick (2005) test, risk aversion based on the Holt & Laury (2002) method, and overprecision as measured by Russo & Schoemaker (1989).⁴ Participants spent 34 minutes on average in

³For images showing examples of the newsvendor task screenshots, see the electronic companion.

⁴Details about instruments for individual heterogeneity measures are included in the electronic

completing the experiment.

The computer program to run the experiment was developed in oTree (Chen et al., 2016) and setup online using a cloud service. The experiment was piloted with undergraduate and graduate students who tested the technical aspects and the clarity of instructions in face-to-face debriefing sessions.

2.5.3 Demand-Chasing Measures

As described in Section 2.4.3, our hypotheses about demand-chasing considered two dimensions of the behavior. The extent to which subjects chased demand in a given round was measured by how much an order quantity had been adjusted between two consecutive rounds with respect to the most recent demand realization. Thus, larger values imply greater adjustments moving toward previous demand (i.e., chasing demand).

On the other hand, we assessed the frequency with which subjects chased demand in terms of the number of rounds in which an individual had adjusted the order quantity from one round to the next in the direction of the most recent demand realization. Therefore, larger values represent more frequent demand-chasing.

2.6 Data Analysis and Results

The following sections present our results. Section 2.6.1 describes our pre-study in which we examined whether counterfactual thinking occurs when subjects make decisions in the newsvendor problem. In Section 2.6.2, we describe our overarching data analysis strategy to test our hypotheses. Next, in Section 2.6.3, we detail the effect of demand information and the role regret and newsvendor knowledge play on chasing demand. Section 2.6.4 extends our results by examining how changes in

companion.

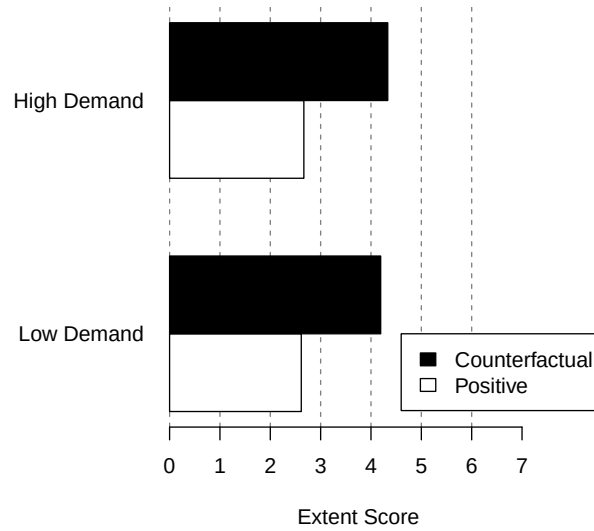
product profit margin influence chasing demand.

2.6.1 Pre-Study

Before conducting the main experiment, 97 undergraduate students participated in an in-class newsvendor task in which they used the same procedure and computer interface as described in Section 2.5. Because counterfactual thinking is the underlying cognitive mechanism through which regret is triggered and experienced (as described in Section 2.4.2), the main objective of the pre-study was to assess whether these types of thoughts are generally present when decision makers place orders in the newsvendor problem. To evaluate whether the pervasiveness of counterfactual thoughts generalized across different demand variability settings, we manipulated the demand distribution (i.e., low versus high demand). Therefore, subjects were randomly assigned to one of two treatment groups in a between-subjects experimental design. Customer demand was modeled as uniformly distributed between 0 and 100 in the low demand group; it was modeled as uniformly distributed between 0 and 5000 in the high demand group.

As described in Section 2.4.3, counterfactual thoughts are more likely to be activated when placing orders for low- versus high-profit-margin products. Thus, we took a conservative approach in the pre-study by restricting subjects to making ordering decisions under high-profit-margin product conditions.

After placing their first order and obtaining demand information, subjects were asked to reflect on the decision they had made and indicate the extent to which certain thoughts had come to mind. To assess the extent of their counterfactual thoughts, we used items adapted from Hafner et al. (2012) and measure these types of thoughts with ratings on a 7-point Likert scale (for details about the instrument, see Appendix A.4). The order of items shown to subjects was randomized to prevent order bias. Participants then continued placing orders for a total of 15 consecutive



Notes: Extent to which counterfactual and positive appraisal thoughts came to mind after placing an order to the supplier in a newsvendor setting. Counterfactual: "If only I had ordered something different."; Positive appraisal: "I did a good job when deciding."

Figure 2.2: Type of Thoughts During Newsvendor Decision Making

rounds.

Results from the pre-study revealed, as shown in Figure 2.2, that within each treatment group, counterfactual thoughts came to mind to a significantly greater extent than positive appraisal thoughts (mean of differences: 1.67, 1.58; paired t -test: $p < 0.01$, $p < 0.01$, respectively). Moreover, the degree to which counterfactual thoughts came to mind did not differ across treatment groups (ANOVA, $F(1, 95) = 0.12$, $p = 0.726$). To the extent that counterfactual thoughts are experienced to a greater extent than positive appraisal thoughts and occur when making ordering decisions in both low and high demand variability settings, the pre-study suggests that counterfactual thoughts are indeed prevalent in the newsvendor setting.

2.6.2 Data Analysis

Although evidence of the association between two variables is not a prerequisite for the existence of an indirect effect through a third variable and significant mediation

is not a requirement for moderated mediation (Shrout & Bolger, 2002; MacKinnon et al., 2000; MacKinnon, 2008; Hayes, 2009), our data analysis strategy followed a simple-to-more-complex approach. In the first part of the analysis, described in Section 2.6.3, we focused on the effects of censored versus uncensored demand information when the product profit margin is low. We started by using ANOVA to look at the relationship between demand information and experienced regret (Hypothesis 1). Then, we formulated a mediation model that, in addition to providing further insight about this hypothesis, also examined the relationship between regret and the extent of demand-chasing (Hypothesis 3A) and the indirect effect of demand information on the extent of demand-chasing (Hypothesis 4A). We estimated the model using ordinary least squares (OLS) regression and relied on bootstrapping methods for inferences as described by Preacher & Hayes (2004, 2008); Hayes (2009, 2018).⁵ A moderation model was then built to test Hypothesis 6A and was estimated using OLS regression following Preacher et al. (2007); Hayes & Matthes (2009); Hayes (2018). As described in Section 2.5.3, the extent to which subjects chase demand is measured based on the order quantity adjustment in a given round. Hence, hypotheses related to the extent of demand-chasing were tested by using the assessment of experienced regret at the end of round one and the adjustment in order quantity at round two.

A similar approach was then used to study the relationship between demand information and the frequency with which subjects chase demand. Using ANOVA, we tested Hypothesis 1. Next, we used a mediation model to extend the analysis beyond this relationship to examine Hypotheses 3B and 4B. Using a moderation model, we tested Hypothesis 6B. The frequency with which subjects chase demand (as described in Section 2.5.3) was measured by aggregating decisions across multiple rounds. Therefore, we tested the hypotheses related to demand-chasing frequency by

⁵Because the Sobel test has been shown to have limitations when testing indirect effects (given that the sampling distribution of the product of random normal variables is not normal), we resorted to bootstrapping techniques to construct 95% confidence intervals that used 5,000 bootstrap samples.

using the assessment of experienced regret at the end of round 25 and the ordering decisions the subjects made across these rounds.

The second part of the analysis shifted attention to the effects of product profit margin when demand information is uncensored and is described in Section 2.6.4. The analysis follows a similar strategy as that described previously in the case of demand information as an antecedent.⁶

2.6.3 The Effect of Demand Information on Demand-Chasing

When out-of-stocks occur, subjects receiving censored demand information know they sold everything they had ordered. However, they will not know how much they could have sold if they had ordered more. Because receiving complete demand information is essential to realizing how one would have fared better with a different choice, we expect censored versus uncensored demand information to affect the extent to which subjects experience regret. An ANOVA with demand information as the independent variable and experienced regret as the dependent variable revealed a significant effect ($F(1, 99) = 10.29, p < 0.01$). In providing support for Hypothesis 1, this result shows that as demand information became uncensored, decision makers experienced greater regret.

Hypothesis 3A proposes that experiencing more regret is associated with chasing demand to a greater extent. In addition, Hypothesis 4A suggests that demand information becoming uncensored affects the extent to which decision makers chase demand through experiencing regret. To test these hypotheses in an integrated framework, we used path analysis methods to develop a mediation model (as described in Section 2.6.2). Results are presented in Table 2.3. As was found by using ANOVA,

⁶All mediation and moderation models were also estimated using structural equation modeling, accounting for the latent nature of “regret” (using R - lavaan package). The seven items were included as reflective indicators of the construct. Maximum likelihood estimation and bootstrapping confidence intervals were used. The results for all hypotheses were consistent with the OLS regression results presented in Sections 2.6.3 and 2.6.4.

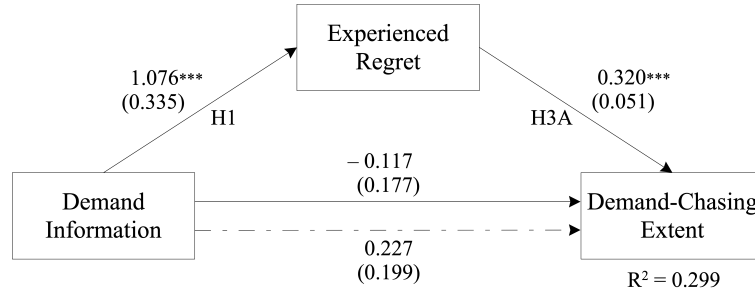
Table 2.3: Effect of Demand Information on Demand-Chasing Extent

	Experienced Regret			Demand-Chasing Extent						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Demand Information	1.076*** (0.335)	0.909** (0.350)	1.094*** (0.342)	0.227 (0.199)	-0.117 (0.177)	0.156 (0.207)	-0.125 (0.184)	0.239 (0.206)	-0.089 (0.189)	
Experienced Regret					0.320*** (0.051)		0.309*** (0.052)		0.299*** (0.055)	0.307*** (0.050)
NVP Knowledge										-0.006 (0.038)
Regret × Knowledge										-0.005 (0.023)
Cognitive Reflection			-0.449*** (0.149)					-0.103 (0.090)	0.031 (0.082)	
Risk Aversion			0.189** (0.086)					0.136*** (0.052)	0.080* (0.046)	
Overprecision			-0.037 (0.076)					0.046 (0.045)	0.057 (0.040)	
Constant	-0.501** (0.229)	0.439 (1.867)	-0.590 (1.879)	-0.106 (0.136)	0.054 (0.118)	-0.464 (1.104)	-0.600 (0.947)	-1.417 (1.129)	-1.240 (0.986)	-0.005 (0.088)
Controls	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No
R ²	0.100	0.133	0.232	0.013	0.299	0.064	0.319	0.144	0.356	0.296

Notes: OLS regression coefficients are reported. $N = 101$. The dependent variable in Columns (1) to (3) is experienced regret. The dependent variable in Columns (4) to (10) is demand-chasing extent. The omitted group in Columns (1) to (9) is the censored demand treatment. Controls are age, gender, student, schooling, and work experience.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

subjects experienced significantly more regret as demand information became uncensored (Column (1), 1.076, $p < 0.01$), lending support to Hypothesis 1. Also, experiencing more regret was significantly associated with chasing demand to a greater extent (Column (5), 0.320, $p < 0.01$), providing support for Hypothesis 3A. Most importantly, the indirect effect corresponds to the product of the direct effect of demand information on experienced regret and the direct effect of experienced regret on demand-chasing extent while controlling for demand information. A bootstrap confidence interval (CI) provides evidence of a significant positive indirect effect of demand information on demand-chasing extent through experiencing regret (0.344, 95% percentile CI [0.12, 0.60]). Compared with those who received censored demand information, subjects who learned of actual customer demand after placing their order chased demand to a greater extent because of having experienced greater regret for the choices they made. This result supports Hypothesis 4A. When controlling for experienced regret, the direct effect of demand information on demand-chasing extent was not significant (Column (5), -0.117, $p = 0.512$). Therefore, independent of the effect of experiencing regret, the extent to which subjects chased demand did



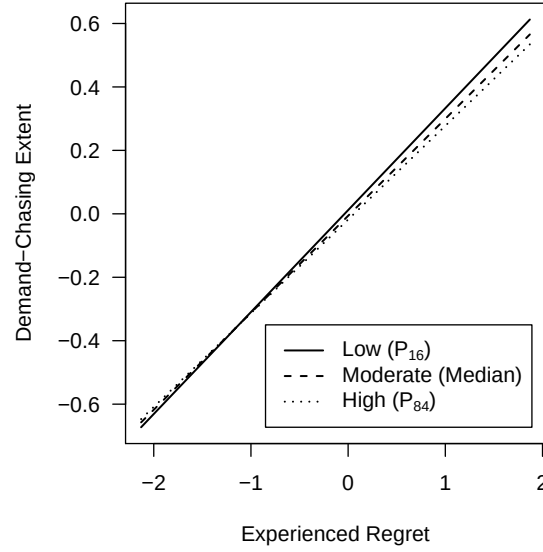
Notes: Path coefficients for the mediation model of demand information on demand-chasing extent through experienced regret. Dotted line denotes the (total) effect of demand information on demand-chasing extent when experienced regret is not included as mediator. Coefficients are based on models without controls.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 2.3: Path Diagram for Indirect Effect of Demand Information on Demand-Chasing Extent

not differ regardless of whether uncensored demand information was disclosed. The mediation model is depicted in Figure 2.3. To test the robustness of our findings, we added control variables (Columns (2) and (6) to (7)) and also individual heterogeneity measures shown to be related with performance outcomes in the newsvendor problem (Columns (3) and (8) to (9)). All results remained unchanged after these covariates were included in the models.

Decision quality serves as a regulatory strategy by reducing the effect of regret on decision making. To the extent that having greater knowledge of the newsvendor problem facilitates decision quality, we expected the effect of experienced regret on demand-chasing extent to depend on how much subjects knew about the newsvendor problem. As presented in Table 2.3 Column (10), results of the moderation analysis revealed that the extent to which subjects chased demand because of regret did not vary in relation to the knowledge they had about the newsvendor problem (-0.005 , $p = 0.818$). Thus, Hypothesis 6A is not supported. Figure 2.4 depicts these relationships in detail. Subjects chased demand to a greater extent as they experienced more regret because of demand information becoming uncensored, and this effect is consistent regardless of the level of newsvendor problem knowledge people had.



Notes: Conditional effects estimated among subjects at the 16th (low), 50th (moderate), and 84th (high) percentiles of the distribution of newsvendor problem knowledge.

Figure 2.4: Moderation of the Effect of Experienced Regret (Manipulated by Demand Information) on Demand-Chasing Extent by Newsvendor Problem Knowledge

In examining the frequency with which subjects chased demand, we looked at behavior across 25 rounds when product profit margin was low. An ANOVA of demand information on experienced regret revealed a significant effect ($F(1, 99) = 10.76$, $p < 0.01$). Further supporting Hypothesis 1, results show that after placing orders for multiple rounds subjects experienced greater regret when obtaining uncensored demand information, as opposed to censored demand information.

Hypothesis 3B suggests that experiencing more regret is related to chasing demand more frequently. Also, Hypothesis 4B proposes that uncensored demand information is associated with decision makers chasing demand more frequently through experiencing regret. The results of the mediation model are presented in Table 2.4. Results show that subjects experienced significantly more regret after placing orders across multiple rounds when demand was uncensored (Column (1), 0.899, $p < 0.01$), providing support for Hypothesis 1. In addition, as subjects' regret worsened, the frequency with which they chased demand increased significantly (Column (5), 1.288, $p < 0.01$).

Table 2.4: Effect of Demand Information on Demand-Chasing Frequency

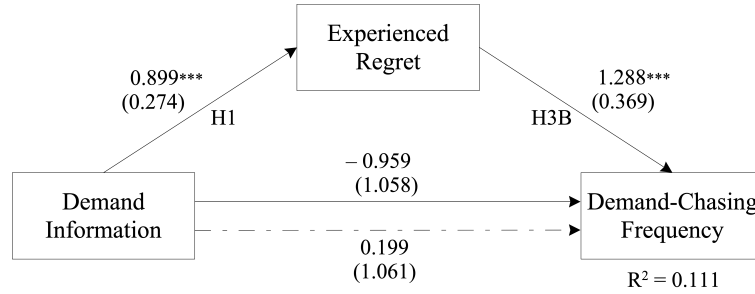
	Experienced Regret			Demand-Chasing Frequency						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Demand Information	0.899*** (0.274)	0.762*** (0.285)	0.913*** (0.282)	0.199 (1.061)	-0.959 (1.058)	-0.250 (1.046)	-1.128 (1.036)	0.125 (1.035)	-0.850 (1.052)	
Experienced Regret					1.288*** (0.369)		1.152*** (0.362)		1.067*** (0.371)	0.798** (0.345)
NVP Knowledge										-0.763*** (0.212)
Regret $\times$ Knowledge										0.237 (0.157)
Cognitive Reflection			-0.342*** (0.123)					-1.147** (0.451)	-0.782* (0.452)	
Risk Aversion			0.123* (0.071)					-0.309 (0.260)	-0.440* (0.254)	
Overprecision			-0.006 (0.062)					-0.138 (0.228)	-0.131 (0.220)	
Constant	-0.418** (0.187)	0.035 (1.518)	-0.766 (1.547)	11.482*** (0.723)	12.020*** (0.703)	22.929*** (5.579)	22.889*** (5.326)	24.177*** (5.683)	24.994*** (5.475)	11.808*** (0.497)
Controls	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No
R^2	0.100	0.146	0.225	0.001	0.111	0.145	0.229	0.225	0.291	0.222

Notes: OLS regression coefficients are reported. $N = 101$. The dependent variable in Columns (1) to (3) is experienced regret. The dependent variable in Columns (4) to (10) is demand-chasing frequency. The omitted group in Columns (1) to (9) is the censored demand treatment. Controls are age, gender, student, schooling, and work experience.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

This result lends support to Hypothesis 3B. Of considerable interest to our study, the results provide evidence of a significant positive indirect effect of demand information on demand-chasing frequency through experiencing regret (1.158, 95% percentile CI [0.29, 2.40]). Compared with those receiving censored demand information, subjects who observed actual customer demand information regardless of whether they faced an out-of-stock, chased demand more frequently across multiple rounds as a result of having experienced greater regret for the orders they had placed. This result supports Hypothesis 4B. Controlling for the effect of experienced regret, the frequency with which subjects chased demand did not significantly differ with either censored or uncensored demand information (Column (5), -0.959 , $p = 0.367$). A visual representation of the mediation model is presented in Figure 2.5. Adding control variables (Columns (2) and (6) to (7)) and individual heterogeneity measures (Columns (3) and (8) to (9)) shows results are robust and remain unchanged.

Similar to its effect on the relationship between experienced regret and demand-chasing extent, knowledge of the newsvendor problem was expected to mitigate the effect of regret on the frequency with which demand-chasing occurs across rounds.



Notes: Path coefficients for the mediation model of demand information on demand-chasing frequency through experienced regret. Dotted line denotes the (total) effect of demand information on demand-chasing frequency when experienced regret is not included as mediator. Coefficients are based on models without controls.

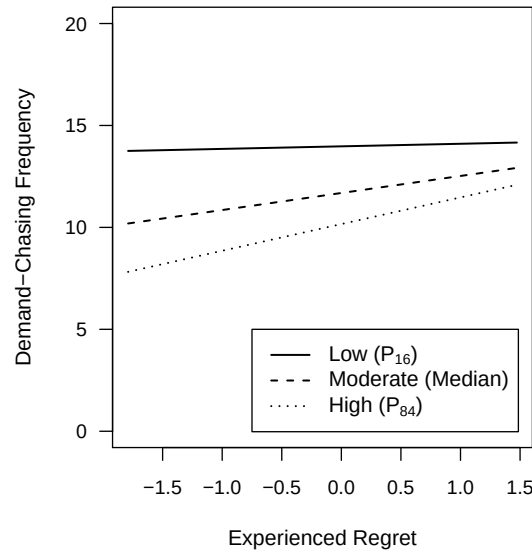
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 2.5: Path Diagram for Indirect Effect of Demand Information on Demand-Chasing Frequency

Table 2.4 Column (10) presents the results of the moderation analysis, showing that the frequency with which subjects chased demand across rounds because of experiencing regret was independent of how much they knew about the newsvendor problem (0.237, $p = 0.136$). Therefore, Hypothesis 6B is not supported. Details about these relationships are presented in Figure 2.6. Regardless of the level of knowledge subjects had about the newsvendor problem, they chased demand more frequently as their regret intensified. Moreover, those subjects who knew the most about the newsvendor problem chased demand less frequently regardless of how much they regretted their choices. However, these subjects also appeared to be more sensitive to changes in experienced regret.

2.6.4 The Effect of Product Profit Margin on Demand-Chasing

Subjects placing orders in the newsvendor problem for low- versus high-profit-margin products are more likely to obtain lower profits and experience losses. An ANOVA of product profit margin on experienced regret when demand information is uncensored, revealed a significant effect ($F(1, 92) = 6.17$, $p < 0.05$). Providing support for Hypothesis 2, this result shows that subjects placing orders for low- versus high-



Notes: Conditional effects estimated among subjects at the 16th (low), 50th (moderate), and 84th (high) percentiles of the distribution of newsvendor problem knowledge.

Figure 2.6: Moderation of the Effect of Experienced Regret (Manipulated by Demand Information) on Demand-Chasing Frequency by Newsvendor Problem Knowledge

profit-margin products experienced more regret.

Hypothesis 3A suggests that experiencing regret is positively associated with the extent to which decision makers chase demand. On the other hand, Hypothesis 5A proposes that placing orders for low- versus high-profit-margin products affects the extent to which decision makers chase demand through experiencing regret. The results of the mediation model are presented in Table 2.5. These results show that subjects experienced significantly more regret when placing orders for low- versus high-profit-margin products (Column (1), -0.875 , $p < 0.05$). This result supports Hypothesis 2. As subjects experienced more regret, they in turn chased demand to a greater extent (Column (5), 0.343 , $p < 0.01$). Thus, this result lends support to Hypothesis 3A. Subjects placing orders for low-profit-margin products, compared with those ordering high-profit-margin products, chased demand to a greater extent as a result of experiencing more regret for the choices they made (-0.300 , 95% percentile CI $[-0.55, -0.06]$). This result supports Hypothesis 5A by showing a significant

Table 2.5: Effect of Product Profit Margin on Demand-Chasing Extent

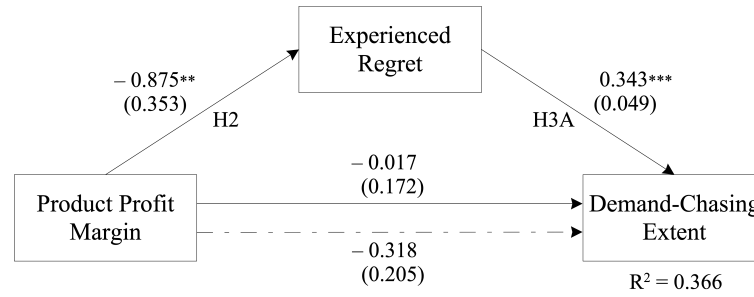
	Experienced Regret			Demand-Chasing Extent						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Product Profit Margin	−0.875** (0.353)	−0.907** (0.368)	−1.118*** (0.369)	−0.318 (0.205)	−0.017 (0.172)	−0.348 (0.212)	−0.048 (0.180)	−0.439** (0.213)	−0.080 (0.187)	
Experienced Regret					0.343*** (0.049)		0.331*** (0.051)		0.321*** (0.053)	0.334*** (0.049)
NVP Knowledge										−0.001 (0.038)
Regret × Knowledge										−0.036 (0.023)
Cognitive Reflection			−0.381** (0.160)					−0.117 (0.092)	0.006 (0.080)	
Risk Aversion			0.105 (0.094)					0.124** (0.054)	0.090** (0.045)	
Overprecision			−0.059 (0.074)					0.001 (0.043)	0.020 (0.036)	
Constant	0.438* (0.249)	0.979 (1.437)	0.915 (1.549)	0.159 (0.145)	0.009 (0.119)	−0.296 (0.828)	−0.620 (0.684)	−0.924 (0.893)	−1.218 (0.747)	−0.031 (0.085)
Controls	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No
R ²	0.100	0.110	0.177	0.026	0.366	0.091	0.390	0.158	0.420	0.383

Notes: OLS regression coefficients are reported. $N = 94$. The dependent variable in Columns (1) to (3) is experienced regret. The dependent variable in Columns (4) to (10) is demand-chasing extent. The omitted group in Columns (1) to (9) is the low-profit-margin product treatment. Controls are age, gender, student, schooling, and work experience.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

negative indirect effect of product profit margin on demand-chasing extent through experiencing regret. When experienced regret was controlled for, the direct effect of product profit margin on demand-chasing extent was not significant (Column (5), -0.017 , $p = 0.921$). Hence, independent of its effect on experiencing regret, the level of product profit margin did not significantly affect the extent to which subjects chased demand. Figure 2.7 depicts the mediation model. Our results remain unchanged after adding control variables (Columns (2) and (6) to (7)) and individual heterogeneity measures (Columns (3) and (8) to (9)), thus attesting to the robustness of findings.

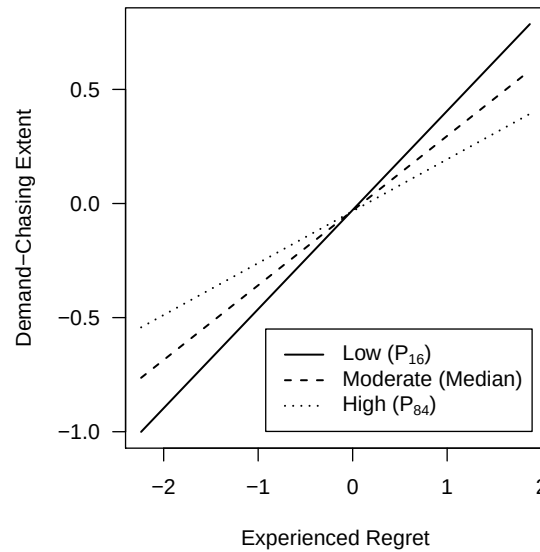
Results of the moderation analysis, presented in Table 2.5 Column (10), indicate that the extent to which subjects chased demand as a result of experiencing regret due to ordering low- versus high-profit-margin products did not vary based on their levels of knowledge of the newsvendor problem (-0.036 , $p = 0.118$). This result does not lend support to Hypothesis 6A. These relationships are presented in more detail in Figure 2.8. Overall, subjects at different levels of knowledge of the newsvendor problem chased demand to a greater extent as they experienced more regret. However,



Notes: Path coefficients for the mediation model of product profit margin on demand-chasing extent through experienced regret. Dotted line denotes the (total) effect of product profit margin on demand-chasing extent when experienced regret is not included as mediator. Coefficients are based on models without controls.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 2.7: Path Diagram for Indirect Effect of Product Profit Margin on Demand-Chasing Extent



Notes: Conditional effects estimated among subjects at the 16th (low), 50th (moderate), and 84th (high) percentiles of the distribution of newsvendor problem knowledge.

Figure 2.8: Moderation of the Effect of Experienced Regret (Manipulated by Product Profit Margin) on Demand-Chasing Extent by Newsvendor Problem Knowledge

Table 2.6: Effect of Product Profit Margin on Demand-Chasing Frequency

	Experienced Regret			Demand-Chasing Frequency						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Product Profit Margin	−1.116*** (0.315)	−1.102*** (0.323)	−1.082*** (0.335)	−1.170 (1.035)	0.157 (1.035)	−0.673 (1.056)	0.500 (1.070)	−1.216 (1.016)	−0.151 (1.025)	
Experienced Regret					1.190*** (0.321)		1.065*** (0.333)		0.984*** (0.315)	0.765** (0.301)
NVP Knowledge										−0.753*** (0.212)
Regret × Knowledge										0.155 (0.133)
Cognitive Reflection			0.002 (0.145)					−1.332*** (0.440)	−1.334*** (0.419)	
Risk Aversion			−0.061 (0.085)					−0.280 (0.258)	−0.220 (0.246)	
Overprecision			0.057 (0.067)					0.268 (0.205)	0.211 (0.196)	
Constant	0.558** (0.223)	1.246 (1.264)	1.376 (1.405)	11.681*** (0.732)	11.017*** (0.709)	19.536*** (4.130)	18.210*** (3.949)	21.214*** (4.267)	19.860*** (4.084)	11.283*** (0.481)
Controls	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No
R ²	0.120	0.192	0.205	0.014	0.143	0.104	0.199	0.239	0.319	0.261

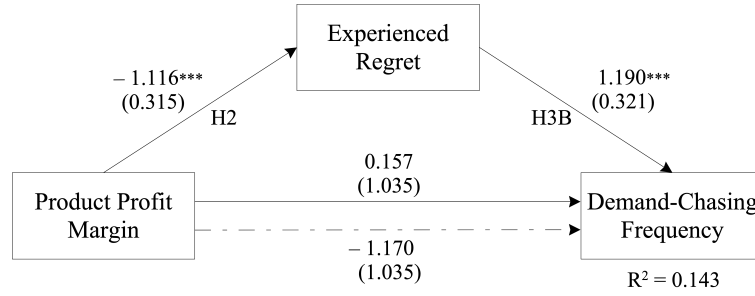
Notes: OLS regression coefficients are reported. $N = 94$. The dependent variable in Columns (1) to (3) is experienced regret. The dependent variable in Columns (4) to (10) is demand-chasing frequency. The omitted group in Columns (1) to (9) is the low-profit-margin product treatment. Controls are age, gender, student, schooling, and work experience.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

based on the extent to which they chased demand, subjects with lesser knowledge of the newsvendor problem appear to be more sensitive to variations in experienced regret.

To study the frequency with which decision makers chased demand at different product profit margin levels, we examined how they made their decisions across 25 rounds. We conducted an ANOVA with product profit margin as the independent variable and experienced regret as the dependent variable. Our results indicate that subjects experienced greater regret after placing orders across multiple rounds for low- compared with high-profit-margin products ($F(1, 92) = 12.53$, $p < 0.01$). This analysis further supports Hypothesis 2.

Hypothesis 3B proposes that experiencing more regret has a positive influence on the frequency with which demand is chased. In addition, Hypothesis 5B suggests that placing orders for low- compared with high-profit-margin products is associated with chasing demand more frequently through experiencing regret. Results for the mediation model are presented in Table 2.6. Subjects placing orders for low-profit-margin products experienced significantly more regret than those ordering high-profit-



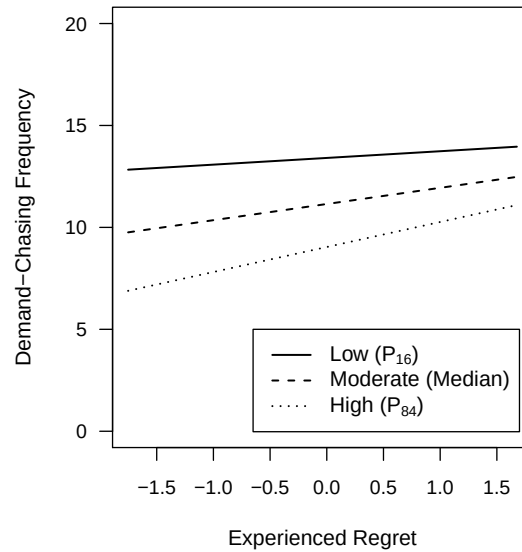
Notes: Path coefficients for the mediation model of product profit margin on demand-chasing frequency through experienced regret. Dotted line denotes the (total) effect of product profit margin on demand-chasing frequency when experienced regret is not included as mediator. Coefficients are based on models without controls.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 2.9: Path Diagram for Indirect Effect of Product Profit Margin on Demand-Chasing Frequency

margin products (Column (1), -1.116 , $p < 0.01$). This result supports Hypothesis 2. Also, subjects experiencing more regret chased demand more frequently (Column (5), 1.190 , $p < 0.01$), providing support for Hypothesis 3B. Relative to those placing orders for high-profit-margin products, subjects ordering low-profit-margin products chased demand more frequently as a result of experiencing greater regret for the choices they had made (-1.327 , 95% percentile CI $[-2.38, -0.51]$). This result lends support to Hypothesis 5B, indicating there is a significant positive indirect effect of product profit margin on demand-chasing frequency through experiencing regret. Independent of its effect on experienced regret, product profit margin did not have a significant effect on demand-chasing frequency (Column (5), 0.157 , $p = 0.880$). A visual depiction of the mediation model is presented in Figure 2.9. Adding control variables (Columns (2) and (6) to (7)) and individual heterogeneity measures (Columns (3) and (8) to (9)) provides a robustness check and shows that our results remain unchanged.

Moderation analysis results, presented in Table 2.6 Column (10), show that the frequency with which subjects chased demand as a result of experiencing regret was independent of their level of knowledge of the newsvendor problem (0.155 , $p = 0.246$). Therefore, Hypothesis 6B is not supported. Figure 2.10 depicts these relationships in



Notes: Conditional effects estimated among subjects at the 16th (low), 50th (moderate), and 84th (high) percentiles of the distribution of newsvendor problem knowledge.

Figure 2.10: Moderation of the Effect of Experienced Regret (Manipulated by Product Profit Margin) on Demand-Chasing Frequency by Newsvendor Problem Knowledge

detail. Subjects with varying levels of knowledge of the newsvendor problem chased demand more frequently as regret intensified. And, although subjects with low knowledge of the newsvendor problem chased demand more frequently, on average, than those with more knowledge, those with high newsvendor problem knowledge were affected to a greater extent by changes in experienced regret.

2.7 Discussion

The main insight of our study is that decision makers in the newsvendor problem display demand-chasing behavior as a result of experiencing a negative emotion—regret—elicited when counterfactual thoughts about what might have happened if a different quantity had been ordered are activated. Two situational conditions affect the degree to which people experience regret when placing orders in the newsvendor problem. First, because receipt of complete demand information plays an important

role in the realization of how a different choice would have bettered one's circumstances, people who receive full disclosure of demand information (i.e., uncensored) experience greater regret when placing orders for low-profit-margin products. Second, decision makers also experience greater regret when placing orders for low- versus high-profit-margin products when demand information is uncensored; this is because counterfactual thoughts are activated as perceived discrepancies between actual and ideal goal states become greater. Regret produces an unpleasant state that people are motivated to regulate (Pieters & Zeelenberg, 2007) and has been shown to influence choice behavior (Zeelenberg & Beattie, 1997; Zeelenberg & Pieters, 1999; Tsiros & Mittal, 2000). In the context of our study, those who experience more regret, chase demand to a greater extent and do so more frequently.

The results of our mediation models show regret drives the association between demand information (i.e., censored versus uncensored demand) and demand-chasing in terms of its extent and frequency. Our findings also show that demand becoming uncensored is positively associated with the onset and intensification of regret, which in turn is positively associated with demand-chasing. Therefore, in contrast to conventional wisdom, it appears that disclosing complete demand information has adverse effects in the newsvendor problem.

Mediation models also show regret drives the relationship between product profit margin (i.e., low- versus high-profit-margin product) and the extent and frequency of demand-chasing. Because decision makers in placing orders for low- versus high-profit-margin products are more likely to obtain lower profits and experience losses, the activation of counterfactual thoughts differs. Results show that those who order low-profit-margin products experience greater regret than those who order high-profit-margin products. Their greater regret is associated, in turn, with chasing demand. This finding is important because past studies have often tried to compare ordering behavior between products with different profit margins without taking into consid-

eration how such conditions affect the situation in which decision making takes place. This is particularly troublesome in settings in which profit margin is designed as a within-subjects factor (e.g., Schweitzer & Cachon, 2000; Zhang & Siemsen, 2018). The problem here stems from a general assumption that, because subjects will be paid comparable payoffs (after all, every subject receives the same number of treatments), accounting for the profit imbalance implied by different product profit margins is unnecessary.

Past studies have suggested certain people are predisposed to chase demand, either because they follow an anchoring and insufficient adjustment heuristic (Schweitzer & Cachon, 2000), they believe that independent draws are correlated (Bolton & Katok, 2008), or they score low in cognitive reflection (Moritz et al., 2013). However, our results show that because decision makers in the newsvendor problem seek to maximize their profits and obtain past demand information, they likely engage in counterfactual thinking when they realize they would have been better off if they had ordered different quantities. As a result, people regret the choices they made and, in accordance with the response strategy of this emotion, want to undo and correct the situation. Thus, rather than attribute demand-chasing behavior to dispositional factors, our research shows that by chasing demand, people behave in accordance with what one would expect from decisions made in this environment. To the extent that one should not explain with dispositions that which can be explained by the situation (Gilbert & Malone, 1995), these results contribute to the existing literature.

Having more knowledge about the newsvendor problem helps decision makers realize there is a trade-off between ordering too much versus too little and to recognize that what they should order depends on the unit cost, selling price, and demand distribution of the product that do not vary across periods. Because such knowledge improves the quality of decisions, it provides standards for choices that can prevent regret as an outcome, thereby reducing the effect of regret on decision making (Pieters

& Zeelenberg, 2007). Rather surprisingly, our study shows that how much or how little decision makers know of the newsvendor problem has no bearing on how their sense of regret affects demand-chasing behavior. In other words, decision makers do not appear to act as they should and the influence of regret seems to dominate their behavior. We are unsure why this may be so, but we speculate that decision makers' cognitive effort might be at play. The literature suggests that decision makers typically weight either effort or decision quality more highly in making trade-offs between the two (Todd & Benbasat, 1994). However, a key idea is that because feedback on effort expenditure is relatively immediate, effort generally tends to receive the higher weighting (Todd & Benbasat, 1994). Thus, the effect of having greater knowledge is limited because decision makers are likely to favor less effort, a preference that may well be tied to self-blame (as in "I did not try hard enough") that corresponds to regret and its dominance.

Our work provides a comprehensive understanding of demand-chasing behavior by considering both the magnitude of changes in order quantities toward realized demand as well as the frequency with which such changes occur. Specifically, we measured the extent to which subjects chased demand in a given round and the frequency with which they chased demand across multiple rounds. Although some decision makers may, for example, make frequent small adjustments, others may display sporadic but bigger adjustments. When the interest shifts from classifying people into categories (i.e., those who chase demand versus those who do not) to describing the behavior of decision makers who may choose to chase demand in one period and abstain from doing so in the next, the use of both dimensions of demand-chasing contributes to a comprehensive understanding of the heterogeneity in behavior across individuals.

2.7.1 Theoretical Implications

Our research shows that there is much more to the role of regret in the newsvendor problem than what economic models have assumed and incorporated to date. The preference for minimizing ex-post inventory error model, proposed by Schweitzer & Cachon (2000), is based on the notion that an economic model of decision making under uncertainty based solely on maximizing the expected utility of monetary assets is incomplete without considering the sense of loss (gain) people experience when discovering or expecting to discover that another alternative would have been desirable (undesirable) (Bell, 1982; Loomes & Sugden, 1982). Although this model represents a reasonable attempt to incorporate non-monetary outcomes into an economic model of the newsvendor problem by including the dis-utility one would expect from choosing an order quantity that deviates from realized demand (i.e., the ex-post optimal order quantity), it differs in important ways from what we proposed in our study. First, as we conceive of and measure it, regret is elicited not only by comparing the outcome of a chosen option with that of a foregone option (as considered by the minimizing ex-post inventory error model), but also by *how* the decision was made (e.g., one may regret a decision that was made in an unjustified way) (Sugden, 1985; Pieters & Zeelenberg, 2007). Indeed, researchers have noted that the regret one feels may also depend on the amount of thought that went into a decision, how close one was to having ordered the alternate option, and the self-recrimination one experiences when a decision involved an error of judgment (Bell, 1982; Sugden, 1985). By manipulating and measuring the extent to which people experience regret when making decisions in the newsvendor problem, our study captures the different components of the construct.

Second, the ex-post inventory error model measures a non-monetary preference based on what people expect or anticipate from possible deviations between what

they plan to order and what demand may be. In contrast to our study, these economic models do not capture the actual or experienced regret people feel after making successive choices and observing how demand actually unfolds. Third, the optimal solution to an economic model that considers ex-post inventory errors may theoretically produce average order quantities that lie between the expected-profit-maximizing order and mean demand as replicated throughout multiple experiments. However, it fails to explain the variation in ordering behavior that occurs within individuals from one period to the next, which is captured in our research by directly measuring the extent to which people experience regret in a given round.

Other descriptive models drawing from the ex-post inventory error principle that are perhaps closest to the empirical evidence presented in our study are the reference dependence model developed by Ho et al. (2010) and the impulse balance equilibrium (IBE) model from Ockenfels & Selten (2014). The reference dependence model is based on the assumption that people face psychological costs for out-of-stocks and overstocks, and that these costs become part of the objective function (as parameters) that decision makers consider when maximizing expected utility. Although similar to the minimizing ex-post inventory error model of Schweitzer & Cachon (2000), the reference dependence model allows the two types of psychological costs to differ. The IBE model assumes that ordering choices are driven by impulses that occur in response to deviations from past demand realizations (i.e., ex-post inventory errors)—upward impulses after out-of-stocks and downward impulses after overstocks—, and that decision makers have a tendency to move in the direction of that impulse (Ockenfels & Selten, 2015). An equilibrium is found by identifying the order that balances out the expected upward and downward impulses. Both models successfully predict that decision making deviates from rational profit maximization and that average orders fall between mean demand and optimal orders, which are robust observations in the behavioral newsvendor problem literature (Schweitzer & Cachon, 2000). However, as

suggested by Becker-Peth & Thonemann (2019), it is difficult to explain such patterns without better understanding the cognitive processes that drive ordering behavior. Our findings complement these descriptive models and, in a way, provide empirical support for why the assumptions they imply may hold. *Psychological costs* and *impulses* are explained by decision makers experiencing regret and acting in accordance with the response strategy of the emotion. Therefore, our study provides evidence that emotional processes, in addition to cognitive processes, play an important role in newsvendor decision making.

Our findings also help to interpret past results in the behavioral newsvendor literature. For example, Moritz et al. (2013) suggested demand-chasing behavior stems from differences in cognitive reflection. The authors showed that those who scored high in cognitive reflection displayed less demand-chasing when ordering medium- and high-profit-margin products, but not in ordering low-profit-margin products. Based on our theoretical perspective, placing orders for low-profit-margin products elicits a high degree of experienced regret that comes from perceived discrepancies between actual and ideal goal states because of low profits and losses. To the extent that emotion becomes a strong motivational force, we would expect decision makers, even those who tend to be more deliberate and reflective, to make choices in accordance with the response strategy of the emotion and thus chase demand. Therefore, one may expect cognitive reflection to play a less relevant role in demand-chasing behavior when decision makers place orders for low-profit-margin products. Thus, acknowledging that experiencing regret is the main driver of demand-chasing behavior reconciles these mixed findings.

As presented in Section 2.3.1 Table 2.1, Lurie & Swaminathan (2009), Kremer et al. (2010), and Rudi & Drake (2014) identified certain experimental conditions as associated with greater demand-chasing. Our research provides a unique mechanism through which these findings can be explained. Lurie & Swaminathan (2009) found

that decision makers chased demand more when they received demand information more frequently (e.g., every round versus every six rounds). Because realization that another choice would have been better is a precondition for experiencing regret, decision makers who receive more frequent feedback will experience higher levels of regret. In turn, they will chase demand to a greater degree. Kremer et al. (2010) found in their study that decision makers are more likely to chase demand when the decision task is described in an operations newsvendor context than in a neutral lottery context. This is no surprise once we acknowledge, as described in our study, that situational factors present in the newsvendor problem account for demand-chasing behavior. To the extent that counterfactual thoughts get activated in response to goals being blocked, differences in how decision makers perceive goal discrepancies in each context play a central role in explaining varying levels of experienced regret and demand-chasing. For example, although in a newsvendor context the goal is to maximize profits, decision makers in a lottery context may pursue a different goal (e.g., minimize the likelihood of incurring a loss). Rudi & Drake (2014) reported higher adjustment behavior occurs as demand variability increases. Because one would expect greater discrepancies between actual and ideal goal states to result from increasing variability in demand, decision makers are more likely to experience regret and adjust their order quantities when demand variability is high.

2.7.2 Limitations and Managerial Implications

Our study addresses decision making in the context of a newsvendor problem in which the unit cost, the selling price, and the demand distribution function are known. Although our findings are limited to the newsvendor setting, they may also inform a broad set of situations characterized by repetitive but independent decision making having clear and measurable goals, uncertain conditions, and trade-offs between incurring losses and foregoing profits. Who decides may also matter in such situations.

Subjects in our study were highly reputable MTurk workers in the United States. Although results are bounded by such a population, some research suggests that some of our findings may carry over to a broader population. For example, Lee et al. (2018) replicated the results obtained by Bolton & Katok (2008) in recruiting MTurk workers instead of students and Bolton et al. (2012) found that students and managers behaved in similar ways in the context of the newsvendor problem.

Although evidence of an association between two variables is not a prerequisite for the existence of an indirect effect through a third variable (Shrout & Bolger, 2002; MacKinnon et al., 2000; MacKinnon, 2008; Hayes, 2009), one may argue that because the relationship between our antecedents of experienced regret and demand-chasing (without controlling for experienced regret) was not significant, experienced regret does not necessarily fully mediate the relationship. We do not claim in this study that experienced regret acts as a “full” mediator (and many are skeptical that such a claim even exists (Hayes, 2018)). However, results from Table 2.5 Columns (8) and (9) show that when control variables and individual heterogeneity measures are accounted for, experienced regret fully mediates the effect of product profit margin on the extent of demand-chasing. The total effect (not including experienced regret) of product profit margin on demand-chasing extent is negative and significant, but the direct effect of product profit margin becomes small and not significant when experienced regret is included.

Our study has several managerial implications. First, because the main driver of demand-chasing behavior is experienced regret, any attempt to mitigate the negative effect of such behavior should begin by addressing the emotional effects of counterfactual thinking. This has been widely overlooked by past research studies in the behavioral newsvendor literature.

Second, not all business settings have access to complete (i.e., uncensored) demand information. For example, many retail stores know how much they sold to customers,

but have trouble estimating lost sales attributable to out-of-stocks. Because decision makers behave differently with censored and uncensored demand information, managers should be aware of the setting in which their business operates. When available, disclosing complete demand information to those in charge of material planning and procurement should be handled with discretion. This discretion is warranted because controlling the information shared with decision makers can limit undesirable reactive behaviors like chasing demand by people experiencing regret when the outcome of a chosen option compares unfavorably to that of a foregone option. The trade-off between more information and the risk of undesired behavior versus less information and avoidance of risk will depend on each specific circumstance. Controlling information does not necessarily mean restricting access to data; instead, it may imply delaying reports or aggregating information in a way that is useful to decision makers.

Third, managers in charge of low-profit-margin products should consider in placing their orders with suppliers the implications such conditions impose. Because lower profits and losses are likely when ordering such products, perceived goal discrepancies become greater and demand-chasing behavior occurs. Acknowledging that such a relationship exists and creating awareness among decision makers so they will avoid self-blame is an important step in addressing this issue. Future research may therefore investigate ways in which people can regulate regret effectively (Pieters & Zeelenberg, 2007) in the context of the newsvendor problem.

Fourth, management should not expect greater knowledge about the newsvendor problem to mitigate the effect of experienced regret on demand-chasing. Our results show this effect does not depend on newsvendor problem knowledge. Therefore, unless the expected-profit-maximizing order quantity or the method to calculate it are explicitly given and decision makers are required to follow them, training decision makers in the newsvendor problem may not reduce the impact regret has on ordering behavior. We are not implying training in the newsvendor problem is unwarranted,

but rather, that it should be done by setting realistic expectations.

Chapter 3

Essay 2: Chasing Demand but Pulling to the Center? The Role of Counterfactual Thinking and Regret in the Newsvendor Problem

3.1 Abstract

Decision makers in the newsvendor problem place orders that when averaged across multiple selling periods and individuals are systematically pulled away from the optimal order quantity and toward mean demand. Although this *pull-to-center effect* has been replicated in almost every behavioral study, why it occurs remains unclear. To date, researchers have argued the effect is due to the dispositions of individuals (e.g., their tendency to follow heuristics), but in this study we explore and find support for an alternative viewpoint, which holds that situational forces influence decision makers' choices when they face the newsvendor problem and these are what lead to average order quantities being pulled-to-center. Specifically, through a series of experiments, we demonstrate that decision makers have counterfactual thoughts and experience regret, that in response to this emotion they chase demand, and that this behavior results in pulled-to-center average order quantities. We find that the effect demand-chasing has on pulled-to-center average orders is contingent on the level of knowledge decision makers have about the problem. Based on the mechanisms we uncover, we design an intervention that addresses the shortcomings of counterfac-

tual thoughts. Our improved feedback intervention leads to better performance and shows that managers interested in achieving better profits while allowing human involvement in newsvendor-type decisions should address counterfactual thinking and regret. We demonstrate this can be achieved by implementing a low cost intervention without imposing restrictions to decision makers. Our results help to interpret past findings by explaining why demand-chasing has been frequently observed, why certain interventions have resulted in improved performance, and why asymmetries in the pull-to-center effect may occur.

3.2 Introduction

The newsvendor problem resembles the situation faced by a newsboy who, in an effort to maximize his profit, must decide how many newspapers to order in advance that will be for sale at his newsstand during the day. When ordering too many, the newsboy incurs in unnecessary costs. When ordering too few, he misses opportunities for sales. Known as a single-period inventory problem with stochastic demand, the newsvendor problem lays the groundwork for more complex inventory management problems and has a wide set of applications in other business domains including revenue management, capacity allocation, staffing in service industries, R&D investment, and scheduling in project management.

Based on the unit cost, selling price, salvage value, and demand distribution function, an optimal solution to the problem that maximizes the expected profit can be found (Arrow et al., 1951). Although the optimal solution prescribes ordering the expected-profit-maximizing (or optimal) order quantity every period, behavioral studies have found that human decision making deviates from the expected-profit-maximizing order (Schweitzer & Cachon, 2000). More surprising yet, is the evidence provided by almost every behavioral newsvendor study of a systematic ordering pat-

tern occurring at an aggregate level: average order quantities tend to fall between the optimal order quantity and mean demand (e.g., Schweitzer & Cachon, 2000; Bolton & Katok, 2008; Kremer et al., 2010; Moritz et al., 2013; Lee & Siems, 2017; Becker-Peth et al., 2018). Because average orders are seen as being pulled away from the optimal order quantity and toward mean demand, this pattern has come to be known as the *pull-to-center effect*. To the extent that moving away from the optimal order quantity reduces the expected profit the newsboy may earn, understanding *why* average orders are pulled-to-center is important and has captivated researchers for almost two decades.

Behavioral studies show that if certain heuristic is used when choosing order quantities in the newsvendor problem (e.g., anchoring and adjustment heuristic (Schweitzer & Cachon, 2000)) or a cognitively biased decision is made (e.g., overprecision bias (Ren & Croson, 2013)), the average order may be pulled-to-center. However, that the average order quantity resulting from a heuristic or cognitive bias falls between the expected-profit-maximizing order quantity and mean demand does not necessarily mean that decision makers follow such heuristic or bias when choosing.

Another stream of literature shows that when other objectives besides maximizing expected profit are considered in the utility function of decision makers (e.g., loss aversion (Schweitzer & Cachon, 2000), mental accounting (Becker-Peth et al., 2013)), the optimal order quantity of such models may display the pull-to-center effect (i.e., moving the optimal order quantity away from the expected-profit-maximizing order quantity and toward mean demand). A set of closely related studies uses special modeling forms that incorporate behavioral assumptions influencing decision making (e.g., quantal choice model (Su, 2008), impulse balance equilibrium (Ockenfels & Selten, 2014)) and shows that the solution to these models predicts order quantities that are pulled-to-center. Still, the fact that the solution to these economic models prescribes an order quantity that is pulled-to-center or that approximates actual

average order quantities does not guarantee that decision makers are indeed following the corresponding objectives or assumptions captured by these models.

In addition, other studies have found certain individual heterogeneity characteristics (e.g., cognitive reflection (Moritz et al., 2013), gender (de Véricourt et al., 2013)) to be associated with the degree to which average order quantities are pulled-to-center. Because individual characteristics being correlated to pulled-to-center average order quantities do not imply these characteristics cause such pattern to occur, it appears opportunity to better understand what the mechanism(s) leading to average order quantities being pulled to center exists.

In sum, these four perspectives through which newsvendor decision making has been studied—heuristics and cognitive biases, utility functions, special modeling forms, and individual heterogeneity characteristics—have helped identify which factors may be related to the pull-to-center effect and develop economic models that predict order quantities exhibiting a similar aggregate level pattern. However, these perspectives fall short of identifying the cognitive processes that take place when decision makers choose order quantities and explaining how such processes may lead to average order quantities that are pulled-to-center (Becker-Peth & Thonemann, 2019). Without answers to these questions, knowing why certain conditions may or may not improve ordering behavior and developing strategies that managers could implement to perform better in newsvendor settings will remain a challenge.

Because the pull-to-center effect is an aggregate level pattern that arises from averaging order quantities (Schweitzer & Cachon, 2000), it is not a tangible phenomenon that can be observed at a specific place or point in time and thus hardly corresponds to an actual choice behavior that occurs here and now. For this reason, it has been difficult, perhaps impossible, for researchers to recognize what the situational forces that influence choice behavior in the newsvendor setting are, given that the phenomenon under study takes place at an abstract level. Undisputedly, the

pull-to-center effect has been the prevailing phenomenon in the behavioral newsvendor literature and has been the focus of most experimental studies (Becker-Peth & Thonemann, 2019). Therefore, although the foregoing perspectives that have been used to study the problem vary, they seem to emerge from a shared viewpoint—the observer’s viewpoint. This viewpoint lacks the awareness of the surrounding environment and the role the situation plays on the behavior of those who are making choices—the actors—, and as a consequence, makes inferences about their dispositions even when situational forces may explain the observed phenomenon well (Gilbert & Malone, 1995).

This is evidenced by the existing plausible explanations provided in the literature to date for why the pull-to-center effect occurs or varies in strength. Whether people display this aggregate level pattern because they are likely to follow a heuristic or incur in a specific bias, consider some other objective in their utility function, behave as assumed by a model, or have certain individual characteristic, these inferences attribute the phenomenon to dispositions of decision makers. However, dispositional inferences are logically unwarranted when people do precisely what the environment or situation demands (Gilbert & Malone, 1995). Therefore, if we hope to make a proper attribution of the pull-to-center effect, it is necessary to consider the experiences of decision makers and how the situation they face shapes these experiences. This leads to the overarching research question that guides our study: Do situational forces explain how decision makers behave when choosing order quantities in the newsvendor problem and can this ordering behavior produce an aggregate level pattern in which average order quantities fall between the expected-profit-maximizing order and mean demand?

Rather than taking an observer’s viewpoint, in this study we propose a different approach. What if we considered the actor’s viewpoint? In the newsvendor problem, after an order is placed, demand occurs and this information then becomes available to

decision makers. As order quantities deviate from what customers demand, decision makers realize that the goal of obtaining better profits is hindered. Thinking one would have been better off if a quantity closer to what customers demanded had been ordered seems inevitable. This special way of thinking about how the past might have been different had some other aspect been different is known as *counterfactual thinking* (Roese & Olson, 1995b). Counterfactual thoughts get activated in response to goals being blocked (e.g., obtaining unsatisfactory profits or making losses) and their content is not random but constrained by how to achieve the unrealized goal (e.g., ordering a quantity closer to customer demand would have resulted in better profits) (Roese & Epstude, 2017). Counterfactual thoughts like those experienced by decision makers in the newsvendor problem, that specify how the past might have been better, focus on oneself, and alter one’s own planned or controllable actions, are the key antecedent of *regret* (Roese, 1997; Roese & Epstude, 2017).

Regret is a negative, cognitive-based emotion we experience when realizing or imagining that our present situation would have been better had we decided differently in the past (Zeelenberg et al., 2001). Two preconditions, both of which are present in the newsvendor setting, are necessary for decision makers to experience regret: an element of personal agency and the realization that another choice would have been better (Zeelenberg & Pieters, 2007). The intensity and severity with which we experience regret depends not only on how the obtained outcome compares to the outcome of a foregone option, but also on how the decision was made (Sugden, 1985; Pieters & Zeelenberg, 2007). Therefore, as orders are placed and demand unfolds in the newsvendor problem, the extent to which decision makers experience regret may vary depending on what they choose, how they choose, and how customer demand unfolds—that is, depending on the specific situation they face. In addition, regret creates an aversive state that people are motivated to regulate (Pieters & Zeelenberg, 2007) and is associated with a clear response strategy that involves wanting to undo

and reverse the decision made (Roseman et al., 1994; Zeelenberg et al., 1998).

By considering the actor’s viewpoint and acknowledging the situation under which decision makers place orders in the newsvendor problem, in this study we show that counterfactual thinking and regret are important situational forces that influence choice behavior. In particular, we find that counterfactual thoughts are indeed present in the newsvendor setting and that, in an effort to undo their choice, decision makers change their order quantity in the direction of past demand—a behavior known as *demand-chasing*—, to a greater extent and more frequently, as they experience greater regret from the choices they have made. Most importantly, we find that the average order quantity of decision makers is pulled-to-center to a greater degree as they chase demand to a greater extent and more frequently, that demand-chasing mediates the effect experienced regret has on average order quantities being pulled-to-center, and that these relationships hold within a critical boundary condition.

In short, our findings show that decision makers in the newsvendor problem behave as expected from a situation in which counterfactual thinking and regret act as forces that alter her or his understanding of the problem. Because their behavior conforms to what one would expect when placing orders in the presence of such situational forces, inferences about decision makers being predisposed to either chase demand or obtain average order quantities that are pulled-to-center should be avoided.

The contributions of our study fall into three categories. First, we identify a cognitive mechanism—counterfactual thinking—and an emotion it elicits—regret—, both of which are present when placing orders in the newsvendor problem and play a role in how decision makers see and interpret the situation they face. We introduce these key factors into the behavioral newsvendor literature, not only by empirically measuring whether counterfactual thoughts occur and the extent to which people experience regret (the first study, to the best of our knowledge, to do so in this literature), but also by providing a theoretical framework based on counterfactual

thinking and regret theories. This framework shows why these factors are relevant in a newsvendor setting and how they are related.

Because in the newsvendor problem one is more likely to obtain lower profits and incur losses when ordering low- versus high-profit-margin products, decision makers will perceive greater discrepancies between actual and ideal goal states when placing orders for low-profit-margin products. To the extent that counterfactual thoughts are activated in response to goals being blocked, we show product profit margin is an important antecedent of counterfactual thinking and regret in the newsvendor setting. Based on this framework, we incorporate antecedents and consequences of these factors into an integrated theoretical model that helps us understand why people chase demand and why average orders tend to fall between expected-profit-maximizing order quantities and mean demand. Therefore, what seemed, so far, to be explained by dispositional factors—heuristics and cognitive biases, utility functions, special modeling forms, and individual heterogeneity characteristics—is in fact well explained by situational factors present in the newsvendor setting.

These findings have important theoretical implications. On one hand, acknowledging that regret plays a crucial role in newsvendor ordering behavior in general and in explaining the relationship between product profit margin and the pull-to-center effect in particular, implies that it is critical to consider the extent to which people experience this emotion when comparing average order quantities between low- versus high-profit-margin products. Although past studies have frequently compared and pointed out differences (often referred to as *asymmetries*) in average order quantities being pulled-to-center across different product profit margin conditions (e.g., Schweitzer & Cachon, 2000; Bostian et al., 2008; Ho et al., 2010), none of them have accounted for experienced regret. This is specially troublesome for studies in which product profit margin is designed as a within-subjects factor (e.g., Schweitzer & Cachon, 2000; Zhang & Siensen, 2018) because making decisions under one profit

margin condition affects the extent to which people experience regret and this, in turn, affects how choices are made under a different profit margin condition. On the other hand, our results also help to interpret and reconcile past findings in the literature. For example, in their study, Bolton & Katok (2008) found that restricting options to decision makers (in number of options to choose from and frequency with which options can be chosen) improves ordering performance. Our theoretical model suggests that restricting options in this way reduces decision makers' sense of control over the situation they face and deter them from realizing that a different option would have been better. Because these are the key preconditions of experiencing regret, when these restrictions are in place decision makers are less likely to experience this emotion and will, in turn, chase demand and have pulled-to-center average order quantities to a lesser extent. Therefore, our results support Bolton & Katok's (2008) findings and provide a rationale for why decision makers change their behavior and obtain better profits under these circumstances.

Second, we uncover a contextual factor that sets a boundary to the relationships in the theoretical model. We show that as people experience regret, they are likely to adjust their order quantity in the direction of past demand. As this regret-induced demand-chasing behavior increases, the historical orders of decision makers start mirroring demand realizations and their average order quantity approaches the demand distribution's mean. One may be tempted to think that the effect demand-chasing has on average order quantities being pulled-to-center holds in general. However, our results show that this relationship depends on the knowledge people have about the newsvendor problem and we introduce an empirical measure of this factor. Surprisingly, the effect demand-chasing has on average order quantities being pulled-to-center is stronger for decision makers that have more knowledge about the newsvendor problem. This is important because studies have often compared average order quantities across decision makers and treatment groups (e.g., Schweitzer & Cachon, 2000; Lau

et al., 2014; Rudi & Drake, 2014) without accounting for knowledge people have about the problem.

Third, although counterfactual thinking is functional in that it serves different purposes related to goal pursuit and affect regulation (Roese & Epstude, 2017), our results show that in the context of the newsvendor problem, counterfactual thoughts lead to ineffective behavioral consequences and performance—demand-chasing and pulled-to-center average order quantities. In the newsvendor setting, thinking one would have achieved better profit if a quantity closer to what customers demanded had been ordered implies, as counterfactual thoughts do by virtue of the falsity of their antecedent, a causal inference: ordering a quantity closer to what customers demanded *causes* profit to improve. However, although it may be true that had one ordered a different quantity closer to what customers demanded better profits might have been obtained, this does not imply that better profits ought to have been obtained—a confusion known as *counterfactual fallacy* (Miller & Turnbull, 1990). To the extent that causal inferences are the link between counterfactual thoughts and behavioral intentions getting implemented, inaccurate inferences will often lead to dysfunctional behavior (Sherman & McConnell, 1995; Roese & Epstude, 2017). By acknowledging the pervasiveness of counterfactual thinking in the newsvendor setting and understanding why it leads to inaccurate causal inferences, we design an intervention that addresses ineffective ordering behavior and improves performance. Rather than focusing on allowing extended experience, providing training about the problem, displaying expected profit of order quantities, reducing feedback frequency, or restricting options to decision makers as proposed by past studies (e.g., Bolton & Katok, 2008; Bostian et al., 2008; Lurie & Swaminathan, 2009; Bolton et al., 2012), our intervention exploits the functional properties of counterfactual thinking while improving the accuracy of their causal inferences. Specifically, we ask decision makers to provide two additional quantities they considered when choosing their first

order and use them to provide improved feedback that facilitates the construction of more accurate counterfactual thoughts. Our results show that decision makers receiving improved versus standard feedback information have average order quantities that are less pulled-to-center as a consequence of chasing demand to a lesser extent, which is, in turn, a result of experiencing less regret. Thus, although counterfactual thinking appeared to be dysfunctional and ineffective in improving ordering performance, this special kind of thinking can in fact be effective when decision makers receive appropriate information.

Our study has relevant managerial implications. To identify the situational forces that are present in the newsvendor problem and negatively affect behavior, is an important first step in developing actionable measures that improve performance. Therefore, our results show that if managers wish to obtain better profits while allowing human involvement in newsvendor decision making, addressing emotion, specifically regret, is crucial but something that has been widely overlooked. In addition, besides providing further evidence about the presence and role of counterfactual thinking, our intervention implies that, contrary to past studies showing slow and often insignificant learning from experience (e.g., Schweitzer & Cachon, 2000; Bolton & Katok, 2008; Bolton et al., 2012), decision makers will learn to make better choices when they receive feedback that allows the construction of counterfactual thoughts that contain accurate causal inferences. Thus, counterfactual thoughts which seemed at first to be dysfunctional, can facilitate performance improvement and become functional when appropriate information is provided to decision makers.

3.3 Literature

The newsvendor problem is one of the fundamental problems in operations management. The order quantity that maximizes the expected profit was introduced and

analytically derived by Arrow et al. (1951). Assuming the product has no salvage value, this expected-profit-maximizing order quantity q^* depends on the demand distribution function F , the unit cost c , and selling price p , and can be expressed as:

$$q^* = F^{-1} \left(\frac{p - c}{p} \right) \quad (3.1)$$

The term in parentheses, known as the critical ratio (or fractile), has been used to classify the type of product being ordered (Schweitzer & Cachon, 2000). High-profit-margin products have a critical ratio above 0.5, while low-profit-margin products have a critical ratio below 0.5. When the demand distribution is symmetric, this solution implies that the optimal order quantity falls above mean demand for high-profit-margin products and below for low-profit-margin products.

The analysis of human behavior in the newsvendor problem originated with Hoskin (1983), who studied how people use opportunity costs when making decisions. However, it was Schweitzer & Cachon's (2000) research, examining why people deviate from the expected-profit-maximizing order, that triggered subsequent studies and the emergence of the behavioral newsvendor literature. One of the main findings reported by Schweitzer & Cachon (2000) is that average order quantities deviate from the optimal order quantity in a systematic way. In the section that follows, we focus on this aggregate level ordering pattern and the literature that has contributed to having a better understanding of this phenomenon.

3.3.1 Pull-to-Center Effect

The observation that average order quantities tend to fall between the optimal order quantity and mean demand was first reported by Schweitzer & Cachon (2000). Although this aggregate level pattern, termed the pull-to-center effect by Bostian et al. (2008), was noticed when order quantities were averaged across periods and

individuals, other studies have used it to describe average orders of single decision makers (e.g., Benzion et al., 2008; Ho et al., 2010). However, the degree to which average order quantities are pulled-to-center varies greatly across individuals, with some having average order quantities falling outside the pull-to-center region (Lau et al., 2014). This systematic pattern raises two important questions. Why are order quantities pulled-to-center when averaged across periods and individuals? And, what explains the variation between individual decision makers in average order quantities being pulled-to-center?

Studies have examined these questions from four main perspectives and have identified relevant factors found to either play a role or not in explaining the phenomenon. Although some studies in the behavioral newsvendor literature analyze phenomena other than the pull-to-center effect or evidence the existence of relevant factors that may be present in the newsvendor setting, our interest lies in studies showing which of these factors play a role in explaining the pull-to-center effect. In an effort to maintain consistency, we follow a similar framework to Becker-Peth & Thonemann’s (2019) review of the literature to classify and examine studies, but with important differences. First, rather than a general review of the literature, our focus is primarily on studies pertaining to the pull-to-center effect and whether factors captured in each study are shown to explain the phenomenon or not. Second, even though a study may provide some support for the presence of a factor in the context of the newsvendor problem, its results may show the factor is insufficient to account for average orders being pulled-to-center. For example, Chen et al. (2013) found that different payment schemes affect order quantities consistent with prospective accounting (i.e., providing support for the presence of this factor in the newsvendor context). However, because this mental accounting rule prescribes order quantities that are greater than the expected-profit-maximizing order quantity under a similar payment scheme to the one implied by the standard newsvendor problem, prospective accounting does

Table 3.1: Behavioral Newsvendor Literature Examining the Pull-to-Center Effect From the Heuristics and Cognitive Biases Perspective

Study	Heuristics & Cognitive Biases			
	Mean Demand Anchoring and Adjustment Toward Optimal	Previous Order Anchoring and Adjustment Toward Previous Demand	Observation Bias	Overconfidence Bias
Schweitzer & Cachon (2000)	+	−		
Benzion et al. (2008)	+			
Bolton & Katok (2008)	+			
Bostian et al. (2008)	+	+		
Katok & Wu (2009)	+			
Kremer et al. (2010)		+		
Feng et al. (2011)	+			
Becker-Peth et al. (2013)	+			
Moritz et al. (2013)		+		
Ren & Croson (2013)				+
Rudi & Drake (2014)			+	
Schiffels et al. (2014)	+			
Becker-Peth & Thonemann (2016)	+			

Notes: Table indicates whether study's results show factor plays (+) or does not play (−) a role in average orders being pulled-to-center.

not seem to explain pulled-to-center average order quantities for high-profit-margin products (i.e., showing this factor is insufficient to account for the pull-to-center effect). Third, and perhaps most importantly, by looking at the studies within each perspective in detail, we identify what the limitation in explaining the pull-to-center effect is for each perspective. We conclude this section by discussing an overarching feature of the four main perspectives that seems to account, at least in part, for these limitations.

Heuristics and Cognitive Biases.

One perspective through which the pull-to-center effect has been studied is *heuristics and cognitive biases*. These studies show that if people use certain heuristics when choosing order quantities or if they make cognitively biased decisions, their average order quantity may be pulled-to-center. Table 3.1 presents a list of studies associated with this perspective in the context of the newsvendor problem and indicates whether their results provide evidence in favor or against the corresponding factor playing a role in average orders being pulled-to-center.

One of the first heuristics and, perhaps, one of the most widely accepted explanations for the pull-to-center effect is the mean demand anchoring and adjustment heuristic introduced by Schweitzer & Cachon (2000). The authors suggest this heuristic assumes decision makers anchor on the demand distribution's mean and adjust toward the expected-profit-maximizing order quantity. Because experimental data showed average order quantities fall between the optimal order quantity and mean demand, they conclude such heuristic might be at play. Since then, several studies provide evidence of average orders anchored on mean demand (e.g., Benzion et al., 2008; Katok & Wu, 2009), while others incorporate elements of the heuristic into behavioral models (e.g., Bostian et al., 2008; Becker-Peth et al., 2013). However, studies have found pulled-to-center average order quantities persist even when decision makers are not informed about the demand distribution or its mean, and they only receive sample demand observations (e.g., Bolton et al., 2012). The fact that in this case the demand distribution's mean is not readily available to decision makers casts doubt on whether such heuristic is followed. Another heuristic, the previous order anchoring and adjustment heuristic, was also proposed by Schweitzer & Cachon (2000) as a possible explanation for the pull-to-center effect. The authors suggest this heuristic assumes decision makers anchor on the previous order quantity and adjust toward previous demand realization. Although Schweitzer & Cachon (2000) found that when subjects change their order quantity they are more than twice as likely to do so toward previous demand than away from it, the authors conclude there is weak support for such heuristic taking place and explaining the pull-to-center effect given that individuals' choices are not described by the same adjustment pattern throughout all periods and the heuristic makes no prediction about initial order quantities. However, as we discuss in Section 3.3.2, even though the behavior does not seem to be due to adopting an anchoring and adjustment heuristic, subsequent studies have continued to evidence adjustment behavior toward the most recent demand realization.

In addition to these heuristics, two cognitive biases have been proposed as having to do with average order quantities being pulled-to-center. The observation bias, as proposed by Rudi & Drake (2014), suggests that past demand information may influence the extent to which average order quantities are pulled-to-center (i.e., level behavior as defined by the authors) due to the tendency people have to estimate the likelihood of an event based on the ease with which related instances can be brought to mind (Tversky & Kahneman, 1973). Results show that differences in demand information (i.e., censored or uncensored) produce salience effects that lead to average order quantities being pulled-to-center to varying degrees. On the other hand, Ren & Croson (2013) propose overconfidence bias, the tendency people have to be more confident in their own judgments than is objectively reasonable, to be associated with average order quantities being pulled-to-center. Overprecision, a specific type of overconfidence in which individuals believe their estimates are more accurate than what they truly are, may lead them to underestimate the variance of the demand distribution and this, in turn, can produce average order quantities that are pulled-to-center. The authors found overprecision, based on two distinct measures captured for each individual, to be correlated with the extent to which average order quantities are pulled-to-center.

To summarize, the heuristics and cognitive biases perspective has helped to identify whether following a decision rule consistently throughout periods could produce pulled-to-center average order quantities or whether making systematically biased decisions that deviate from rationality is associated with average order quantities being pulled-to-center. However, even if it were true that following a heuristic gives rise to pulled-to-center average order quantities, it remains unclear whether individuals indeed use these decision rules to choose their order quantities in the newsvendor problem. Also, an association between a cognitive bias and the pull-to-center effect does not imply that such systematic deviation from rationality causes average order

quantities to fall between mean demand and the expected-profit-maximizing order quantity.

To be sure, people's tendency to follow heuristics and make cognitively biased decisions may influence choices in the newsvendor problem. However, attributing pulled-to-center average order quantities to decision makers' dispositions like these, without first ruling out that the observed phenomenon violates what one would expect from making choices under the conditions set by the situation, may lead to serious attributional flaws. For the sake of argument, imagine something in the situation decision makers experience leads them to choose orders in a way that produces pulled-to-center average order quantities. For example, suppose that in an effort to reduce variability, suppliers only accept and ship orders that are close to each retailer's mean demand and that in response, decision makers (acting as retailers) shift their orders towards mean demand. Under these circumstances, would we be satisfied asserting that average order quantities are pulled-to-center because decision makers are biased even though they are responding to the situational constraints, and in doing so, their average order quantity is expected to be pulled-to-center? Only when situational forces cannot explain the observed phenomenon should dispositional inferences be drawn.

Utility Functions.

The second perspective uses *utility functions* to study the pull-to-center effect. This stream of research suggests that deviations from the expected-profit-maximizing order quantity may be due to decision makers having other objectives in their utility function besides expected profit. A list of studies associated with this perspective is presented in Table 3.2 and indicates whether their results provide evidence in favor or against the corresponding factor playing a role in average orders being pulled-to-center.

Table 3.2: Behavioral Newsvendor Literature Examining the Pull-to-Center Effect From the Utility Functions Perspective

Study	Utility Functions				
	Risk Preferences	Prospect Theory	Loss Aversion	Mental Accounting	Ex-Post Inventory Error
Hoskin (1983)				–	
Schweitzer & Cachon (2000)	–	–	–		+
Bolton & Katok (2008)	–				
Bostian et al. (2008)					+
Katok & Wu (2009)					+
Wang & Webster (2009)			–		
Ho et al. (2010)				+	+
Becker-Peth et al. (2013)			+	+	
Chen et al. (2013)			–	–	
Herweg (2013)			–		
Kremer et al. (2014)	–				+
Nagarajan & Shechter (2014)		–			
Ockenfels & Selten (2014)			+		
Schiffels et al. (2014)				+	
Long & Nasiry (2015)		+			
Ockenfels & Selten (2015)			+		
Becker-Peth & Thonemann (2016)			+		
Uppari & Hasija (2018)		+			
Becker-Peth et al. (2018)	+				

Notes: Table indicates whether study's results show factor plays (+) or does not play (–) a role in average orders being pulled-to-center.

Because the outcomes that result from choices made in the newsvendor problem are uncertain, one objective decision makers may include in the utility function is their risk preference. Analytically, Eeckhoudt et al. (1995) found that when risk preference is considered, risk-averse decision makers would order less than the expected-profit-maximizing order quantity while risk-seeking decision makers would order more. Based on this result, Schweitzer & Cachon (2000) conclude that because in practice individuals ordered more than the expected-profit-maximizing order quantity for low-profit-margin products and less for high-profit-margin products, risk preference alone could not explain the pull-to-center effect. In their study, Kremer et al. (2014) analyzed decision makers' willingness to pay for the option to reduce uncertainty by placing orders after knowing customer demand in advance, and found that individuals overpay for this option and this behavior is better explained by a preference to minimize ex-post inventory error (an objective described later in this section) than

by their risk preference. Although the aforementioned studies bring into question the role risk preference has on decision makers' utility function prescribing pulled-to-center order quantities, risk preference does seem to influence order quantities, at least in part. Becker-Peth et al. (2018) elicited individual risk preferences and found that even though the average order quantity of risk-averse, risk-neutral, and risk-seeking individuals was pulled-to-center when placing orders for a high-profit-margin product, average order quantities increased as risk aversion decreased.

Risk preference may be reference dependent as proposed by prospect theory (Kahneman & Tversky, 1979). If this is the case, decision makers would be risk-averse in choices involving sure gains but risk-seeking in choices involving sure losses. This risk preference asymmetry may be captured in the utility function of decision makers in the newsvendor problem. Schweitzer & Cachon (2000) designed an experiment by manipulating the demand range such that in one of the treatments losses were not possible and profits remained entirely in the realm of gains. Results showed that average order quantities for low-profit-margin products are greater than the expected-profit-maximizing order (i.e., consistent with the pull-to-center effect), but because under these conditions prospect theory predicts risk-averse preference and decision makers with this preference are expected to order less than the expected-profit-maximizing order quantity, the authors do not find support for prospect theory explaining the pull-to-center effect. Modifying the assumptions with respect to the reference point inherent in prospect theory, other studies have analytically derived utility functions that either provide support against Nagarajan & Shechter (2014) or in favor (Long & Nasiry, 2015; Uppari & Hasiya, 2018) of prospect theory explaining the pull-to-center effect.

Another objective decision makers may include in their utility function is a preference for loss aversion. According to this preference, which also stems from Kahneman & Tversky's (1979) work, decision makers prefer avoiding losses to acquiring

equivalent gains. Analytically, Schweitzer & Cachon (2000) showed that a loss-averse decision maker (under certain assumptions) would order less than the expected-profit-maximizing order quantity. Therefore, the authors found no support for this preference explaining the pull-to-center effect given that in their experiments average order quantities for low-profit-margin products were consistently greater than the expected-profit-maximizing order quantity. Analytically, other studies have extended these findings by showing that when a high out-of-stock penalty cost is included, a loss-averse decision maker would order more than the expected-profit-maximizing order quantity (Wang & Webster, 2009) and that when the reference point depends on the expectations decision makers have about profits, an expectation-based loss-averse decision makers would order less than the expected-profit-maximizing order quantity (Herweg, 2013). Several studies have also developed behavioral models that capture elements of loss aversion (e.g., Becker-Peth et al., 2013; Chen et al., 2013; Ockenfels & Selten, 2014, 2015).

Utility functions in the newsvendor problem may also capture different cognitive operations described by mental accounting (Thaler, 1985) which are used by decision makers to organize, assess, and monitor financial activities. Some of these operations include how decision makers perceive outcomes, assign activities to specific accounts, and evaluate accounts with varying frequency. Hoskin (1983) examined how opportunity costs (associated with out-of-stocks) are perceived in comparison to actual costs (associated with overstocks), and found that providing feedback about opportunity costs after demand occurs increases average order quantities across different product profit margin conditions. Thus, that decision makers underweight opportunity costs may explain average order quantities being pulled-to-center for high-profit-margin products but not for low-profit-margin products. Considering elements of mental accounting and reference dependence, Ho et al. (2010) suggest decision makers' utility is affected by psychological costs of having overstocks and out-of-stocks and that

these costs are asymmetric, such that the psychological pain of having an overstock is greater than that of having an out-of-stock. The authors found that a utility function that captures these psychological costs would prescribe pulled-to-center order quantities and that making overstocks or out-of-stocks more salient decrease or increase order quantities, respectively. Becker-Peth et al. (2013) developed a behavioral model to help design supply chain contracts (specifically, buyback contracts) based on the notion that because the source of income matters, decision makers form separate accounts for customer sales and returns to suppliers. Their model, which also captures elements from loss aversion and mean anchoring, can lead to order quantities that are pulled-to-center under certain conditions. Similarly, separating transactions that occur before and after demand realizes in the newsvendor problem, Chen et al. (2013) study how different payment schemes affect order quantities by introducing a model that considers how decision makers mentally couple these transactions over time. Analytically, the authors concluded that under a similar payment scheme to the one implied by the standard newsvendor problem (i.e., own financing), the model prescribes order quantities that are greater than the expected-profit-maximizing order quantity. Although this model does not seem to explain pulled-to-center order quantities for high-profit-margin products, the experimental data shows payment schemes influence order quantities across different product profit margin conditions. Schiffels et al. (2014) suggest decision makers weight the cost of out-of-stocks and overstocks differently and propose a model that assumes mean anchoring, captures this cost asymmetry, and can prescribe order quantities that are pulled-to-center. Framing the cost of out-of-stocks as either an opportunity cost (like in the standard newsvendor problem) or a penalty cost, researchers found decision makers underweight opportunity costs compared to penalty costs, the cost of out-of-stocks when framed as opportunity costs compared to the cost of overstocks, and the cost of overstocks compared to the cost of out-of-stocks when framed as penalty costs.

In addition to the objectives presented so far, decision makers may consider the disutility they would expect from choosing an order quantity that deviates from realized demand (i.e., the ex-post optimal order quantity). This non-monetary objective, introduced in the behavioral newsvendor literature by Schweitzer & Cachon (2000), is known as the preference for minimizing ex-post inventory error. The authors proved, analytically, that when this preference is introduced in the utility function and the penalty for ordering a quantity that deviates from realized demand is greater than zero, the optimal solution prescribes order quantities that are pulled-to-center. Other studies have incorporated the same preference for minimizing ex-post inventory error into their behavioral models (Bostian et al., 2008), developed variants using similar non-monetary objectives (Ho et al., 2010), and found evidence that suggests order quantities are influenced by ex-post optimal order quantities (Katok & Wu, 2009; Kremer et al., 2014).

In sum, different attempts have been made to capture other objectives, in addition to expected profit, that decision makers may consider in their utility function when placing orders in the newsvendor problem. The utility functions perspective has contributed greatly to our understanding of the problem and the identification of objectives capable of prescribing order quantities that are pulled-to-center, similar to those observed in practice. This, in turn, has facilitated the design of contracts that improve performance for the supply chain partners involved. However, that the optimal solution to a utility function that includes other objectives is pulled-to-center does not necessarily imply that decision makers pursue those objectives. Above all, if pulled-to-center average order quantities were expected from how decision makers choose their orders under the situational constraints inherent in the newsvendor problem, would we feel comfortable explaining the pull-to-center effect by considering what other objectives could individuals may have had when choosing? Before attributing pulled-to-center average order quantities to decision makers attending to

Table 3.3: Behavioral Newsvendor Literature Examining the Pull-to-Center Effect From the Other Modeling Forms Perspective

Study	Other Modeling Forms		
	Learning	Quantal Choice	Impulse Balancing
Bostian et al. (2008)	+		
Su (2008)		+	
Kremer et al. (2010)		−	
Ockenfels & Selten (2014)			+
Ockenfels & Selten (2015)			+

Notes: Table indicates whether study's results show factor plays (+) or does not play (−) a role in average orders being pulled-to-center.

other specific objectives, it is important to be certain that conditions present in the situation in which decision are made do not account for the phenomenon.

Other Modeling Forms.

Another closely related perspective uses *other modeling forms* to study the pull-to-center effect. These models incorporate certain assumptions regarding the behavior of decision makers when choosing order quantities. Table 3.3 contains a list of studies pertaining to this perspective.

Bostian et al. (2008) assume learning effects and develop models that capture this dynamic using two approaches: introducing time-varying parameters in existing models (i.e., mean demand anchoring and adjustment heuristic, previous order anchoring and adjustment heuristic, and preference for minimizing ex-post inventory error) and adapting the experience-weighted attraction learning model to the newsvendor setting. These models can prescribe order quantities that are pulled-to-center, and experimental data showed that in terms of predicting observed order quantities, models with time-varying parameters generally outperformed their fixed counterparts, and the experience-weighted attraction learning model outperformed models with time-varying parameters.

Assuming decisions are characterized by random errors but better alternatives that maximize expected profit are chosen more often, Su (2008) develop a model based

on the quantal choice model and show the model can predict pulled-to-center order quantities. Kremer et al. (2010) suggest that if it were true that choices are determined by random errors and the optimal order quantity, one would expect decision makers to make similar choices independent of whether the problem is framed in an operations (i.e., newsvendor problem) or neutral (i.e., lottery) context. In contrast, the authors found that context influences choices and that average order quantities are pulled-to-center to a greater degree when the problem is framed in an operations versus neutral context. Together, Kremer et al.'s (2010) findings, the fact that the model is restricted to bounded demand distributions, and that it suggests the mode of order quantities is the expected-profit-maximizing order quantity (Becker-Peth & Thonemann, 2019) indicate the assumptions of the model based on quantal choice are not robust.

Based on the impulse balance equilibrium (IBE), Ockenfels & Selten (2014) introduce a model that assumes choices in the newsvendor problem are characterized by upward or downward impulses that depend on whether an out-of-stock or over-stock, respectively, occurred. Therefore, it captures the idea that decision makers are concerned about minimizing ex-post inventory errors. The model then adjusts order quantities to mitigate the imbalances between both types of impulses and assigns a higher weight to losses than gains. The authors show the model can predict order quantities that are pulled-to-center for low- and high-profit-margin products, and extend their model to allow for multiple-period feedback (Ockenfels & Selten, 2015).

Without question, these modeling forms have provided better insight about choice behavior in the newsvendor problem by examining which assumptions seem to be reasonable and whether prescribed orders follow similar patterns to those observed in practice. However, this perspective faces a similar limitation to that of the utility functions perspective. Finding that predictions from models are consistent with patterns from observed order quantities does not ensure that what drives these choices

Table 3.4: Behavioral Newsvendor Literature Examining the Pull-to-Center Effect From the Individual Heterogeneity Characteristics Perspective

Study	Individual Heterogeneity Characteristics									
	Culture	Managerial Position	Schooling	Age	Work Experience	College Major	Gender	Risk Preferences	Cognitive Reflection	Overprecision
Feng et al. (2011)	+									
Bolton et al. (2012)		– (students vs. managers, high CR) + (within managers, high CR)	+ (within managers, high CR)	+ (within managers, high CR)	– (within managers, high CR)					
Cui et al. (2013)	–									
de Véricourt et al. (2013)							+ (high CR)	+ (high CR)		
Moritz et al. (2013)		+ (high CR)			– (high CR)	+ (high CR)			+ (high CR)	
Ren & Croson (2013)										+
Becker-Peth et al. (2018)							+ (high CR)	+ (high CR)		

Notes: Table indicates whether study's results show factor plays (+) or does not play (–) a role in average orders being pulled-to-center.

are the assumptions implied by those models.

Individual Heterogeneity Characteristics.

The fourth perspective examines whether *individual heterogeneity characteristics* are associated with average order quantities being pulled-to-center. The list of studies that have measured individual heterogeneity characteristics is presented in Table 3.4.

One such characteristic is culture. Although Feng et al. (2011) found that Chinese decision makers place order quantities that are on average pulled-to-center to a greater degree than those placed by their American counterparts, Cui et al. (2013) found that the deviation between actual order quantities and optimal order quantities between decision makers from these countries does not differ significantly.

Other characteristics that have been studied are managerial position, schooling, age, work experience, and college major. Managers compared to students (i.e., graduates and freshmen) display similar pulled-to-center average order quantities, except for when expected profit information is provided to decision makers (Bolton et al., 2012). However, within managers, position and schooling are positively associated with average order quantities moving toward the expected-profit-maximizing order quantity, while age shows a negative association (Bolton et al., 2012). With a sample of professionals, Moritz et al. (2013) also found that having a managerial position

moved order quantities closer to the expected-profit-maximizing order quantity. Although years of work experience do not seem to play a role in average order quantities being closer to the optimal order quantity (Bolton et al., 2012; Moritz et al., 2013), college major does (Moritz et al., 2013).

Gender and risk preferences have also been examined in the newsvendor problem. Compared to females, males seem to place order quantities that on average are closer to the expected-profit-maximizing order quantity for high- but not for low-profit-margin-products (de Véricourt et al., 2013; Becker-Peth et al., 2018). de Véricourt et al. (2013) found that this effect (when ordering high-profit-margin products) may be due in part to differences in risk attitude as measured by the financial items of the Domain-Specific-Risk-Taking (DOSPERT) scale (Weber et al., 2002). The authors also found greater financial risk-taking attitude (i.e., low risk aversion) to be associated with average order quantities being less pulled-to-center when high-profit-margin products were ordered. Similarly, Becker-Peth et al. (2018) found that in a high-profit-margin product condition, less risk-averse decision makers, as measured by Holt & Laury’s (2002) method, placed orders that were closer to the expected-profit-maximizing order quantity.

In addition, cognitive reflection and overprecision have been shown to be related with average order quantities. Cognitive reflection, the tendency to let System 2 processes—analytical and reflective—moderate an initial System 1 response—intuitive and rapid, is positively associated with average order quantities moving toward the expected-profit-maximizing order quantity, although this effect was found when ordering high- but not low-profit-margin products (Moritz et al., 2013). On the other hand, using two distinct measures of overprecision (introduced in the Heuristics and Cognitive Biases perspective), Ren & Croson (2013) found that individuals high in overprecision placed order quantities that were on average pulled-to-center to a greater degree.

The individual heterogeneity characteristics captured by this perspective have provided an important list of factors that correlate with average order quantities being pulled-to-center. They also show that decision makers are different and thus, relevant characteristics should be taken into account when analyzing order quantities. However, showing that individual characteristics are correlated to pulled-to-center average order quantities does not imply these characteristics cause this aggregate level pattern. Most importantly, if the situation encountered by decision makers led them to place average order quantities that were pulled-to-center, would we attribute this phenomenon to decision makers' characteristics? Indeed, these characteristics may affect ordering choices. However, using dispositions to account for a phenomenon that is explained by the situational factors in which decisions are made may lead to fundamental attributional errors.

Pull-to-Center Perspectives: Concluding Remarks.

Although the pull-to-center effect has received most of the attention in the behavioral newsvendor literature (Becker-Peth & Thonemann, 2019), this phenomenon occurs at an aggregate level from averaging order quantities. Therefore, the pull-to-center effect is not observable at a specific place or point in time and thus hardly corresponds to an actual choice behavior occurring here and now. Because this phenomenon takes place at an abstract level, focusing on it has hampered efforts to recognize the situation in which decision makers place their orders and identify the situational forces that influence choice behavior in the newsvendor problem. Therefore, although the foregoing perspectives used to analyze the phenomenon vary, they seem to emerge from a common viewpoint—the observer's viewpoint. This viewpoint lacks the awareness of the surrounding environment and the role the situation plays on the behavior of those who make choices—the actors. Thus, not surprisingly, existing plausible explanations for why the pull-to-center effect occurs attribute the phenomenon to dispositional fac-

tors: the decision maker is following a heuristic or is cognitively biased, he or she is considering other objectives in the utility function besides expected profit, the person places orders following the assumptions of a model, or the individual has certain characteristic that makes him or her different from others. To the extent that dispositional inferences are logically unwarranted when people do precisely what the environment or situation demands (Gilbert & Malone, 1995), any hope of making a more accurate attribution of the pull-to-center effect must begin by considering the situation decision makers face and how they experience it. To this end, we begin to adopt the actor’s viewpoint by shifting our attention from this aggregate level pattern to a behavior observed at a choice level that takes place when decision makers place orders in the newsvendor setting.

3.3.2 Demand-Chasing

Consider the situation confronted by a decision maker who, acting on behalf of a retailer, has placed an order to a supplier and then finds out how much customers were willing to buy. This person must now decide how many units to order for the following selling period and, at a basic level, has two options to pick from: choose the same quantity that was ordered for the previous period (i.e., repeat choice) or choose a different quantity by adjusting it upward or downward. Demand-chasing is the behavior that occurs when the decision maker chooses to order a different quantity for the following period by adjusting the previous order in the direction of the most recent demand realization. Therefore, the new order quantity shortens the distance between the initial order and the corresponding actual demand that proceeded. Although chasing demand has generally been considered sub-optimal behavior given that the conditions of the problem that determine the optimal solution do not change across periods, its presence in newsvendor decision making is undeniable (e.g., Schweitzer & Cachon, 2000; Bolton & Katok, 2008; Kremer et al., 2010; Moritz et al., 2013; Schultz

et al., 2018). These past studies also show that although some people tend to chase demand more often than others (i.e., variation between individuals), a single person seldom chases or refrains from chasing demand every period (i.e., variation within individuals).

The literature to date offers three reasons for why demand-chasing may occur. However, existing findings cast doubt on whether these reasons robustly explain why people chase demand. Schweitzer & Cachon (2000) indicated the behavior occurs because individuals follow a previous order anchoring and adjustment heuristic (described in Section 3.3.1 as a plausible explanation for average order quantities being pulled-to-center). To the extent that using such heuristic implies people would adjust their order quantity toward past demand realization every period whenever these two quantities differ, the authors concluded there is only some evidence of the use of this heuristic given that people chase demand in some rounds but not in all. Bolton & Katok (2008) proposed the behavior could be associated with the fallacious belief that independent draws are correlated (i.e., gambler’s fallacy). Although the authors did not examine whether the mechanism underlying this belief is at play, people who erroneously believe independent draws are correlated would adjust their order quantities consistently toward or away from past demand every period. Thus, Schweitzer & Cachon’s (2000) finding that individuals do not consistently chase demand when deviations between order quantities and realized demand occur appear to also cast doubt on this reason. Moritz et al. (2013) suggested the behavior is associated with cognitive reflection, the tendency to override an intuitive and spontaneous System 1 response (introduced in Section 3.3.1). The authors found people low in cognitive reflection (i.e., following a more intuitive, less reflective process) display greater demand-chasing when placing orders for medium- and high-profit-margin products, but found no support for this relationship when low-profit-margin products were ordered. Besides falling short of describing the results across difference conditions, the

existence of an association between cognitive reflection and demand-chasing does not imply that this behavior is caused by such cognitive ability.

In addition to the preceding shortcomings, what is perhaps most important, is that none of the explanations for demand-chasing appear to account for differences observed within individuals choosing to chase demand in one period and declining to do so in the next. It thus seems reasonable to suggest that a robust explanation for why decision makers chase demand in the newsvendor problem is in order. We focus on this issue by developing our theoretical framework in the following section.

3.4 Theory

The objective of focusing on the actor's viewpoint is to recognize the situation in which decision makers place orders in the newsvendor problem and determine whether situational forces may influence their choices. If the observed behavior violates what is expected from choosing order quantities under these conditions, then dispositional inferences about decision makers could be drawn (Gilbert & Malone, 1995). However, if decision makers behave in ways that are not different from what the situation leads us to expect, then dispositional inferences are unwarranted and the behavior should be attributed to situational forces instead (Gilbert & Malone, 1995). Therefore, being aware of the situation that decision makers face when placing orders in the newsvendor setting is essential to performing a proper attributional analysis. Although the conditions defined by the problem, such as how demand is distributed or whether choice options are restricted, set constraints on decision makers' capacity to choose order quantities, other more subtle forms of situational constraints may emerge. For this reason, it is not enough to acknowledge the situation as objectively established by the problem, and an effort must be made to infer how the situation is subjectively interpreted by the actor. In the newsvendor problem, after decision makers place an

order, demand occurs and then they receive this information. When the quantity that was ordered is different from the quantity demanded by customers, decision makers realize their goal of obtaining better profits is hindered. Thinking about how one would have been better off if a different quantity closer to what customers demanded had been ordered seems inevitable. The consequences of this special way of thinking, known as counterfactual thinking, may alter decision makers' understanding of the problem and the choices they face.

3.4.1 Counterfactual Thinking

Counterfactual thoughts are mental representations of alternatives to past events (Roese, 1997). They occur when thinking about what might have been, of how the past might have been different had some other aspect been different (Roese & Olson, 1995a). Early assertions about counterfactuals were informed by norm theory from Kahneman & Miller (1986). Counterfactual thoughts describe a situation that did not actually happen (i.e., contrary to the facts or counterfactual) by altering the antecedent of an outcome and imagining a different possible consequence (Roese, 1997). Therefore, these thoughts imply a juxtaposition of an imagined versus factual state of affairs and they are characterized by conditional propositions containing an antecedent and a consequent (i.e., *if-then* statement) (Roese & Epstude, 2017).

Counterfactual thoughts are reflections of goals and capture the varying means through which these goals could have been reached (Roese & Epstude, 2017). In this way, these thoughts are functional in that they serve different purposes related to goal pursuit and affect regulation, and generally lead to performance benefits (Roese & Epstude, 2017). Because they are closely connected to goal-directed cognition, counterfactual thoughts are constrained and usually require small changes to actual events to provide practical alternatives (Seelau et al., 1995). Therefore, counterfactual thoughts are disciplined, rather than random, suppositions.

The two key elements that determine a counterfactual thought are how it gets *activated* and, once this happens, what its *content* is. On one hand, counterfactual thoughts are activated in response to goals being blocked (Roese & Epstude, 2017). Thus, situations in which a discrepancy between actual and ideal goal states occurs are likely to trigger these thoughts, and the greater the perceived discrepancy, the more likely they are to come to mind. A sense of failure, perception of a problem, lack of goal progress, negative outcome, and disconfirmed expectancy are some ways in which goal blockage may manifest and be experienced (Roese & Epstude, 2017). On the other hand, once counterfactual thoughts are activated, their content takes a particular form that is determined by how to achieve the unrealized goal (Roese & Epstude, 2017). Some aspect of the situation is altered in a way that produces an alternative outcome that bridges the gap between actual and ideal goal states. For counterfactuals to be useful in terms of informing about goal progress and driving effective action, they generally focus on those aspects of the situation that are controllable (McMullen et al., 1995; Roese & Olson, 1995a; Roese & Epstude, 2017).

To the extent that counterfactual thoughts act as mental simulations contrasting two outcomes that differ only by the presence of an antecedent, they are considered experimental proxies and therefore, contain a causal inference (Roese, 1997). This causal insight, which stems from a belief that modifying a specific antecedent would have been sufficient to produce a desired outcome, carries informational content that facilitates a behavioral intention (Roese & Epstude, 2017). When opportunity exists, the behavioral intention aimed at reducing the difference between actual and ideal goal states gets implemented and gives rise to corresponding behavior.

Counterfactual thoughts are accompanied by affective responses (Kahneman & Miller, 1986; Roese & Olson, 1995a). These responses are relevant because they signal whether a problem needs attention and further action is required. The form of the counterfactual thought provides hints as to which specific emotion is elicited (Nieden-

thal et al., 1994; Roese, 1997). Therefore, it is useful to describe counterfactuals in terms of dimensions such as direction and social focus (Roese & Epstude, 2017). Direction refers to whether the counterfactual compares reality to a superior and more desirable alternative (i.e., upward counterfactuals) or to an inferior and less desirable alternative (i.e., downward counterfactuals), while social focus has to do with whether the counterfactual focuses on one’s own actions or the actions of others. A prevalent emotion closely tied to upward, self-focused counterfactuals that alter past choices is regret (Pieters & Zeelenberg, 2007; Roese & Epstude, 2017).

3.4.2 Regret

Regret is thus a cognitive-based emotion that is felt when realizing or imagining that one’s present situation would have been better had a different choice been made (Pieters & Zeelenberg, 2007). It is a negative emotion of self-blame that is closely related to decision making (Zeelenberg & Pieters, 1999) and is one of the most frequently experienced emotions (Shimanoff, 1984). There are two main preconditions for people to experience regret (Zeelenberg & Pieters, 2007). First, there must be an element of personal agency. Identifying oneself as a causal agent in the situation that produced a less desirable outcome is crucial in experiencing regret. Second, one must realize that another choice would have been better. Thus, being aware of other options and their possible consequences is important. For this reason, feedback about actual and foregone outcomes is one of the main antecedents associated with regret (Zeelenberg & Beattie, 1997; Creyer & Ross, 1999; Tsiros & Mittal, 2000).

One may feel regret from past decisions (i.e., experienced regret) or in anticipation of future decisions (i.e., anticipated regret) (Pieters & Zeelenberg, 2007). Because decision makers in the newsvendor problem receive demand information after choosing an order quantity and must then make decisions for subsequent periods, experienced regret stemming from past decisions plays a central role and is the focus of the present

study. However, we do not rule out the possibility that individuals may also feel regret in anticipation of future decisions in this context.

Regret encompasses two components inherent in decision making (Sugden, 1985; Pieters & Zeelenberg, 2007). This emotion can be experienced from comparing the outcome of a chosen option with that of a foregone option (i.e., outcome component). For example, when the obtained outcome contrasts poorly with what might have been obtained if a different choice had been made. However, regret can also be experienced from how the decision was made (i.e., process component). For example, when the decision involved an error in judgment.

Regret has a unique appraisal combination that determines when it gets triggered and a specific set of response components that defines how people cope with a given situation when the emotion is felt (Roseman, 2013). In accordance with the literature on counterfactual thinking, events that are appraised as being inconsistent with current goals, offering low control to get less of the current negative stimuli, and assessing oneself as having caused the situation (i.e., agency), set the stage for regret to emerge (van Dijk & Zeelenberg, 2002; Roseman, 2013). When regret is experienced, the response strategy includes the following components (Roseman et al., 1994; Zeelenberg et al., 1998; Zeelenberg & Pieters, 1999; Coricelli et al., 2005; Roseman, 2013): phenomenological (i.e., thinking about the mistake made, a sinking feeling, thinking about the opportunity that was lost, and feeling like kicking oneself), physiological (i.e., increased activity in the medial orbitofrontal region of the brain), expressive (i.e., eyes closed and lips stretched and pressed together), behavioral (i.e., doing over and doing differently), and emotivational or goals people want to pursue when experiencing the emotion (i.e., wanting to improve performance and wanting to undo and correct the situation).

Regret is a negative emotion that causes an aversive state that people are motivated to regulate (Pieters & Zeelenberg, 2007). Therefore, consistent with the emoti-

vational component of the response strategy in terms of wanting to undo and correct the situation, regret has been found to influence choice behavior in different settings by reversing and switching to alternate options (Zeelenberg & Beattie, 1997; Zeelenberg & Pieters, 1999; Tsiros & Mittal, 2000).

3.4.3 Hypotheses

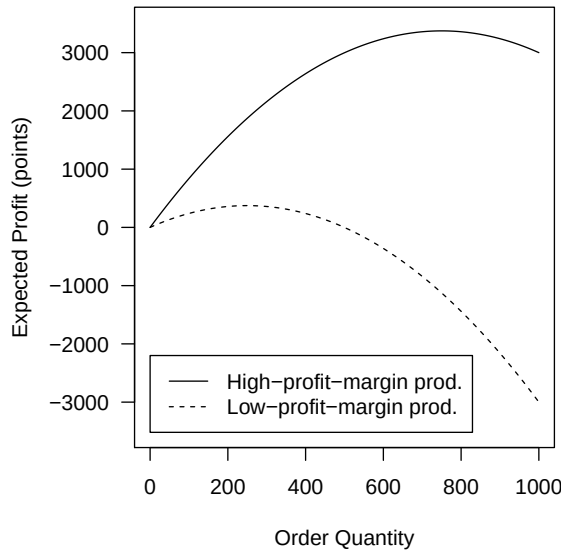
In the newsvendor problem, decision makers place an order for the upcoming selling period to their supplier. Customer demand then unfolds and this information becomes available. We believe this situation creates opportunities for people to experience counterfactual thoughts and these, in turn, will elicit feelings of regret. First, the two key determinants of counterfactual thinking are present. Because counterfactual thoughts are activated in response to goals being blocked, we can expect these type of thoughts to be triggered whenever decision makers observe customer demand deviated from what was ordered to suppliers and realize that this hinders their goal in terms of obtaining better profits. This is likely to happen more often than not because demand is random. Also, given that the content of counterfactual thoughts is determined by how to achieve the unrealized goal, decision makers will likely alter some controllable aspect of the situation that would have narrowed the discrepancy between their actual and ideal goal states. Therefore, thoughts like “if I had ordered more papers, I would have been able to sell more” or “if I had ordered fewer papers, I would have incurred fewer costs” will likely come to mind.

Second, this upward, self-focused counterfactual alters decision makers’ past choices and can thus be reasonably expected to elicit regret. In fact, the two preconditions for experiencing this emotion are satisfied. The situation involves a decision maker that is responsible for choosing an order quantity and therefore, a sense of personal agency is present. And because customer demand information becomes available to decision makers after placing an order, they realize another choice would have been

better when their order quantity deviates from what was demanded by customers.

In addition to creating opportunities for decision makers to have counterfactual thoughts and feel regret, the situation under which decisions are made in the newsvendor problem includes conditions that may influence the extent to which this type of thought and this emotion are experienced. Based on the demand distribution function of a product, the expected profit from choosing any given order quantity can be estimated. Analyzing the expected profit as a function of order quantity provides useful insight about the choice decision makers face and the differences between ordering low- versus high-profit-margin products. Besides identifying the order quantity that maximizes profit, this analysis shows that under similar demand characteristics the expected profit from low-profit-margin products is less than or equal to that from high-profit-margin products for any given order quantity. When the corresponding expected-profit-maximizing order quantity is placed for low- and high-profit-margin products respectively, the expected profit from low-profit-margin products is lower. Figure 3.1 depicts this visually by comparing the expected profit function of a low- versus high-profit-margin product.

Also, when based on the problem parameters it is possible for losses to occur, decision makers are more likely to experience losses for low- versus high-profit-margin products. In fact, the expected profit from high-profit-margin products is generally nonnegative regardless of the problem parameters (except when a cost for not satisfying demand or a fixed cost is included). In sum, under similar demand characteristics, ordering low-profit-margin products increases the likelihood of obtaining lower profits and experiencing losses compared to high-profit-margin products. Thus, low- and high-profit-margin products create conditions for decision makers to perceive their goal in terms of profits to be blocked to varying degrees. To the extent that counterfactual thoughts are activated as perceived discrepancies between actual and ideal goal states become greater (Roese & Epstude, 2017), and these thoughts, in turn,



Notes: Expected profit corresponding to a product exhibiting uniformly distributed demand between 0 and 1000, selling price of 12 points, and unit cost of 3 and 9 points for high- and low-profit-margin products, respectively.

Figure 3.1: Single Period Expected Profit as a Function of Order Quantity

play a crucial role in eliciting regret (Pieters & Zeelenberg, 2007; Roese & Epstude, 2017), we expect product profit margin to have a significant effect on experienced regret. Therefore, we make the following prediction.

Hypothesis 7 *Decision makers experience greater regret when ordering low- versus high-profit-margin products with similar demand characteristics.*

In experimental settings that study the behavioral aspects of decision making, profit differences like those described above may produce inequitable payoffs across subjects if they are assigned to different treatments and their compensation is tied to how they perform. Some behavioral studies in the newsvendor problem have accounted for this imbalance by using different exchange rates to convert from experimental to real-world currency (e.g., Chen et al., 2013) or fixed costs to modify the profit earned (e.g., Bolton & Katok, 2008) in each treatment. Because in this study we are interested in the effect this profit imbalance has, we converted experimental

profits to their corresponding real-world amount at the end of the session and used an exchange rate for each treatment to ensure subjects on average received similar compensation.

One of the core elements of prospect theory (Kahneman & Tversky, 1979) is that losses loom larger than gains. If this is the case, then the perceived difficulty in achieving better profits should intensify as the likelihood of obtaining losses increases. Therefore, this aspect of prospect theory should reinforce the activation of counterfactual thoughts in response to goal blockage when losses are possible and reflect on how people feel about the choices they make.

Feeling regret causes an aversive state that people are motivated to regulate (Pieters & Zeelenberg, 2007). This emotion has a clear response strategy that involves wanting to undo and correct the situation (Roseman et al., 1994; Zeelenberg et al., 1998; Roseman, 2013) and has thus been found to influence choice behavior by reversing and switching to alternate options (Zeelenberg & Beattie, 1997; Zeelenberg & Pieters, 1999; Tsiros & Mittal, 2000). In addition, the content of counterfactual thoughts that accompany the emotion also provides important cues about the behavioral intention that follows (Roese & Epstude, 2017). In the newsvendor problem, when counterfactual thoughts get activated, their content will be about how to achieve better profits. Because actual versus foregone profits differ only by whether one ordered what one did or what customers demanded, this antecedent can be inferred to be causal and altering this aspect of the situation is expected to lead to a better outcome. The informational content carried by these causal inferences implies that if opportunity exists (e.g., a similar decision is made in the future), a behavioral intention to modify the order to a quantity that is closer to what customers demanded should be implemented. Together, a clear response strategy associated with wanting to undo and reverse the decision made when experiencing regret and a behavioral intention facilitated by counterfactual thinking related with adjusting the previous

order quantity in the direction of realized demand, suggests that as decision makers experience regret, they will be more likely to adjust their order quantity in the direction of the most recent demand realization.

Hypothesis 8A *Decision makers chase demand to a greater extent as they experience more regret.*

Hypothesis 8B *Decision makers chase demand more frequently as they experience more regret.*

Based on our theoretical framework, demand-chasing occurs in response to the specific situation decision makers experience when choosing an order quantity and receiving customer demand information. For this reason, an individual's display of demand-chasing behavior can vary across time and manifest in different ways. First, decision makers can chase demand to a greater or lesser extent based on how much they adjust the order quantity in the direction of the most recent demand realization. Second, decision makers may chase demand more or less frequently across time periods. This distinction is relevant because, although some decision makers may choose to make smaller adjustments every period, others may settle on making sporadic adjustments that are larger in size. To examine these differences in behavior, we present hypotheses in terms of both, the extent and frequency with which decision makers chase demand.

The pull-to-center effect is an aggregate level pattern that describes average order quantities falling between the expected-profit-maximizing order quantity and mean demand (e.g., Schweitzer & Cachon, 2000; Bolton & Katok, 2008; Bostian et al., 2008). The more pulled-to-center the average order quantity is, the closer to mean demand it will be. Because decision makers have counterfactual thoughts and experience regret, they chase demand by adjusting their previous order quantity in the direction of the most recent demand realization. When individuals behave this way, their orders

begin to mirror past demand realizations as they make greater and more frequent adjustments. Consequently, the average of these historical order quantities approaches the mean of the demand distribution.

If decision makers have an idea of which quantity maximizes their expected profit, we would expect them to choose order quantities that are close to the expected-profit-maximizing order if they do not chase demand, and the average order quantity will thus be close to the optimal order quantity. In contrast, if these decision makers chase demand, their orders will mimic demand realizations and the average of these quantities will approach mean demand. Hence, knowledgeable decision makers who have an idea of where the expected-profit-maximizing order quantity lies will have average order quantities that are more pulled-to-center when they chase demand to a greater degree, compared to when they chase demand to a lesser degree.

However, not all individuals have the same knowledge about the newsvendor problem and the insight behind its optimal order quantity. Less knowledgeable decision makers will likely choose order quantities without having the expected-profit-maximizing order quantity in mind. Therefore, we expect decision makers who do not have an idea of which quantity maximizes their expected profit to choose orders without favoring any specific quantity, thus determining them indiscriminately when they do not chase demand. Because these order quantities will resemble random draws from the demand's distribution, their average will be similar to mean demand. If these decision makers chase demand, their orders will mirror past demand realizations and the average order quantity will remain close to mean demand. Therefore, the average order quantity of less knowledgeable decision makers who do not have an idea of which quantity maximizes their expected profit will be near the demand's mean regardless of whether they chase demand to a greater or lesser degree. Accordingly, we make the following predictions.

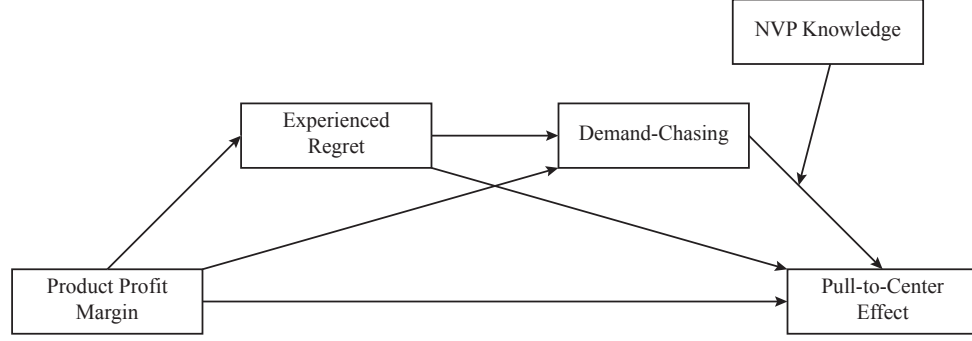
Hypothesis 9A *When decision makers have more knowledge about the newsvendor*

problem, chasing demand to a greater extent results in average order quantities being more pulled-to-center than when demand is chased to a lesser extent relative to decision makers with less newsvendor problem knowledge.

Hypothesis 9B *When decision makers have more knowledge about the newsvendor problem, chasing demand more frequently results in average order quantities being more pulled-to-center than when demand is chased less frequently relative to decision makers with less newsvendor problem knowledge.*

According to Hypothesis 7, decision makers experience greater regret when ordering low- versus high-profit-margin products with similar demand characteristics. As they experience greater regret, Hypotheses 8A and 8B suggest decision makers will chase demand to a greater extent and more frequently, respectively. In addition, Hypotheses 9A and 9B argue that the effect demand-chasing has on average order quantities being pulled-to-center is contingent on the level of knowledge decision makers have about the newsvendor problem. Specifically, when newsvendor problem knowledge is high, a significant positive effect of demand-chasing on pulled-to-center average order quantities is expected. However, when newsvendor problem knowledge is low, average order quantities are not expected to be pulled-to-center any differently whether demand is chased to a greater or lesser degree. Therefore, our theoretical model, which is represented graphically in Figure 3.2, suggests an indirect effect between product profit margin and pulled-to-center average order quantities operating through experienced regret and demand-chasing, and moderated by newsvendor problem knowledge.

Hypothesis 10A *The indirect effect of product profit margin on the pull-to-center effect through experienced regret and demand-chasing extent is moderated by newsvendor problem knowledge.*



Notes: Causal model of the effect of ordering a high- versus low-profit-margin product on average order quantities being pulled-to-center through experienced regret and demand-chasing, moderated by newsvendor problem knowledge.

Figure 3.2: Theoretical Model of Product Profit Margin on the Pull-to-Center Effect

Hypothesis 10B *The indirect effect of product profit margin on the pull-to-center effect through experienced regret and demand-chasing frequency is moderated by newsvendor problem knowledge.*

Essentially, what this model implies is that under the specific conditions of the situation decision makers in the newsvendor problem face, one would expect them to chase demand in response to experiencing regret from the choices they make, and this, in turn, will lead their average order quantity to be pulled-to-center. In the sections that follow we describe the experimental design and data analysis used to study the aforementioned hypotheses.

3.5 Experimental Design

To test our hypotheses, we designed an experiment that simulated the newsvendor problem by asking participants to place multiple successive orders to their supplier, while acting on behalf of a retailer. As described in Section 3.4.3, the extent to which decision makers feel regret was manipulated by varying the profit margin level of the product they were asked to order. The instructions and experimental procedures

presented to participants resemble those used in previous studies (e.g., Schweitzer & Cachon, 2000; Bolton & Katok, 2008; Becker-Peth & Thonemann, 2016).

3.5.1 Subjects

A total of 94 subjects participated in the experiment through Amazon Mechanical Turk (MTurk) in exchange for a \$4.00 participation fee plus a payoff contingent on how well they performed in the newsvendor task. The total payoff, including the participation fee, was \$4.68 on average, and ranged from \$4.00 to \$5.53. Subjects were on average 35.5 years old and about 38% were females. All participants had at least a high school degree and approximately half of them had at least a bachelor's degree.

The experimental program prevented subjects from participating more than once by blocking access to the task for MTurk workers who had previously accepted it. To ensure data quality and respondent attentiveness, participation was restricted to workers with high reputation who had completed a minimum of 100 tasks and who had an approval rating above 95% (Peer et al., 2014; Hauser & Schwarz, 2016). Using similar conditions, Lee et al. (2018) replicated the main results obtained by Bolton & Katok (2008) when conducting the same newsvendor experiment with MTurk workers instead of students.

3.5.2 Experimental Procedures

The experiment was divided into three parts. First, participants received a short self-paced training covering the basic features of the newsvendor problem. The main objective of the training was to create a common understanding of the situation experienced by decision makers facing this problem. The training included six slides describing the motivation of the problem, the trade-off between ordering too much ver-

sus too little, and insight about the effect of parameters.¹ After completing the training, but before the newsvendor task, each participant answered nine multiple choice questions that provided a means to assess their knowledge about the problem. These questions measured whether individuals were capable of identifying the information and intuition that are relevant in finding where the expected-profit-maximizing order is located, regardless of whether the exact quantity can be calculated or not. Given different scenarios, participants were specifically asked about the unit cost of having an out-of-stock and an overstock, the number of units sold, the profit earned, whether an out-of-stock or overstock occurred and their corresponding cost, and most importantly, whether ordering quantities in certain region of the demand distribution would provide better profits in the long term (see Appendix A.1 for details). Except for the number of units sold and the profit earned, the answers to all remaining questions included in the assessment are not readily available or described in the experimental instructions that are generally provided to participants in behavioral newsvendor studies. Also, a solution or a method to estimate the expected-profit-maximizing order quantity were never presented or discussed during the experiment.

In the second part of the experiment, participants were randomly assigned to one of two treatment groups intended to manipulate the extent to which they experienced regret by varying the product profit margin level (i.e., low- versus high-profit-margin product). Participants' demographic information and average order quantities by treatment group are presented in Table 3.5. Subjects received detailed instructions about the task they were to perform, including the cost of each unit ordered from the supplier (which depended on the treatment group they were assigned to), the price of each unit sold to customers ($p = 12$ points), the demand distribution (uniform between 0 and 1000), and the goal they were to accomplish. The unit cost was $c = 9$ points for participants ordering the low-profit-margin product and $c = 3$ points

¹A transcript of the training slides is available from the authors upon request.

Table 3.5: Participant Demographic Characteristics and Average Orders

Treatment	Observations	Baseline Characteristic					Order Quantity
		Age	Gender	Student	Schooling	Work Experience	
Low-Profit-Margin Product	47	33.13	0.40	0.06	4.06	12.19	418.41
High-Profit-Margin Product	47	37.94	0.36	0.09	4.43	16.38	522.78
Total	94	35.53	0.38	0.07	4.24	14.29	470.59
		(10.82)	(0.49)	(0.26)	(1.28)	(10.11)	(142.38)

Notes: Treatment and total sample means. Gender is the proportion of subjects who are females ($f = 1$). Schooling is coded using an 8-point scale: Less than HS, HS degree, Some college, Associate degree, Bachelor's degree, Master's degree, Professional degree, and Doctorate. Work experience is measured in years. Order quantity is the average order quantity across all rounds. Standard deviation of baseline characteristics for total sample in parentheses.

for those ordering the high-profit-margin product. Based on these parameters, the expected-profit-maximizing order quantities were 250 and 750 units, respectively. The instructions also explained how ordering decisions and rounds took place, and how payoffs were estimated and paid. Except for the unit cost, all subjects received identical instructions (see Appendix A.2 for the exact transcript of task instructions for one treatment group).

In each experimental round, which simulated an individual selling period, participants chose an order quantity and were then informed about the number of units customers had demanded. Subjects also received a summary of the number of units they had ordered and the profit earned in points. All participants made inventory ordering decisions for 25 consecutive rounds. When orders were to be placed, subjects could display the complete set of instructions and were presented with summary information for all previous decisions made, including order quantity, demand, units sold, cost, sales, profit, and cumulative profit.² Demand draws were randomly generated before the experiment and were the same for all participants. At the conclusion of the newsvendor task, each participant received a summary of their ordering decisions and the total profit (or loss) they had made in points. When a profit had been earned, it was converted to U.S. dollars and paid to participants at the end of the session.

Participants then entered into the third and last part of the experiment in which demographic data were collected. In addition, individual heterogeneity measures

²For images showing examples of the newsvendor task screenshots, see the electronic companion.

that have been used in previous behavioral newsvendor studies and shown to be related with performance outcomes were assessed. These measures included cognitive reflection (Frederick, 2005), risk aversion (Holt & Laury, 2002), and overprecision (Russo & Schoemaker, 1989).³

The experiment was programmed in oTree (Chen et al., 2016) and setup online using a cloud service. It was piloted with undergraduate and graduate students who tested technical aspects and clarity of instructions in face-to-face debriefing sessions.

3.5.3 Dependent Measures

We assessed the extent to which participants felt regret for past ordering decisions they had made using seven items adapted from existing scales designed by Marcatto & Ferrante (2008) and Buchanan et al. (2016). Participants provided responses to these items on a 7-point Likert scale at three different points in time throughout the newsvendor task and their responses were averaged to create a composite measure of experienced regret (see Appendix A.3 for details about the instrument). Measurement items were randomly ordered when presented to subjects to prevent order bias. The items reported a high level of internal consistency (Cronbach's $\alpha = 0.92$).

We considered two different dimensions of demand-chasing behavior as described in Section 3.4.3. The extent to which subjects chased demand was measured by accumulating how much order quantities had been adjusted toward the most recent demand realization each round. Hence, larger values represent greater adjustments in the direction of past demand. The frequency with which subjects chased demand was assessed by the number of rounds in which subjects had adjusted their order quantities in the direction of the most recent demand realization. Thus, larger values represent more frequent demand-chasing.

Past studies have primarily used four different measures to identify subjects who

³Details about instruments for individual heterogeneity measures are presented in the electronic companion.

chase demand: comparing changes towards versus away from past demand, contrasting separate adjustment scores for changes toward and away from past demand, estimating a regression coefficient for a term that captures the weight given to the deviation between ordered quantity and demand realization in the previous period, and evaluating the correlation between order quantities and previous demand realizations. Using simulated data from two different stochastic processes (i.e., ordering decisions sensitive versus independent of past demand), Lau & Bearden (2013) produced thousands of 31-period decision sets and found that using a measure based on correlation performed better in identifying which process had produced each set. These results are relevant when assuming ordering decisions come from people who either chase demand or not, and the objective is to avoid reporting false positives and false negatives.⁴ In contrast, our study suggests that chasing demand occurs in response to feeling regret due to situational factors present in the newsvendor problem. Therefore, most or all decision makers are expected to chase demand at some point depending on what and how they choose in previous rounds. Our interest lies in describing the variation in demand-chasing—both extent and frequency—for individuals who may choose to do so in one round but refrain from doing so in the next.

The pull-to-center effect describes average order quantities falling between the expected-profit-maximizing order quantity and mean demand, such that more pulled-to-center average order quantities are closer to mean demand. Let q_j^* and μ_j be the expected-profit-maximizing order quantity and mean demand for treatment j , respectively. The size of the pull-to-center effect for subject i in treatment j with an

⁴Recently, Kirshner & Moritz (2020) found that the false positives reported by Lau & Bearden (2013) when using a regression-based measure were overstated due to autocorrelated errors, and that an alternate regression-based measure that includes a lagged response variable performs as well as a measure that is based on correlation.

average order quantity $\bar{q}_{i,j}$ can be expressed as:

$$PTC_{i,j} = \frac{q_j^* - \bar{q}_{i,j}}{q_j^* - \mu_j} \quad (3.2)$$

Larger values of PTC indicate more pulled-to-center average order quantities, which are closer to mean demand and farther away from the optimal order quantity.⁵ Consequently, a pull-to-center effect value of 0.5 indicates the average order quantity is halfway between the expected-profit-maximizing order quantity and mean demand, while a value of 0.9 indicates the average order quantity is closer to mean demand and far away from the expected-profit-maximizing order quantity.

3.6 Data Analysis and Results

In previous sections we provide theoretical support for the existence of situational forces that influence decision makers' choices in the newsvendor problem. Specifically, we argue that when placing orders, decision makers have counterfactual thoughts which, in turn, elicit regret. Wanting to undo and correct the situation (as predicted by the response strategy of the emotion), decision makers are expected to adjust their order toward a quantity closer to the foregone option (i.e., past demand realization). This behavior, described as demand-chasing, is likely to influence average order quantities by pulling them closer to mean demand. Because counterfactual thoughts are the underlying cognitive mechanism through which people feel regret, in Section 3.6.1 we describe and present the results of our pre-study in which we examined whether these type of thoughts are generally present when decision makers choose their order quantities in the newsvendor problem. The objective of the pre-study was to evidence the presence of these thoughts in this context, and not to

⁵In their meta-analysis, Zhang & Siems (2018) use a similar formulation at the treatment group level instead of at an individual level.

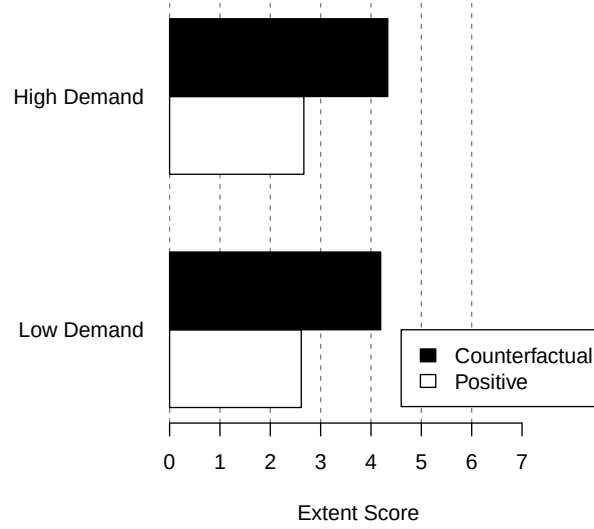
test the individual elements and propositions of counterfactual thinking theory. The main reason to conduct this assessment on a separate sample—instead of doing it as part of the experiment itself—was to avoid demand effects (Lonati et al., 2018). After describing the pre-study, we turn our attention to the results of the experiment in Section 3.6.2.

3.6.1 Pre-Study

Undergraduate students ($N = 97$, $M_{age} = 23.6$ years, 54% female) completed an in-class experiment using the same procedure and computer interface described in Section 3.5. As described in Section 3.4.3, counterfactual thoughts are more likely to be activated when placing orders for low- compared to high-profit-margin products. Therefore, we took a conservative approach in the pre-study by focusing on ordering decisions of a high-profit-margin product with a unit cost of $c = 3$ points. However, to evaluate whether the presence of counterfactual thoughts generalized across different demand variability settings, participants were randomly assigned to either a low or high demand variability treatment. In the former treatment group, customer demand for the product was uniformly distributed between 0 and 100, while in the latter treatment group, customer demand was uniformly distributed between 0 and 5000.

After choosing the order quantity and receiving customer demand information for the first round, participants were asked to reflect on the decision they had made and indicate whether certain thoughts had come to mind. We assessed the extent to which counterfactual and positive appraisal thoughts occurred using items adapted from Hafner et al. (2012) with ratings on a 7-point Likert scale (see Appendix A.4 for details about the instrument). Items shown to subjects were randomly ordered to prevent order bias. After the assessment, participants continued making ordering decisions until completing a total of 15 rounds.

The results of the pre-study revealed, as depicted in Figure 3.3, that counterfactual



Notes: Extent to which counterfactual and positive appraisal thoughts came to mind after placing an order to the supplier in a newsvendor setting. Counterfactual: "If only I had ordered something different."; Positive appraisal: "I did a good job when deciding."

Figure 3.3: Type of Thoughts During Newsvendor Decision Making

thoughts ($M_{\text{low}} = 4.19$, $SD = 1.83$ and $M_{\text{high}} = 4.33$, $SD = 2.12$) came to mind to a significantly greater extent than positive appraisal thoughts ($M_{\text{low}} = 2.62$, $SD = 1.78$ and $M_{\text{high}} = 2.67$, $SD = 1.65$) in both low and high demand variability conditions ($t(51) = 4.07$, $p < 0.01$ and $t(44) = 3.56$, $p < 0.01$, respectively). Also, the degree to which counterfactual thoughts came to mind did not differ across treatment groups (ANOVA, $F(1, 95) = 0.12$, $p = 0.726$). Together, that counterfactual thoughts are experienced to a greater extent than positive appraisal thoughts and come to mind across different demand variability conditions suggests counterfactual thoughts are prevalent when placing orders in the newsvendor problem. Because the type of counterfactual thoughts occurring in this context are upward, self-focused counterfactuals that alter past choices, decision makers are likely to experience regret and behave in accordance with the response strategy of this emotion. This is the focus of our main experiment for which the results are presented next.

Table 3.6: Path Analysis Results of Product Profit Margin on Pull-to-Center Effect Through Experienced Regret and Demand-Chasing Extent

	Experienced Regret			Demand-Chasing Extent			Pull-to-Center Effect		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Product Profit Margin	-1.116*** (0.315)	-1.102*** (0.323)	-1.082*** (0.335)	-0.151 (0.207)	-0.158 (0.219)	-0.230 (0.219)	0.341*** (0.111)	0.350*** (0.119)	0.334*** (0.119)
Experienced Regret				0.204*** (0.064)	0.184*** (0.068)	0.168** (0.067)	0.042 (0.037)	0.040 (0.039)	0.041 (0.039)
Demand-Chasing Extent							0.102* (0.058)	0.106* (0.060)	0.081 (0.060)
NVP Knowledge							-0.037 (0.025)	-0.032 (0.027)	-0.010 (0.030)
DC Extent $\times$ Knowledge							0.058** (0.026)	0.056** (0.027)	0.064** (0.027)
Cognitive Reflection			0.002 (0.145)			-0.141 (0.090)			-0.032 (0.053)
Risk Aversion			-0.061 (0.085)			-0.043 (0.053)			-0.030 (0.030)
Overprecision			0.057 (0.067)			0.060 (0.042)			0.051** (0.024)
Constant	0.558** (0.223)	1.246 (1.264)	1.376 (1.405)	0.076 (0.142)	0.514 (0.810)	0.665 (0.874)	0.661*** (0.078)	0.689 (0.443)	0.784 (0.493)
Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
R^2	0.120	0.192	0.205	0.132	0.149	0.213	0.197	0.203	0.264

Notes: OLS regression coefficients of moderated mediation model of the effect of product profit margin on pull-to-center effect through experienced regret and demand-chasing extent, moderated by newsvendor problem knowledge. $N = 94$. The dependent variable in Columns (1) to (3) is experienced regret, in Columns (4) to (6) is demand-chasing extent, and in Columns (7) to (9) is pull-to-center effect. The omitted group is the low-profit-margin product treatment. Controls are age, gender, student, schooling, and work experience.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

3.6.2 Results

Our hypotheses imply a causal model which suggests that greater experienced regret stemming from placing orders for low- compared to high-profit-margin products is associated with more pulled-to-center average order quantities through demand-chasing. However, the effect demand-chasing has on average order quantities being pulled-to-center is contingent on the level of knowledge decision makers have about the newsvendor problem. To test our moderated mediation model, we conducted a path analysis with product profit margin as the predictor variable, experienced regret and demand-chasing (both extent and frequency, in separate models) as serial mediators, pull-to-center effect as the dependent variable, and newsvendor problem knowledge as a moderator on the path from demand-chasing to pull-to-center effect (Preacher et al., 2007; Hayes, 2018). The results of the analysis are presented in Tables 3.6 and 3.7 (for demand-chasing extent and frequency, respectively).

Table 3.7: Path Analysis Results of Product Profit Margin on Pull-to-Center Effect Through Experienced Regret and Demand-Chasing Frequency

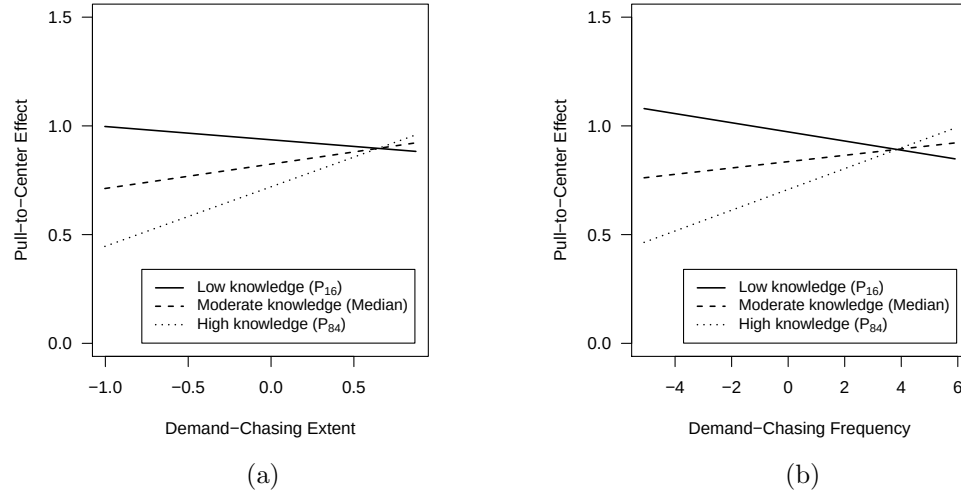
	Experienced Regret			Demand-Chasing Frequency			Pull-to-Center Effect		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Product Profit Margin	-1.116*** (0.315)	-1.102*** (0.323)	-1.082*** (0.335)	0.157 (1.035)	0.500 (1.070)	-0.151 (1.025)	0.286** (0.112)	0.280** (0.120)	0.258** (0.119)
Experienced Regret				1.190*** (0.321)	1.065*** (0.333)	0.984*** (0.315)	0.031 (0.039)	0.025 (0.041)	0.025 (0.041)
Demand-Chasing Frequency							0.012 (0.012)	0.013 (0.013)	0.005 (0.013)
NVP Knowledge							-0.046* (0.027)	-0.042 (0.029)	-0.019 (0.030)
DC Frequency $\times$ Knowledge							0.012** (0.005)	0.012** (0.006)	0.015** (0.006)
Cognitive Reflection			0.002 (0.145)			-1.334*** (0.419)			-0.046 (0.054)
Risk Aversion			-0.061 (0.085)			-0.220 (0.246)			-0.036 (0.029)
Overprecision			0.057 (0.067)			0.211 (0.196)			0.053** (0.023)
Constant	0.558** (0.223)	1.246 (1.264)	1.376 (1.405)	-0.078 (0.709)	7.114* (3.949)	8.764** (4.084)	0.701*** (0.083)	0.686 (0.450)	0.883* (0.496)
Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
R^2	0.120	0.192	0.205	0.143	0.199	0.319	0.190	0.197	0.268

Notes: OLS regression coefficients of moderated mediation model of the effect of product profit margin on pull-to-center effect through experienced regret and demand-chasing frequency, moderated by newsvendor problem knowledge. $N = 94$. The dependent variable in Columns (1) to (3) is experienced regret, in Columns (4) to (6) is demand-chasing frequency, and in Columns (7) to (9) is pull-to-center effect. The omitted group is the low-profit-margin product treatment. Controls are age, gender, student, schooling, and work experience.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Consistent with Hypothesis 7, product profit margin is negatively associated with experienced regret (Tables 3.6 and 3.7, Column (1), $\beta = -1.116$, $p < 0.01$), such that placing orders for a low- compared to high-profit-margin product elicited significantly greater regret. An ANOVA with product profit margin as the independent variable and experienced regret as the dependent variable further supported this hypothesis ($F(1, 92) = 12.53$, $p < 0.01$). In addition, experienced regret is positively associated with chasing demand to a greater extent (Table 3.6, Column (4), $\beta = 0.204$, $p < 0.01$) and chasing demand more frequently (Table 3.7, Column (4), $\beta = 1.190$, $p < 0.01$). These results support Hypotheses 8A and 8B, respectively.

The analysis also revealed a significant interaction of the extent and frequency of demand-chasing and newsvendor problem knowledge on the pull-to-center effect (Table 3.6, Column (7), $\beta = 0.058$, $p < 0.05$ and Table 3.7, Column (7), $\beta = 0.012$, $p < 0.05$, respectively). Therefore, the effect of demand-chasing on average order quantities being pulled-to-center depends on the level of knowledge decision makers



Notes: Conditional effects of demand-chasing extent (panel (a)) and demand-chasing frequency (panel (b)) on the pull-to-center effect estimated among subjects at the 16th (low), 50th (moderate), and 84th (high) percentiles of the distribution of newsvendor problem knowledge.

Figure 3.4: Moderation of the Effect of Demand-Chasing on Pulled-to-Center Average Order Quantities by Newsvendor Problem Knowledge

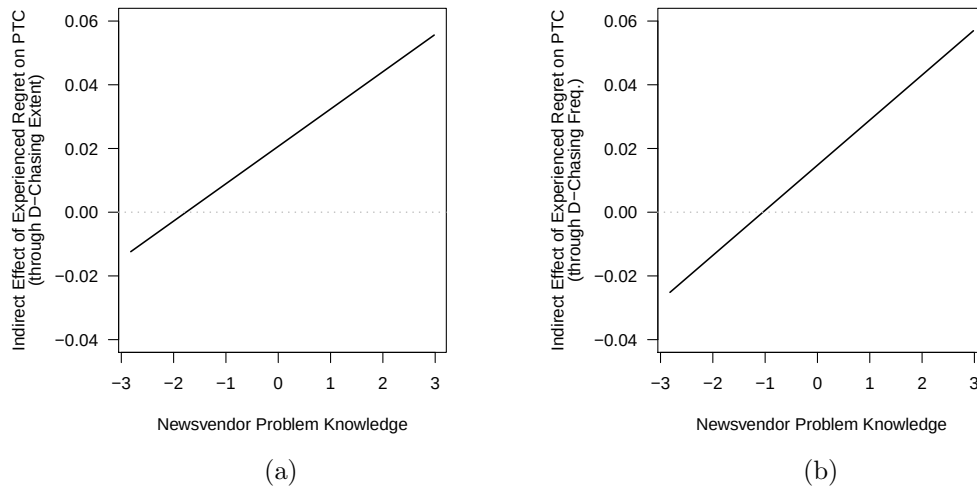
have about the newsvendor problem. Specifically, as depicted graphically in Figure 3.4, among those relatively low and moderate in newsvendor problem knowledge, chasing demand to a greater extent and more frequently does not lead to average order quantities being significantly more or less pulled-to-center (demand-chasing extent: conditional effect (ce) = -0.061 , $p = 0.492$ and ce = 0.112 , $p = 0.061$, respectively; demand-chasing frequency: ce = -0.021 , $p = 0.279$ and ce = 0.015 , $p = 0.229$, respectively). As expected, these individuals display pulled-to-center average order quantities regardless of whether they chase demand or not. However, among those relatively high in newsvendor problem knowledge, greater demand-chasing results in average order quantities that are significantly more pulled-to-center (demand-chasing extent: ce = 0.273 , $p < 0.01$; demand-chasing frequency: ce = 0.048 , $p < 0.05$). These results lend support to Hypotheses 9A and 9B. Counter to what one would expect, decision-makers with more knowledge about the newsvendor problem who generally placed orders closer to the expected-profit-maximizing order quantity were

those for whom chasing demand was most detrimental.

Most important for examining the underlying mechanism through which ordering products with different profit margins affects pulled-to-center average order quantities is the test of moderated mediation. Results of the path analysis revealed the indirect effect of product profit margin on the pull-to-center effect through experienced regret and demand-chasing is moderated by newsvendor problem knowledge (demand-chasing extent: index of moderated mediation (imm) = -0.013 , 95% percentile CI $[-0.034, -0.002]$; demand-chasing frequency: imm = -0.016 , 95% percentile CI $[-0.037, -0.002]$).⁶

Further analysis of the indirect effect conditioned on different values of newsvendor problem knowledge indicated that among decision makers relatively low and moderate in newsvendor problem knowledge, there was no evidence that product profit margin indirectly affected average order quantities from being pulled-to-center to a different degree through experienced regret and demand-chasing (demand-chasing extent: conditional indirect effect (cie) = 0.014 , 95% percentile CI $[-0.031, 0.072]$ and cie = -0.025 , 95% percentile CI $[-0.072, 0.003]$, respectively; demand-chasing frequency: cie = 0.028 , 95% percentile CI $[-0.020, 0.085]$ and cie = -0.019 , 95% percentile CI $[-0.058, 0.008]$, respectively). However, among those relatively high in newsvendor problem knowledge, the indirect effect is negative and significant, indicating that placing orders for a low- compared to high-profit-margin product results in average order quantities that are more pulled-to-center (demand-chasing extent: cie = -0.062 , 95% percentile CI $[-0.147, -0.014]$; demand-chasing frequency: cie = -0.063 , 95% percentile CI $[-0.148, -0.009]$). Relative to a high-profit-margin product, ordering a low-profit-margin product results in experiencing greater regret, which in turn is associated with chasing demand to a greater extent and more

⁶The Sobel test has been shown to have limitations when testing indirect effects (given that the sampling distribution of the product of random normal variables is not normal), thus we resorted to bootstrapping methods to construct 95% confidence intervals using 5,000 bootstrap samples for all indirect effects reported in our study following Preacher & Hayes (2004); Preacher et al. (2007).



Notes: Graphical representation of the indirect effect of experienced regret on the pull-to-center effect through demand-chasing extent (panel (a)) and demand-chasing frequency (panel (b)) as a function of newsvendor problem knowledge.

Figure 3.5: Indirect Effect of Experienced Regret on Pulled-to-Center Average Order Quantities through Demand-Chasing

frequently, which is associated with more pulled-to-center average order quantities. These results support Hypotheses 10A and 10B.

To provide additional insight about the effect experiencing regret has on average order quantities being pulled-to-center through demand-chasing, Figure 3.5 displays the indirect effect as a function of newsvendor problem knowledge. As the level of knowledge decision makers have about the newsvendor problem increases, experiencing greater regret leads to average order quantities that are more pulled-to-center. Also, to test the robustness of our findings, we included in our analysis control variables (Tables 3.6 and 3.7, Columns (2), (5), and (8)) and individual heterogeneity measures shown to be related with performance outcomes in the newsvendor problem (Columns (3), (6), and (9)). All results remained unchanged after adding these covariates to our models.

3.7 Addressing Dysfunctional Counterfactual Thinking

Results from Section 3.6 show that when decision makers place orders in the newsvendor problem, they are likely to have counterfactual thoughts and experience regret. Wanting to undo and reverse the decision they have made, decision makers chase demand and this, in turn, affects average order quantities by pulling them closer to mean demand. However, if counterfactual thoughts have generally been shown to be functional and lead to performance benefits, why are they detrimental in helping decision makers make better choices in this situation? And, how can this dysfunctionality be addressed to improve decision making in the newsvendor problem? To study these questions, we return to the theoretical underpinnings of counterfactual thinking.

As described in Section 3.4.1, counterfactual thoughts imply causal inferences which facilitate a behavioral intention aimed at reducing the discrepancy between actual and ideal goal states. When opportunity exists, behavioral intentions get implemented and give rise to corresponding behavior. Through this process, counterfactual thoughts are generally functional and result in performance improvement (Roese & Epstude, 2017). However, the actual impact on performance depends on the accuracy of the causal inference implied by the counterfactual thought (Sherman & McConnell, 1995; Roese & Epstude, 2017).

One source of inaccuracy may stem from believing that because an event is highly mutable—that an alternate antecedent that would have resulted in a different outcome easily comes to mind—altering its antecedent would have necessarily led to a different outcome (Miller & Turnbull, 1990; Sherman & McConnell, 1995). Although it may be true that modifying the antecedent of an event *might have* resulted in some other outcome, this does not imply that this outcome *ought to have* happened

(Miller & Turnbull, 1990). This confusion of what might have been with what ought to have been is called the counterfactual fallacy and is based on the perception that events that can be easily imagined otherwise (i.e., that are highly mutable) should have indeed occurred otherwise (Miller & Turnbull, 1990; Sherman & McConnell, 1995). Because counterfactual thoughts imply a causal inference, the counterfactual fallacy may lead people to erroneously believe that altering the antecedent of an event necessarily causes a different outcome. Such inferences, based exclusively on mutability perceptions rather than on the reasonableness of the judgment, are therefore inaccurate.

3.7.1 Hypotheses

In the newsvendor problem, actual versus foregone profits in a given period differ only by whether one ordered what one did or what customers demanded. Therefore, thinking that if a quantity closer to what customers demanded had been ordered then one would have achieved better profit suggests, as counterfactual thoughts do by virtue of the falsity of their antecedent, a causal insight: ordering a quantity closer to what customers demanded *causes* profit to improve. To recognize that a different choice might have led to a better outcome after noticing that the order quantity one chose is different from the quantity demanded by customers is sensible. However, it is another thing to assume that a different choice should have been made.

After receiving customer demand information, imagining a different order quantity that would have resulted in a better outcome easily comes to mind. As a result, the situation becomes highly mutable in that it can be easily imagined otherwise and, in accordance with the counterfactual fallacy, this will often cause one to believe that altering the quantity one had ordered would have necessarily led to a better outcome (Miller & Turnbull, 1990; Sherman & McConnell, 1995). Although it may be true that had one ordered a different quantity closer to what customers demanded better profits

might have been obtained, this does not imply, as suggested by the type of causal inferences occurring in the newsvendor problem, that better profits *ought to have* been obtained. To the extent that causal inferences are the link between counterfactual thoughts and behavioral intentions that may get implemented, inaccurate inferences like these will often lead to dysfunctional behavior (Sherman & McConnell, 1995; Roese & Epstude, 2017).

Because decision makers' goal in the newsvendor problem is concerned with total profits obtained over a series of selling periods, goal progress should be informed by profits accumulated over multiple periods instead of profits achieved in a single period. However, once an order quantity is placed, the standard feedback decision makers receive corresponds to the quantity customers were willing to demand in the previous selling period. Deviations between what one ordered and what customers demanded indicate either lost sales or unnecessary costs, and are thus perceived as preventing one from achieving an ideal goal state. This perception of lack of goal progress, which is likely to happen more often than not because demand is random, activates counterfactual thoughts containing, as described earlier, inaccurate causal inferences. And even if cumulative profits are presented after customer demand becomes available, this perceived goal blockage will persist because decision makers do not have other reference values to compare these profits to.

In contrast, if decision makers receive improved feedback that, in addition to past demand realizations, contains information about how the total profit they have made during a series of selling periods compares to that which they would have achieved if a different quantity had been ordered, their goal progress would be better informed. Realizing that one would have accumulated better total profit if a different quantity had been ordered consistently over time, is indeed accurate. Because goal progress when improved feedback is received depends less on single-period deviations and is informed by profits accumulated over multiple periods, decision makers who

receive this feedback will perceive less discrepancies between actual and ideal goal states than those who receive standard feedback. In fact, decision makers receiving improved feedback may notice that, in some instances, their total profit is greater than the one they would have obtained if a different quantity had been ordered for multiple periods. In addition, because improved feedback leads to accurate inferences (which, in turn, lead to behavioral intentions better suited to improve performance), decision makers receiving this feedback are expected to choose order quantities that are closer to the expected-profit-maximizing order and perceive better goal progress than decision makers who receive standard feedback.

In sum, inevitable and frequent deviations between order quantities and customer demand each period will lead decision makers to perceive a lack of goal progress when standard feedback is received. However, when improved feedback that facilitates the construction of more accurate counterfactual thoughts is available, perceived goal blockage is expected to decline for two reasons. First, goal progress will depend less on single-period deviations and will be informed by profits accumulated over multiple periods. Therefore, decision makers may realize their total profit is better than the one they would have obtained if a different quantity had been ordered for a series of periods. Second, accurate inferences will lead to order quantities that are closer to the expected-profit-maximizing order and therefore, better goal progress will be achieved. To the extent that counterfactual thoughts are activated in response to goals being blocked (Roe & Epstude, 2017), and these thoughts, in turn, are crucial in eliciting regret (Pieters & Zeelenberg, 2007; Roe & Epstude, 2017), we expect standard versus improved feedback to have a significant effect on experienced regret. Therefore, we make the following prediction.

Hypothesis 11 *Decision makers experience greater regret when they receive standard versus improved feedback information.*

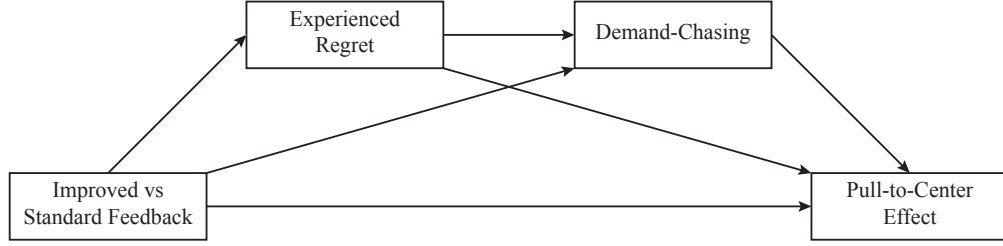
Based on Hypotheses 8A and 8B, we expect decision makers who experience more

regret to chase demand to a greater extent and more frequently, compared to those who experience less regret. In addition, according to Hypotheses 9A and 9B greater demand-chasing results in average order quantities being pulled-to-center, specifically when decision makers have more knowledge about the newsvendor problem. When improved feedback information that facilitates the construction of more accurate counterfactual thoughts is available, decision makers are expected to order quantities that are closer to the expected-profit-maximizing order. Because decision makers who are expected to chase demand less are precisely those who receive improved feedback (i.e., as a consequence of experiencing less regret), their average order quantity will thus be close to the optimal order quantity regardless of the level of knowledge they had about the newsvendor problem. Therefore, independent of newsvendor problem knowledge, decision makers who chase demand to a lesser degree are expected to have average order quantities closer to the expected-profit-maximizing order. In contrast, decision makers who chase demand to a greater degree will order quantities that mirror demand realizations and their average order quantities will approach mean demand. Accordingly, we make the following prediction.

Hypothesis 12A *When regret is induced by providing standard versus improved feedback information, average order quantities are more pulled-to-center as decision makers chase demand to a greater extent.*

Hypothesis 12B *When regret is induced by providing standard versus improved feedback information, average order quantities are more pulled-to-center as decision makers chase demand more frequently.*

Based on the hypotheses presented thus far, our model suggests that receiving standard versus improved feedback information leads to more pulled-to-center average order quantities indirectly through experiencing regret and chasing demand, and is represented graphically in Figure 3.6. Consequently, we predict the following indirect



Notes: Causal model of the effect of receiving improved versus standard feedback on average order quantities being pulled-to-center through experienced regret and demand-chasing.

Figure 3.6: Theoretical Model of Type of Feedback on the Pull-to-Center Effect

effect.

Hypothesis 13A *The effect of receiving standard versus improved feedback information on average order quantities being pulled-to-center is mediated by experienced regret and the extent to which decision makers chase demand.*

Hypothesis 13B *The effect of receiving standard versus improved feedback information on average order quantities being pulled-to-center is mediated by experienced regret and the frequency with which decision makers chase demand.*

3.7.2 Experimental Design

To test these hypotheses, participants ($N = 97$, $M_{age} = 34.3$ years, 39% female) were randomly assigned to either a standard or improved feedback treatment. Participants in both groups were asked to choose an order quantity for the corresponding round, and then received customer demand information and a summary of the number of units ordered and the profit earned. However, in the improved feedback treatment, when participants chose the order quantity for the first round, they were also asked to enter two other quantities they thought they could have ordered instead. These two quantities were used to provide participants with feedback about how the total profit they had made during a series of rounds compared to that which they would have achieved had they decided to order one of these other quantities they had con-

sidered. This information was presented to subjects in an additional screen after they had received customer demand and summary information contained in the standard feedback.

To test whether such intervention could potentially be implemented in practical settings, we allowed participants to choose all quantities without suggesting a specific number or influencing their decision. The only restriction when choosing the other two quantities that were considered was that their values had to be apart from each other and this was imposed by asking participants to enter a low and high value.⁷ Except for these differences and the fact that participants in both groups placed orders for a product with a unit cost of $c = 9$ points, all remaining aspects of the experiment followed the same procedures, problem parameters, payoffs, and dependent measures to those described in Section 3.5.

3.7.3 Results

The hypotheses described in Section 3.7.1 suggest that receiving standard versus improved feedback information results in more pulled-to-center average order quantities through experiencing regret and chasing demand. To test this causal model, we conducted a path analysis with type of feedback as the predictor variable, experienced regret and demand-chasing (both extent and frequency, in separate models) as serial mediators, and pull-to-center effect as the dependent variable (Preacher & Hayes, 2004; Hayes, 2018). The results of the analysis are presented in Tables 3.8 and 3.9 (for demand-chasing extent and frequency, respectively).

We found that receiving standard compared to improved feedback information is associated with experiencing greater regret (Tables 3.8 and 3.9, Column (1), $\beta = -0.702$, $p < 0.05$). A similar result was obtained using ANOVA with type of feedback as the independent variable and experienced regret as the dependent variable

⁷For images showing screens of the newsvendor task that were different in the improved feedback treatment, see the electronic companion.

Table 3.8: Path Analysis Results of Type of Feedback on Pull-to-Center Effect Through Experienced Regret and Demand-Chasing Extent

	Experienced Regret			Demand-Chasing Extent			Pull-to-Center Effect		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Type of Feedback	-0.702** (0.279)	-0.690** (0.284)	-0.877*** (0.274)	-0.102 (0.203)	-0.091 (0.205)	-0.104 (0.210)	-0.167* (0.090)	-0.194** (0.090)	-0.096 (0.087)
Experienced Regret				0.188** (0.073)	0.212*** (0.074)	0.219*** (0.078)	-0.001 (0.033)	0.004 (0.034)	0.044 (0.034)
Demand-Chasing Extent							0.137*** (0.045)	0.127*** (0.046)	0.143*** (0.045)
Cognitive Reflection			-0.369*** (0.131)			-0.137 (0.100)			0.160*** (0.042)
Risk Aversion			0.194** (0.081)			-0.088 (0.061)			-0.051** (0.025)
Overprecision			-0.056 (0.053)			0.047 (0.039)			-0.005 (0.016)
Constant	0.362* (0.200)	0.739 (1.292)	0.063 (1.408)	0.053 (0.144)	-0.036 (0.904)	0.718 (1.021)	0.656*** (0.063)	0.555 (0.396)	0.666 (0.424)
Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
R^2	0.063	0.105	0.227	0.080	0.142	0.202	0.139	0.203	0.338

Notes: OLS regression coefficients of mediation model of the effect of improved versus standard feedback on pull-to-center effect through experienced regret and demand-chasing extent. $N = 97$. The dependent variable in Columns (1) to (3) is experienced regret, in Columns (4) to (6) is demand-chasing extent, and in Columns (7) to (9) is pull-to-center effect. The omitted group is the standard feedback treatment. Controls are age, gender, student, schooling, and work experience. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3.9: Path Analysis Results of Type of Feedback on Pull-to-Center Effect Through Experienced Regret and Demand-Chasing Frequency

	Experienced Regret			Demand-Chasing Frequency			Pull-to-Center Effect		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Type of Feedback	-0.702** (0.279)	-0.690** (0.284)	-0.877*** (0.274)	0.701 (0.890)	0.950 (0.875)	0.334 (0.864)	-0.174* (0.094)	-0.193** (0.093)	-0.110 (0.092)
Experienced Regret				1.057*** (0.317)	1.109*** (0.315)	0.887*** (0.320)	0.035 (0.035)	0.045 (0.036)	0.079** (0.036)
Demand-Chasing Frequency							-0.010 (0.011)	-0.013 (0.011)	-0.004 (0.012)
Cognitive Reflection			-0.369*** (0.131)			-1.415*** (0.409)			0.134*** (0.046)
Risk Aversion			0.194** (0.081)			-0.144 (0.250)			-0.064** (0.027)
Overprecision			-0.056 (0.053)			0.074 (0.160)			0.002 (0.017)
Constant	0.362* (0.200)	0.739 (1.292)	0.063 (1.408)	-0.361 (0.629)	5.800 (3.862)	9.299** (4.200)	0.660*** (0.066)	0.627 (0.414)	0.806* (0.459)
Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
R^2	0.063	0.105	0.227	0.106	0.205	0.314	0.063	0.149	0.260

Notes: OLS regression coefficients of mediation model of the effect of improved versus standard feedback on pull-to-center effect through experienced regret and demand-chasing frequency. $N = 97$. The dependent variable in Columns (1) to (3) is experienced regret, in Columns (4) to (6) is demand-chasing frequency, and in Columns (7) to (9) is pull-to-center effect. The omitted group is the standard feedback treatment. Controls are age, gender, student, schooling, and work experience. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

($F(1, 95) = 6.35, p < 0.05$). These results support Hypothesis 11. Also, consistent with findings reported in Section 3.6.2 and further supporting Hypotheses 8A and 8B, experienced regret is positively associated with the extent (Table 3.8, Column (1), $\beta = 0.188, p < 0.05$) and frequency (Table 3.9, Column (1), $\beta = 1.057, p < 0.01$) with which decision makers chase demand.

Results show the extent to which decision makers chase demand is positively associated with pulled-to-center average order quantities (Table 3.8, Column (1), $\beta = 0.137, p < 0.01$). However, there was no evidence that the frequency with which demand is chased affects the degree to which average order quantities are pulled-to-center (Table 3.9, Column (1), $\beta = -0.010, p = 0.348$). Therefore, Hypothesis 12A is supported but Hypothesis 12B is not. Indeed, the extent and frequency measures capture different dimensions of demand-chasing behavior and these results indicate that the degree to which average order quantities are pulled-to-center does not only depend on the number of adjustments toward past demand realizations but also on the size of these adjustments. We also examined whether the relationship between demand-chasing and pulled-to-center average order quantities is contingent on newsvendor problem knowledge when regret is induced through changes in feedback information. As expected, the level of knowledge decision makers had about the newsvendor problem did not moderate the effect of demand-chasing extent ($\beta = 0.017, p = 0.441$) and frequency ($\beta = 0.008, p = 0.115$) on average order quantities being pulled-to-center in this setting.

To assess how receiving standard compared to improved feedback influences pulled-to-center average order quantities, we tested whether the relationship was mediated through experienced regret and demand-chasing. The analysis revealed a significant negative indirect effect operating through experienced regret and the extent to which demand-chasing occurred (indirect effect (ie) = -0.018 , 95% percentile CI $[-0.056, -0.002]$). Relative to decision makers who receive improved feedback, those

receiving standard feedback experience greater regret, which in turn is associated with chasing demand to a greater extent, which is associated with more pulled-to-center average order quantities. In this analysis, neither the remaining specific indirect effects (ie (operating only through experienced regret) = 0.001, 95% percentile CI $[-0.049, 0.048]$ and ie (operating only through demand-chasing extent) = -0.014 , 95% percentile CI $[-0.092, 0.042]$) nor the direct effect (Table 3.8, Column (1), $\beta = -0.167$, $p = 0.065$) were significant, implying that differences in average order quantities being pulled-to-center resulting from receiving standard versus improved feedback seem to operate exclusively through the underlying mechanisms uncovered in this study—experienced regret and demand-chasing.

There was no evidence that the effect of type of feedback on the pull-to-center effect is mediated by experiencing regret and the frequency with which demand is chased (ie = 0.008, 95% percentile CI $[-0.007, 0.034]$). Thus, the extent and not the frequency with which demand-chasing occurs proved to be more relevant in explaining pulled-to-center average order quantities in this specific setting in which the type of feedback information varied. These results lend support to Hypothesis 13A but not to Hypothesis 13B.

All results remained consistent after including in our analysis control variables (Tables 3.8 and 3.9, Columns (2), (5), and (8)) and individual heterogeneity measures (Columns (3), (6), and (9)), thus attesting to the robustness of findings. Finally, to examine whether addressing dysfunctional counterfactual thinking through improved feedback results in performance benefit, we compared the total profits (or losses) decision makers made. Indeed, decision makers who received improved feedback information ($M = -1519.38$ points, $SD = 6528.24$) compared to those receiving standard feedback information ($M = -4808.62$ points, $SD = 8891.27$) performed better in terms of profit ($t(84) = 2.07$, $p < 0.05$). To reduce the impact luck may have had when choosing order quantities each round on performance, we also estimated the pro-

portion of the maximum expected profit achieved (Bolton & Katok, 2008) to compare the impact of addressing dysfunctional counterfactual thoughts. Similar results were obtained, such that the expected profit achieved was higher for decision makers who received improved feedback information ($M = 0.15$, $SD = 0.57$), relative to those who received standard feedback ($M = -0.14$, $SD = 0.80$; $t(83) = 2.08$, $p < 0.05$).

3.8 Discussion

Ever since Schweitzer & Cachon (2000) reported the “too low/too high” pattern in the newsvendor problem describing order quantities averaged across periods and individuals for high- and low-profit-margin products, respectively, the same finding has been replicated in almost every subsequent behavioral newsvendor study. In addition, this systematic pattern demonstrates decision makers often obtain much lower profits than those they could have achieved if they had ordered a quantity closer to the expected-profit-maximizing order. Together, the prevalence of the pull-to-center effect in newsvendor ordering as well as its detrimental economic consequences for decision makers have made this effect one of the most widely studied phenomenon in the literature (Becker-Peth & Thonemann, 2019). However, it remains unclear why this systematic pattern occurs and which cognitive processes drive ordering behavior in the newsvendor problem (Becker-Peth & Thonemann, 2019).

Drawing from the literature on counterfactual thinking and regret, in this study we have documented how the key elements and preconditions captured by these constructs are present in the newsvendor problem and have developed a theoretical framework that establishes demand-chasing as the driver of the link between experienced regret and pulled-to-center average order quantities. We have shown that individuals in the newsvendor problem have counterfactual thoughts, that they come to mind more often than other type of thoughts, and that they occur in both low and high

demand variability conditions (Pre-study). The type of counterfactual thoughts that are present in the newsvendor problem—upward, self-focused counterfactuals that alter past choices—are the antecedent of feeling regret (Pieters & Zeelenberg, 2007; Roese & Epstude, 2017). We provide evidence that decision makers experience regret, and that assigning them to order either a low- or high-profit-margin product influences the extent to which they feel this emotion (Main experiment).

Our analysis further shows that decision makers chase demand to a greater extent and more frequently as they experience greater regret (Main experiment). Thus, counterfactual thinking and regret are important situational forces that influence choice behavior in the newsvendor problem. Also, we established how experiencing regret leads to pulled-to-center average order quantities (Main experiment). As decision makers experience greater regret, they in turn chase demand to a greater degree, which then results in average order quantities being more pulled-to-center. However, we have shown the effect demand-chasing has on pulled-to-center average order quantities is contingent on the level of knowledge decision makers have about the newsvendor problem. Specifically, when newsvendor problem knowledge is relatively low or moderate, chasing demand to a greater extent and more frequently does not result in average order quantities being more or less pulled-to-center. Although as expected, the average order quantity of these individuals is generally pulled-to-center regardless of whether they chase demand or not. In contrast, among those relatively high in newsvendor problem knowledge, greater demand-chasing leads to average order quantities being more pulled-to-center. Our results indicated that the indirect effect of experiencing regret on pulled-to-center average order quantities through demand-chasing is moderated by the level of knowledge decision makers have about the newsvendor problem (Main experiment). However, assessing and controlling for differences in newsvendor problem knowledge has rarely been done in the past. Interestingly, decision makers who have more knowledge about the newsvendor problem

generally place orders that are closer to the expected-profit-maximizing order quantity, but these same individuals are those for whom experiencing regret and chasing demand is most detrimental.

Although counterfactual thoughts are considered to be functional and generally lead to performance benefit (Roesse & Epstude, 2017), our results indicate that in the newsvendor problem, as evidenced by demand-chasing behavior and pulled-to-center average order quantities, counterfactual thoughts lead to ineffective behavioral consequences and performance. Drawing from the literature on counterfactual thinking, we identify the counterfactual fallacy as a possible source of inaccuracy in the causal inference these type of thoughts imply. By acknowledging the pervasiveness of these thoughts in the newsvendor problem and understanding why they lead to inaccurate inferences, we designed a new intervention aimed at improving the accuracy of causal inferences through improved feedback. Our results revealed that when decision makers receive improved versus standard feedback information, they experience less regret, which in turn leads to less demand-chasing, which results in less pulled-to-center average order quantities (Follow-up experiment). We found that the extent and not the frequency with which decision makers chase demand was positively associated with pulled-to-center average order quantities. In addition, improved feedback significantly changed the profit decision makers earned (Follow-up experiment). These results are important for two reasons. First, the mechanisms we have uncovered in this study (i.e., counterfactual thinking and regret) are not only the basis for our improved feedback intervention, but they also provide a rationale for why other interventions that have been reported in past studies (e.g., reducing feedback frequency and restricting options to decision makers) appear to be effective in improving performance. Second, our research suggests that managers concerned with improving performance while allowing human involvement in newsvendor decision making should address counterfactual thinking and regret (both of which have

often been overlooked), and we offer a low cost intervention for managers that helps in this regard. We further discuss these implications in Section 3.8.3.

3.8.1 Dispositional or Situational Factors?

In attributing observed behavior one must determine whether dispositional or situational factors explain the phenomenon. Are average order quantities pulled-to-center because decision makers tend to follow a heuristic or be cognitively biased, consider other objective in their utility function, behave as assumed by a model, or have certain individual characteristic? Or do decision makers display this aggregate level pattern because the situation they face influences how they choose their order quantities? Our analysis shows that as decision makers receive customer demand information, counterfactual thoughts likely come to mind and lead to experiencing regret, which in turn affects ordering behavior through chasing demand, which results in average order quantities being pulled-to-center. Therefore, to the extent that one can expect pulled-to-center average order quantities to result from choices made under the circumstances decision makers face in the newsvendor problem, we attribute the pull-to-center effect to situational factors—counterfactual thinking and experienced regret. Because one should not explain with dispositions that which has been explained by the situation (Gilbert & Malone, 1995), we discourage drawing dispositional inferences.

That situational rather than dispositional factors explain the pull-to-center effect has relevant implications. On one hand, by making the proper attribution of this aggregate level pattern we understand why average order quantities move away from the expected-profit-maximizing order quantity, and most importantly, we can improve ordering performance by addressing the appropriate factors. Our improved feedback intervention aimed at addressing the inaccuracy of the causal inferences implied by counterfactual thoughts provides an example of how this can be done. On the other

hand, that the pull-to-center effect has previously been attributed to decision makers' dispositions probably explains why only a limited number of actions have been proposed in the literature to improve performance and why we know so little about why certain interventions are more effective than others. We hope that having identified counterfactual thinking and experienced regret as critical situational forces driving ordering behavior spurs more work in this area.

In addition, our results show that individuals relatively low or moderate in newsvendor problem knowledge display average order quantities that lie close to mean demand regardless of the degree to which demand-chasing occurs. In contrast, for individuals relatively high in newsvendor problem knowledge, whether average order quantities are pulled-to-center does depend on the degree to which they chase demand. To the extent that one group of decision makers obtains average order quantities that are close to mean demand (i.e., those who have relatively low and moderate knowledge, and those who have relatively high knowledge and chase demand to a greater degree), and the other group obtains average order quantities that are closer to the expected-profit-maximizing order quantity (i.e., those who have relatively high knowledge and chase demand to a lesser degree), one would expect that averaging order quantities across periods and individuals would result in an average quantity falling between mean demand and the optimal order quantity. Therefore, counterfactual thinking and regret seem to be important mechanisms driving ordering behavior, newsvendor problem knowledge appears to be a critical boundary condition, and together they improve our understanding of why at an aggregate level averaging order quantities across periods and decision makers results in the "too low/too high" pattern replicated in behavioral newsvendor studies.

3.8.2 What Drives Ordering Behavior?

The literature provides evidence that demand-chasing is a frequently observed behavior when decision makers choose order quantities in the newsvendor problem. For example, Schweitzer & Cachon (2000) found that although 64.3% of decisions in their experiment were characterized by repeat choice, when individuals changed their order quantity they were more than twice as likely (24.7% versus 11.0%) to make adjustments toward previous demand realizations. When studying the impact of contracting mechanisms on supply chain performance, Katok & Wu (2009) found that in every treatment of their retailer game in which decision makers faced the newsvendor problem, retailers placed orders that were positively correlated with past demand. Moritz et al. (2013) reported that 86% of individuals from their sample of 313 experienced practitioners displayed a positive correlation between their orders and past demand. Our results indicate that the underlying mechanism driving this demand-chasing behavior is an emotion—regret. Regret is elicited as counterfactual thoughts come to mind and motivates further action according to its response strategy and the behavioral intention implied by these thoughts (Pieters & Zeelenberg, 2007; Roese & Epstude, 2017).

Assuming decision makers face a dis-utility from choosing an order quantity that deviates from realized demand and introducing a *penalty* for such deviations in the utility function, Schweitzer & Cachon (2000) showed, analytically, that the optimal solution to this model, referred to as a preference for minimizing ex-post inventory error, prescribes order quantities that are pulled-to-center. Similarly, Ho et al. (2010) developed a reference dependence model based on the assumption that decision makers face *psychological costs* for out-of-stocks and overstocks, and found that when these costs are included in the utility function, the model predicts order quantities that fall between the expected-profit-maximizing order quantity and mean demand.

The IBE model of Ockenfels & Selten (2014), which is based on the assumption that ordering choices are driven by *impulses* that occur in response to deviations from past demand realizations (upward impulses following out-of-stocks and downward impulses following overstock), and that decision makers have a tendency to move in the direction of this impulse, also predicts pulled-to-center order quantities. Even though these analytical models predict the pull-to-center effect, it is unclear whether the assumptions they imply—penalties, psychological costs, and impulses—are justified and what the driver of each of these is. Our results provide a unifying theoretical perspective for the three seemingly independent models.

Even though demand-chasing appears to be the most prevalent behavior in the newsvendor problem, we do not believe it is the only behavior that characterizes decision making in this context. Future research can investigate other behaviors, such as decision makers consistently ordering mean demand, and identify the cognitive processes that lead to choosing order quantities in this way. In addition, we do not rule out the possibility that other emotions besides regret also play a role in newsvendor decision making. To be sure, a growing body of literature suggests that different affective states may coexist (e.g., Cacioppo et al., 1997; Larsen et al., 2001; Williams & Aaker, 2002) so we do not rule out the possibility that other emotions could play a role when choosing order quantities in the newsvendor problem. Whether other emotions such as fear and anxiety are experienced and what their impact on decision makers' behavior is constitute an interesting venue for future research.

Although our results remained unchanged after controlling for individual characteristics that have been shown to play a role in newsvendor decision making, this does not imply that these characteristics are unrelated to demand-chasing behavior that results from experiencing regret. For example, because people high in cognitive reflection let System 2 processes moderate their initial System 1—intuitive and spontaneous—response (Frederick, 2005), it may be that when these individuals ex-

perience regret when placing orders in the newsvendor problem, following a more reflective and deliberate process leads them to be less likely to react in accordance with the response strategy of the emotion and thus chase demand less. Future work could explore how individual characteristics interact with the mechanisms that drive demand-chasing behavior. Specifically, whether certain people are more likely to have counterfactual thoughts and experience regret, and when they feel this emotion, whether they tend to chase demand to a greater degree.

3.8.3 Can Regret and Dysfunctional Counterfactual Thoughts be Addressed?

Behavioral newsvendor studies have tested different interventions aimed at improving ordering performance. These interventions include allowing decision makers to acquire experience through learning-by-doing over an extended set of periods (Schweitzer & Cachon, 2000; Bolton & Katok, 2008), offering training (Bolton et al., 2012), displaying the expected profit associated with each choice option (Bolton & Katok, 2008) or displaying the expected profit as a function of order quantity graphically (Bolton et al., 2012), presenting foregone profit information for options not chosen (Bolton & Katok, 2008), reducing feedback frequency (Lurie & Swaminathan, 2009), and restricting options to decision makers (in number of options to choose from and/or frequency with which options can be chosen) (Bolton & Katok, 2008; Bostian et al., 2008; Lurie & Swaminathan, 2009; Feng et al., 2011). Not surprisingly, offering training (that includes details about the rationale behind the optimal order quantity calculation and informs decision makers that an often observed tendency to order toward mean demand is wrong) and displaying the expected profit as a function of order quantity graphically (signaling the quantity that produces the maximum average profit) results in significant performance improvement (Bolton et al., 2012).

Interestingly, restricting decision makers to choose from among three options (from

a complete set of 100 possible demand quantities) and to keep the same order quantity for 10 consecutive periods, Bolton & Katok (2008) found an improvement in ordering performance. Based on our theoretical model, restricting options to decision makers (in number of options to choose from and frequency with which options can be chosen) reduces their sense of control (i.e., personal agency) over the situation they face (e.g., because the option to order the quantity demanded by customers was not available when they made their choice, decision makers may believe they were less responsible for the outcome they obtained). In addition, because customer demand information is received for 10 periods before an ordering decision can be made, an order quantity that may have seemed to be a better option in one round may well then be seen as a poor choice the following round. To the extent that personal agency and realizing that a different option would have been better are both key preconditions of experiencing regret, decision makers are less likely to experience this emotion when options are restricted in this way and, in turn, will chase demand and have pulled-to-center average order quantities to a lesser extent. Therefore, our study enriches Bolton & Katok's (2008) findings by providing an explanation for why decision makers change their behavior and obtain better profits when these restrictions are in place.

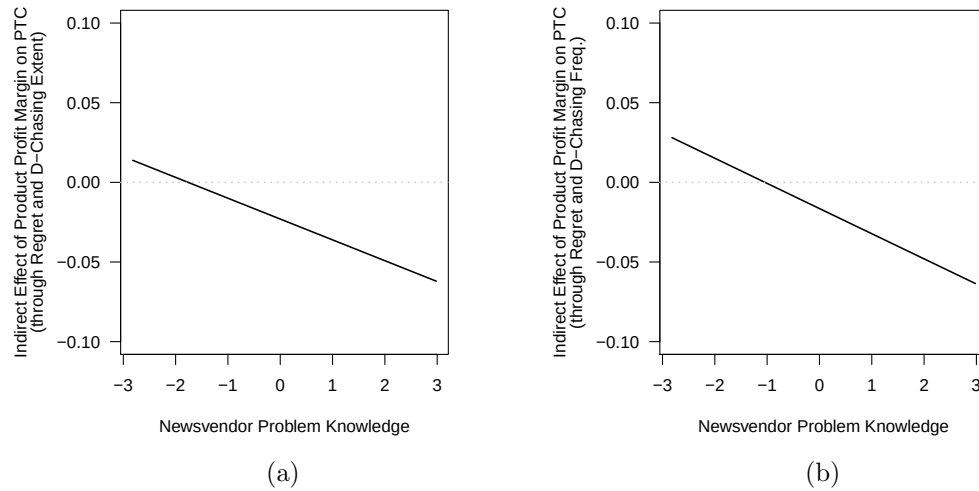
In this study we proposed a new intervention intended specifically to address the dysfunctionality of counterfactual thoughts stemming from the inaccuracy of the causal inferences they imply. Unlike past interventions, we provided decision makers with improved feedback that facilitates the construction of more accurate counterfactual thoughts based on two other quantities they thought they could have ordered instead, and showed how such intervention leads to better performance. These results suggest that if managers wish to achieve better profits while allowing human involvement in newsvendor decision making, addressing regret and dysfunctional counterfactual thoughts is critical but something frequently overlooked. In addition, improved feedback appears to be a promising intervention not only because it can be imple-

mented by managers at a low cost, but also because it does not impose restrictions on the frequency with which feedback is presented, the number of options to choose from, and frequency with which order quantities can be changed.

Because the intervention was designed specifically to facilitate the construction of accurate counterfactual thoughts, that results show decision makers indeed experience less regret and chase demand less after obtaining improved feedback helps validate that the mechanisms we have uncovered are in fact drivers of ordering behavior in the newsvendor problem. Although in our study we only asked decision makers to enter the additional two quantities they had considered once (in the first period), one would expect that a modified version of the intervention in which these quantities are subsequently updated after several periods to outperform the original version. Future research could examine different variations of our improved feedback intervention. As with most other emotions and cognitive processes, simply asking a person to dismiss how they feel or what they think proves useless and in some cases, even detrimental. Therefore, future research could also explore other interventions that could potentially reduce experiencing regret and the generation of dysfunctional counterfactual thoughts when placing orders in the newsvendor problem.

3.8.4 The Pull-to-Center Effect Asymmetry

Although some studies have found average order quantities to be more pulled-to-center for low-profit-margin products (e.g., Schweitzer & Cachon, 2000; Moritz et al., 2013), others report the opposite (e.g., Ho et al., 2010; Ren & Croson, 2013). Recently, in their meta-analysis comparing the pull-to-center effect across most newsvendor studies, Zhang & Siensen (2018) concluded that average order quantities being more pulled-to-center for low- or high-profit-margin products varies greatly across studies and depends on experimental design aspects such as the likelihood of obtaining losses and the way underage costs are presented. Whether there exists a systematic asym-



Notes: Graphical representation of the indirect effect of product profit margin on the pull-to-center effect through experienced regret and demand-chasing extent (panel (a)) and demand-chasing frequency (panel (b)) as a function of newsvendor problem knowledge.

Figure 3.7: Indirect Effect of Product Profit Margin on Pulled-to-Center Average Order Quantities through Experienced Regret and Demand-Chasing

metry in the pull-to-center effect that depends on product profit margin remains open for debate.

Although the objective of varying product profit margin in our study was to manipulate experienced regret based on our theoretical framework, our findings help shed some light on the pull-to-center effect asymmetry. Our results show that among decision makers relatively low and moderate in newsvendor problem knowledge, the effect of product profit margin on the pull-to-center effect through experienced regret and demand-chasing is not significantly different from zero. Thus, whether a low- or high-profit-margin product is ordered results in similarly pulled-to-center average order quantities. However, among decision makers relatively high in newsvendor problem knowledge, the indirect effect of product profit margin on the pull-to-center effect is negative and significant. Hence, in this case, when a high- compared to low-profit-margin product is ordered, average order quantities are less pulled-to-center. These relationships are displayed graphically in Figure 3.7. In sum, we would expect a

pull-to-center effect asymmetry among decision makers relatively high in newsvendor problem knowledge (i.e., less pulled-to-center average order quantities when ordering high- versus low-profit-margin products) but not among decision makers relatively low in newsvendor problem knowledge. Therefore, our analysis suggests that in studying the pull-to-center effect asymmetry, it is critical to consider the mechanisms—experienced regret and demand-chasing—and boundary condition—newsvendor problem knowledge—through which product profit margin affects the pull-to-center effect.

These findings also help to interpret past results in the literature with regards to the pull-to-center effect asymmetry. To the extent that counterfactual thoughts are activated in response to goals being blocked, product profit margin is an important antecedent of counterfactual thinking and regret because decision makers are more likely to obtain lower profits and incur losses when ordering low- versus high-profit-margin products (as described in Section 3.4.3). However, when the experimental setting is designed so that expected profits are similar across different product profit margin conditions, the activation of counterfactual thoughts and experienced regret will also be comparable across these conditions. Therefore, based on the indirect effect of product profit margin on the pull-to-center effect through experienced regret and demand-chasing, we would expect average order quantities in such settings to be pulled-to-center to a similar degree. This is likely to explain why average order quantities were similarly pulled-to-center (i.e., small pull-to-center effect asymmetry: $PTC = 0.52$ and 0.56 for low- and high-profit-margin conditions, respectively) in Bolton & Katok’s (2008) study in which expected profits across different product profit margin conditions were designed to be almost identical through the use of a fixed cost.

In addition, the same mechanisms we have uncovered are also likely to explain why Zhang & Siems (2018) found the pull-to-center effect asymmetry to be driven by experimental design characteristics. For example, because the likelihood of obtain-

ing losses (which is one such design characteristic) is closely related to the activation of counterfactual thoughts (as described in Section 3.4.3), it is now clear how this characteristic affects the pull-to-center effect and may result in asymmetries when decision makers are assigned to a low- or high-profit-margin product. These findings are important because even though it may seem that the pull-to-center effect asymmetry is driven by experimental design characteristics, our study suggests the asymmetry is in fact due to how decision makers interpret the situation they face through counterfactual thinking and experienced regret.

Chapter 4

Conclusions

To date, the behavioral newsvendor literature attributes demand-chasing behavior and the pull-to-center effect to dispositions of individuals. For example, their tendency to follow heuristics or consider other objective in their utility function. By considering the actor's viewpoint, this research has attempted to recognize the surrounding environment and the role the situation plays on the behavior of decision makers in the newsvendor problem. A theoretical model based on existing literature on counterfactual thinking and regret was developed and tested. This model suggests that because individuals facing the newsvendor problem receive customer demand information after placing an order, they are likely to have counterfactual thoughts as they think about what might have happened had they ordered a different quantity, and in turn, feel regret when realizing that their present situation would have been better had they decided differently. The results showed that both patterns, demand-chasing behavior and pulled-to-center average order quantities, are expected from decision makers placing orders under the influence of these situational forces—counterfactual thinking and regret—which are present in the newsvendor problem. Therefore, this research attributes demand-chasing and the pull-to-center effect to the situation decision makers face, suggesting that dispositional inferences are likely unwarranted.

The first essay demonstrated that decision makers in the newsvendor problem have

counterfactual thoughts and that they come to mind in both low and high demand variability conditions. Two conditions affect the degree to which decision makers experience regret. First, because receiving demand information plays a critical role in realizing that a different choice would have been better, decision makers who receive full disclosure of demand information (i.e., uncensored demand) experience greater regret than those who receive only sales information (i.e., censored demand). Second, because counterfactual thoughts are activated as perceived discrepancies between actual and ideal goal states become greater, decision makers who place orders for low- compared to high-profit-margin products experience greater regret. In addition, following the response strategy of the emotion which is associated with wanting to undo and reverse the decision made (Roseman et al., 1994; Zeelenberg et al., 1998) and in accordance with the content of counterfactual thoughts that likely come to mind (Roese & Epstude, 2017), results showed that decision makers who experience more regret chase demand to a greater extent and more frequently. The analysis indicated that regret mediates the effect demand information and product profit margin have on demand-chasing behavior.

The second essay provided further evidence of the association between feeling regret and chasing demand, and extended these results by showing how regret and demand-chasing lead to pulled-to-center average order quantities. As decision makers have counterfactual thoughts and experience regret, they adjust their previous order quantity in the direction of the most recent demand realization. When individuals behave this way, their orders begin to mirror past demand realizations as they make greater and more frequent adjustments. As a consequence, the average of these historical order quantities approaches the mean of the demand distribution (i.e., pulled-to-center). However, as predicted, the effect demand-chasing has on pulled-to-center average order quantities is contingent on the level of knowledge decision makers have about the newsvendor problem. Thus, results showed that the indirect

effect of experiencing greater regret on average order quantities being pulled-to-center is moderated by newsvendor problem knowledge.

In addressing dysfunctional counterfactual thoughts occurring in the newsvendor problem, the causal inferences they imply were examined and the counterfactual fallacy was identified as a source of inaccuracy. An intervention providing decision makers with improved feedback was designed and results showed that when receiving improved versus standard feedback, individuals experience less regret, which in turn leads to less demand-chasing, which results in less pulled-to-center average order quantities. Results also showed that the extent and not the frequency with which decision makers chase demand is positively associated with pulled-to-center average order quantities. The analysis demonstrated that decision makers who receive improved feedback obtain better profits.

This research has important theoretical implications. These essays have proposed a comprehensive theoretical model based on the psychology of counterfactual thinking and regret which indicates *what* factors play a role in explaining demand-chasing and the pull-to-center effect, *how* these factors are related, *why* these factors and their relationships matter in the newsvendor problem, and under *which* conditions these relationships hold. Our analysis explains why people chase demand and obtain average order quantities that are pulled-to-center, and help interpret past results in the literature which are discussed in detail in each essay.

Although results revealed that experiencing regret is an important mechanism leading to demand-chasing and pulled-to-center average order quantities, past studies have not accounted or controlled for this emotion. We expect that having introduced an empirical measure of regret in the behavioral newsvendor literature will facilitate future studies to consider this construct in their analyses. In addition, results showed that the knowledge decision makers have about the newsvendor problem is an important boundary condition of the effect demand-chasing has on pulled-to-center average

order quantities. However, individuals' knowledge about the problem has rarely been assessed in the past and when done, the main purpose has been to filter which subjects should participate in the study.

Instead of using existing demand-chasing measures designed to identify decision makers who chase demand from those who do not, this research proposed two distinct measures to describe demand-chasing behavior: the extent and frequency with which decision makers chase demand. Results from the improved feedback intervention provided evidence that these measures capture different dimensions of the behavior and that considering both is important.

Practical implications that are relevant for practitioners are also in order. Because the main drivers of demand-chasing and pulled-to-center average order quantities are counterfactual thoughts and experienced regret, any attempt to mitigate the negative effect of these patterns should start by addressing these mechanisms. Acknowledging counterfactual thinking and regret as drivers of behavior also helps explain why certain interventions proposed in past studies, like restricting options to decision makers (in number of options to choose from and frequency with which options can be chosen), have worked in improving performance and allows practitioners to evaluate the impact of interventions they design. In addition, results suggest that providing training that focuses on decision makers acquiring more knowledge about the newsvendor problem is not necessarily the most efficient way to improve performance. On one hand, the effect regret has on demand-chasing does not depend on the level of knowledge decision makers have. On the other hand, chasing demand is most detrimental for decision makers who have relatively more knowledge about the newsvendor problem.

This research also demonstrated that demand information and product profit margin affect ordering behavior. Thus, inventory managers should be aware that full disclosure of demand information (i.e., uncensored demand) and ordering low-profit-

margin products leads to experiencing greater regret. These results do not suggest that demand information should be restricted or that product profit margins should be modified. Instead, by being aware of how these conditions affect demand-chasing and average order quantities being pulled-to-center, inventory managers are better suited to address the effect these conditions have on ordering performance. The intervention proposed in this research intended specifically to address the dysfunctionality of counterfactual thinking is one example. By providing decision makers with improved feedback that facilitates the construction of more accurate counterfactual thoughts, managers can achieve better profits while allowing human involvement in newsvendor decision making at a low cost and without imposing restrictions to individuals.

Several opportunities for future research stem from this work. Introducing a measure of regret that is captured *in situ* opens the possibility for future research to study the effect this emotion has on other operations management problems. After all, regret is one of the emotions that is closely related to decision making. Also, to the extent that regret is an important mechanism driving demand-chasing and pulled-to-center average order quantities, future research can examine whether past results hold and how these results can be reinterpreted after accounting for this emotion. For example, examining whether individual heterogeneity characteristics interact with experiencing regret on the effect it has on demand-chasing is a promising venue for future research. Determining whether past interventions influence ordering performance through experienced regret is another example of a research opportunity in this area.

Even though the improved feedback intervention designed and implemented in this research proved to be successful in addressing dysfunctional counterfactual thoughts, it is by no means the only intervention that can accomplish this goal. Not only can future research improve the intervention that has been proposed, but new in-

terventions can also be developed and assessed. Although demand-chasing appears to be the most prevalent behavior in the newsvendor problem, other behaviors such as decision makers consistently ordering mean demand may also be at play. Future research can examine other behaviors and identify the cognitive processes that lead to choosing order quantities in this way. In addition, a growing body of literature suggests that different affective states may coexist (e.g., Cacioppo et al., 1997; Larsen et al., 2001; Williams & Aaker, 2002). Therefore, exploring whether other emotions such as fear and anxiety are experienced and what their effect on decision making in the newsvendor problem is constitutes another area for future research.

Although these research opportunities clearly indicate there is still work to be done in this field, hopefully this research has provided answers to some of the most relevant questions pertaining to *why* decision makers chase demand and obtain average order quantities that are pulled-to-center when placing orders in the newsvendor problem. The results evidence that, although often ignored, emotions play an important role in human decision making and demonstrate that emotions are pervasive even in contexts like the newsvendor problem, which are generally characterized by more rational decision processes.

Appendix A

Supplemental Material

A.1 Newsvendor Problem Knowledge Instrument

Please answer the questions below based on the following problem description.

Imagine that you work in the purchasing department of a retailer and you are responsible for buying a product from a supplier at a cost of \$4 per unit. The product is then sold by your company to customers at a price of \$5 per unit. For each of multiple selling periods, you must first order units to the supplier without knowing with certainty how many units will be sold to customers. Customer demand is random and could be for any quantity between 10 and 20 units, such that each number in the range is equally likely. The demand for any one round is independent of the demand from earlier rounds.

1. What is the retailer's underage cost per unit? a) \$1 b) \$4 c) \$5 d) None of the above
2. What is the retailer's overage cost per unit? a) \$1 b) \$4 c) \$5 d) None of the above
3. If in a given period you ordered 20 units and customer demand was 15 units, how many units did the retailer sell? a) 5 units b) 15 units c) 20 units d) None of the above

4. Based on question 3, what was the retailer's profit that period? a) -\$5 b) \$0
c) \$5 d) None of the above
5. Based on question 3, did the retailer incur in an underage cost or an overage cost that period? If so, what was the total value of this cost? a) An underage cost with a total value of \$5. b) An overage cost with a total value of \$5. c) An underage cost with a total value of \$20. d) An overage cost with a total value of \$20.
6. If in a given period you ordered 10 units and customer demand was 15 units, how many units did the retailer sell? a) 5 units b) 10 units c) 15 units d) None of the above
7. Based on question 6, what was the retailer's profit that period? a) \$0 b) \$5
c) \$10 d) None of the above
8. Based on question 6, did the retailer incur in an underage cost or an overage cost that period? If so, what was the total value of this cost? a) An underage cost with a total value of \$20. b) An overage cost with a total value of \$20. c) An underage cost with a total value of \$5. d) An overage cost with a total value of \$5.
9. Given the retailer's underage and overage cost per unit (see question 1 and 2), which of the following strategies should you choose when ordering from the supplier to obtain a better profit in the long run? a) Order a quantity above average demand. b) Order a quantity below average demand. c) Not possible to tell with the information that is given. d) None of the above

A.2 Newsvendor Task Instructions for Uncensored/Low-Profit-Margin Product Group

Description of the Task

- You are a retailer who sells a single item called a widget. To sell widgets to your customers, you must first order them from your supplier. In each one of multiple rounds, you order widgets from the supplier at a cost of 9 points per unit and sell widgets to your customers at a price of 12 points per unit, resulting in a profit of 3 points per unit.
- Your goal is to maximize the total profit you make over all rounds.
- You will know for certain what quantity your customers demand each round after you have ordered widgets from the supplier.
- Demand for the widgets you sell in a round is random and could be for any quantity between 0 and 1000 units, such that each number in this range is equally likely. The demand for any one round is independent of the demand from earlier rounds. In other words, a small or large demand in earlier rounds has no influence on whether demand is small or large in later rounds.

Calculating Profit

- If the number of widgets ordered (W) is less than the quantity demanded (D), you lose opportunities for sales and forgo some profit. Your profit for the round in this case will be:

$$\text{Profit} = \text{Sales} - \text{Costs} = (12 \text{ points} \times W) - (9 \text{ points} \times W)$$

For example, if you order 20 widgets and the demand is 50, then your profit for the round is: $(12 \text{ points} \times 20) - (9 \text{ points} \times 20)$

- If the number of widgets ordered (W) is greater than the quantity demanded (D), you must dispose of the unsold units without recovering the cost you paid. Unsold units cannot be carried as inventory into future rounds. Your profit for the round in this case will be:

$$\text{Profit} = \text{Sales} - \text{Costs} = (12 \text{ points} \times D) - (9 \text{ points} \times W)$$

For example, if you order 80 widgets and the demand is 50, then your profit for the round is: $(12 \text{ points} \times 50) - (9 \text{ points} \times 80)$

Ordering and Rounds

- In each one of multiple rounds, you will place an order for widgets and incur the corresponding cost. Customers will then purchase widgets from you and you will receive information about what the total demand for that round was. You will earn profits based on what you sold in every round.
- At the end of each round, you will receive a summary of the number of widgets you ordered, the number of widgets demanded by customers, how many you sold, and the profit you earned.

You will also have access to this summary information for previous rounds you have played.

Payoffs

- During this part of the study, the profit you earn in points will be converted to US dollars. Upon completion of the study, you will be paid the points you earned converted to US dollars plus an additional payment of \$4.00 for your participation (reward).

A.3 Experienced Regret Instrument

Please indicate to what extent do you agree that the following statements describe the way you feel or think right now after having placed orders and knowing what demand was. Provide a rating from *Completely Disagree* (1) to *Completely Agree* (7), using the following scale ...

1. I am experiencing self-blame for the decisions I made.
2. I feel sorry for having ordered what I did.
3. I feel like kicking myself.
4. Things would have gone better if I had chosen other options.
5. I wish I had made different choices.
6. I should have decided differently.
7. I do not feel bad about having ordered what I did. (R)

A.4 Type of Thoughts Instrument

Take a minute to think about your decision, the order quantity you ordered, and what customer demand was for the previous round. Click "Next" when you are ready. Using the rating scale below, please indicate to what extent did any of the following thoughts come to your mind ...

1. If only I had ordered something different.
2. I did a good job when deciding.

Appendix B

Electronic Companion

B.1 Newsvendor Task Screenshots for Uncensored/Low-Profit-Margin Product Group

Decision for Round 1

Instructions

You can show/hide the instructions at any time by clicking the Instructions button.

Instructions

My Decision

Recall that:

- Demand is random between **0 and 1000 units**, such that each number in the range is equally likely.
- Widgets **cost you 9 points** per unit and you sell them to customers at a **price of 12 points** per unit.
- Your goal is to **maximize the total profit you make over all rounds**.

Enter the number of widgets you want to order for **round 1**.

My order quantity is:

Next

Figure B.1: Newsvendor Task Screenshot - First Round Decision

Results for Round 1

Order Quantity & Cost
You ordered 500 widget(s) to your supplier this round.
The cost per unit is 9 points, so you paid a total of 4500 points for widgets.

Demand & Sales
Customer demand for widgets this round was 508. Thus, you were able to sell 500 widget(s).
The price per unit is 12 points, so you received a total of 6000 points in sales.

Profit
Your total profit this round is 1500 points.

Next

Figure B.2: Newsvendor Task Screenshot - Results

Decision for Round 2

Instructions

You can show/hide the instructions at any time by clicking the Instructions button.

Instructions

History

The table below shows the history of all the decisions you have made.

Round	Order Quantity (units)	Demand (units)	Units Sold (units)	Cost (points)	Sales (points)	Profit (points)	Cumulative Profit (points)
1	500	508	500	4,500	6,000	1500	1,500

My Decision

Recall that:

- Demand is random between **0 and 1000 units**, such that each number in the range is equally likely.
- Widgets **cost you 9 points** per unit and you sell them to customers at a **price of 12 points** per unit.
- Your goal is to **maximize the total profit you make over all rounds**.

Enter the number of widgets you want to order for **round 2**.

My order quantity is:

Next

Figure B.3: Newsvendor Task Screenshot - Subsequent Decision

B.2 Individual Heterogeneity Instruments

B.2.1 Cognitive Reflection

(Based on Frederick (2005))

Please answer the following questions. Feel free to use a pen and scratch paper, but do not use anything else.

1. A bat and a ball cost \$1.10 in total. The bat costs \$1 more than the ball. How much does the ball cost in cents?
2. If it takes 5 machines 5 minutes to make 5 widgets, how many minutes would it take 100 machines to make 100 widgets?
3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how many days would it take for the patch to cover half the lake?

B.2.2 Risk Aversion

(Based on Holt & Laury (2002))

You will be asked to make a series of successive decisions. For each decision, you will be given two lottery options to choose from. For example, for the first decision: Option A gives you a 10% chance to win \$2.00, and a 90% chance to win \$1.60; while Option B gives you a 10% chance to win \$3.85, and a 90% chance to win \$0.10.

Please indicate whether you prefer Option A or Option B for each decision.

Table B.1: Risk Aversion Lottery Options

	Option A	Option B
Decision 1:	o 10% chance to win \$2.00 and a 90% chance to win \$1.60	o 10% chance to win \$3.85 and a 90% chance to win \$0.10
Decision 2:	o 20% chance to win \$2.00 and a 80% chance to win \$1.60	o 20% chance to win \$3.85 and a 80% chance to win \$0.10
Decision 3:	o 30% chance to win \$2.00 and a 70% chance to win \$1.60	o 30% chance to win \$3.85 and a 70% chance to win \$0.10
Decision 4:	o 40% chance to win \$2.00 and a 60% chance to win \$1.60	o 40% chance to win \$3.85 and a 60% chance to win \$0.10
Decision 5:	o 50% chance to win \$2.00 and a 50% chance to win \$1.60	o 50% chance to win \$3.85 and a 50% chance to win \$0.10
Decision 6:	o 60% chance to win \$2.00 and a 40% chance to win \$1.60	o 60% chance to win \$3.85 and a 40% chance to win \$0.10
Decision 7:	o 70% chance to win \$2.00 and a 30% chance to win \$1.60	o 70% chance to win \$3.85 and a 30% chance to win \$0.10
Decision 8:	o 80% chance to win \$2.00 and a 20% chance to win \$1.60	o 80% chance to win \$3.85 and a 20% chance to win \$0.10
Decision 9:	o 90% chance to win \$2.00 and a 10% chance to win \$1.60	o 90% chance to win \$3.85 and a 10% chance to win \$0.10
Decision 10:	o 100% chance to win \$2.00 and a 0% chance to win \$1.60	o 100% chance to win \$3.85 and a 0% chance to win \$0.10

B.2.3 Overprecision

(Based on Russo & Schoemaker (1989))

For each of the following ten questions, you are asked to provide two numbers. The Low number should be less than or equal to the High number. Your goal is to choose these numbers so that 90 percent of the time, the true answer to each question is between these two numbers. If you successfully meet this challenge you should have 10 percent misses, that is, exactly one miss.

Note: Only enter numbers. No symbols, commas, or periods are allowed.

Table B.2: Overprecision Measurement Items

	Low	High
1. Martin Luther King's age at death (in years).	---	---
2. Length of the Nile River (in miles).	---	---
3. Number of countries that are members of OPEC.	---	---
4. Number of books in the Old Testament.	---	---
5. Diameter of the moon (in miles).	---	---
6. Weight of an empty Boeing 747 (in pounds).	---	---
7. Year in which Wolfgang Amadeus Mozart was born.	---	---
8. Gestation period of an Asian elephant (in days).	---	---
9. Air distance from London to Tokyo (in miles).	---	---
10. Deepest (known) point in the oceans (in feet).	---	---

B.3 Newsvendor Task Screenshots for Improved Feedback Treatment Group

Decision for Round 1

Instructions

You can show/hide the instructions at any time by clicking the Instructions button.

Instructions

My Decision

Recall that:

- Demand is random between **0 and 1000 units**, such that each number in the range is equally likely.
- Widgets **cost you 9 points** per unit and you sell them to customers at a **price of 12 points** per unit.
- Your goal is to **maximize the total profit you make over all rounds**.

Enter the number of widgets you want to order for **round 1**.

My order quantity is:

Other Options You Considered

When choosing the order quantity entered above, other quantities may have come to mind.

Please enter a low and a high quantity that you think you could have ordered instead.

Low Option: (between 0 and 500)	High Option: (between 500 and 1000)

Next

Figure B.4: Intervention Screenshot - First Round Decision

Up-to-Date Summary for Round 1

How Well You Could Be Doing									
The table below shows an up-to-date summary of how well you are doing compared to your other options.									
Round	Your Order Quantity			If You Had Chosen Your Low Option			If You Had Chosen Your High Option		
	Quantity (units)	Profit (points)	Cumulative Profit (points)	Quantity (units)	Profit (points)	Cumulative Profit (points)	Quantity (units)	Profit (points)	Cumulative Profit (points)
1	500	1,500	1,500	300	900	900	700	-204	-204

Next

Figure B.5: Intervention Screenshot - Improved Feedback

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