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Comments

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The newsvendor problem is a workhorse model in operation management research. We introduce a related game that operates in the price dimension rather than the inventory dimension: the price gouging game. Using controlled laboratory experiments, we compare news vending and price gouging behavior. We replicate the standard pull-to-center effect for news vending and find that the equivalent pattern occurs with price gouging. Further, we find that the pull-to-center is asymmetric both for newsvendors and price gougers. More broadly, the experimental results reveal that choices are similar across the theoretically isomorphic games, suggesting that observed behavior in newsvendor experiments is representative of a broader class of games and not driven by the operations context that is often used in newsvendor experiments. Finally, we do not find evidence that behavior in these games is systemically affected by sex, risk attitude, or cognitive reflection.

Keywords: behavioral operations, price gouging, newsvendor game, inventory, pull-to center effect

1. Introduction

The newsvendor problem has proven to be a workhorse in operation management research. This model is perhaps the simplest inventory decision setting – a newsvendor orders inventory at a set cost per unit to be resold at a prespecified price before the quantity demanded is determined. The theoretically optimal solution for an expected profit maximizing newsvendor has been known since Arrow, Harris, and Marshak (1951). However, starting with Schweitzer and Cachon (2000) controlled laboratory experiments have consistently observed behavior that systematically differs from the optimal inventory order. In their recent chapter on inventory behavior in *The Handbook of Behavioral Operations*, Becker-Peth and Thonemann (2019, p. 427) note “*the pull-to-center effect is the dominant observation in previous experimental studies.*” Pull-to-center is term that has been given to the observation that people order too few units when the per unit inventory cost is relatively low and too many units when the cost is relatively high.¹

Several scholars have investigated the drivers of the pull-to-center effect. This pattern is not consistent with typical explanations for why behavior differs from standard models such as risk aversion or loss aversion nor is it consistent with stock out aversion, waste aversion, or the consequences of underestimating opportunity costs (Schweitzer and Cachon 2000, Nagarajan and Shechter 2013, Long and Nasiry 2014).² Schweitzer and Cachon (2000) hypothesize and Kremer, Minner and Van Wassenhove (2010) find evidence that subjects behave as if have a preference to reduce ex-post inventory error. Schweitzer and Cachon (2000), Su (2008), Long and Nasiry (2014), Shen, Zhao and Xie (2017), Ren and Croson (2013) and Pavlov, Katok and Haruvy (2016) argue for the role of biases and bounded rationality. For example, Schweitzer and Cachon (2000) consider anchoring bias while Long and Nasiry (2014) as well as Shen, Zhao and Xie (2017) consider the impact of reference points.

The pull-to-center is also persistent in that experience has been shown to attenuate the pattern, but not eliminate it. Whereas Schweitzer and Cachon (2000) had subjects make 15 inventory decisions,

¹ Lau, Hasija and Bearden (2014) suggest the pull-to-center is an aggregate data phenomenon, but point out that individual decision makers are highly heterogeneous.

² Becker-Peth, Thonemann and Gully (2017) do find a significant correlation between individual risk preferences and order quantities.

Bolton and Katok (2008) have subjects make 100 choices. Bolton and Katok (2008) also vary the types of feedback given to the decision makers and find it has little impact (see also Feng, Keller and Zheng 2011). Bolton, Ockenfels, and Thonemann (2012) compare undergraduate freshman with no operations background, graduate students who have taken a course in operations, and inventory ordering professionals who have been on the job for more than a year and find little difference among the three groups in terms of behavior. Bolton, Ockenfels, and Thonemann (2012) also examine the effect of giving subjects extensive, hour long training immediately prior to facing the inventory ordering decision and found it did not eliminate the pull-to-center effect.

Given the overwhelming evidence of a pull-to-center effect in the news vendor game, it is important to understand the degree to which observed choices are driven by the structure of the underlying problem as opposed to being shaped by the specific operation management framing of the task as this would suggest directions for future work that can identify the cause of the pattern and tools for helping decision makers overcome the desire to follow it. There has been some previous efforts in this vein. For example, Schiffels, Fugener, Kolisch and Brunner (2014) present an inventory shortfall as either not being able to meet realized demand resulting in an opportunity cost of missed sales or a shortage cost for having to rush order additional inventory after the demand is known. Schultz, Robinson, Thomas, Schultz, and McClain (2018) vary the saliency of the revenue and loss aspects of the task. Kocabiyikoglu, Gogus, and Gonul (2014) describe the task as a revenue management problem where the subject decides how to allocate inventory across two markets - a low value and a high value market - with the catch being the low value market moves first and the size of the high value market is unknown. While these two studies change the framing of the task, the decisions are still made in an operations context. There are only two studies of which we are aware that consider a non-operations context for the task. Kremer, Minner, and Van Wassenhove (2010) consider a neutrally framed version of newsvendor's problem and report that behavior differs between the operations framed game and the neutrally framed version suggesting context dependent behavior. But more recently, Katok, Stangl, and Thonemann (2017) did not observe significant behavioral differences between operations framed and a neutrally framed versions of the task suggesting observed behavior is inherent to the structure of the task and not merely a framing effect. One key difference between these studies is that Kremer, Minner, and Van Wassenhove (2010) use a fairly discrete version of the news vendor game with only 7 inventory

levels while Katok, Stangl and Thonemann (2017) study a more continuous version with 100 inventory levels.

To push further on the robustness of the pull-to-center effect and to help determine if it is inherent to the structure of the task or an artifact of the operations framing, we introduce a new game which we refer to as the price gouging game. The price gouging game is distinct from the newsvendor game, but under certain restrictions, the two games can be made isomorphic. From our between subjects experimental design, we find that behavior in the two games is similar suggesting that the pull-to-center is systematic response to a broader class of games. Further, we find that responses are similarly asymmetric in both games. However, the games are not viewed as interchangeable by the subjects as the amount of demand or price chasing systematically differs between the game formats.

The remainder of the paper is organized as follows. The next section introduces mathematically describes the news vendor game and formally introduces the price gouging game. Section 3 and 4 presents our experimental design and behavioral results, respectively. A final section concludes.

2. Theoretical Background on News Vendor and Price Gouging Games

2.1 The News Vendor Game

The newsvendor's problem is to decide how much inventory to hold prior to the quantity demanded being realized when the price is fixed. Because the newsvendor has to pay for each unit of inventory regardless of whether or not it is sold, the newsvendor has to balance the excess cost of acquiring too much inventory and the missed opportunity to make profitable sales from not holding enough inventory. Formally, let p be the price, c be the per unit cost, and $f(\cdot)$ be the distribution determining the quantity demanded. The newsvendor's objective is to select the inventory level, q^* , that maximizes her expected profit of $(1 - F(q))(p - c)q + \int_0^q (px - cq)f(x) dx$. The solution, due to Arrow, Harris, and Marshak (1951), is such that $F(q^*) = \frac{p-c}{p}$.

2.2 Background on Price Gouging

Price gouging is defined by Zwolinski (2008, p.347) as occurring when “*in the wake of an emergency, sellers of certain necessary goods sharply raise their prices beyond the level needed to cover increased costs.*” For example, after the hurricane Irma in Florida and Harvey in Texas, packs of bottled water typically priced under \$10 reached prices between \$40 and \$99 and hotel rooms became three or four times more expensive.³ Stories are now emerging about price gouging along the US gulf coast as hurricane Michael moved through the region.⁴ Airline fares have been observed to jump almost 10-fold overnight after a natural disaster.⁵ From a classical economic perspective, this is a rational response by profit maximizing sellers who suddenly faced increased demand. It can be argued that price gouging actually benefits the affected consumers because the high prices ration goods to those most in need and incentivises sellers to increase supply (e.g. Deacon and Sonstelie 1985). As a case in point, a Kentucky man observing the high prices of generators in Mississippi after hurricane Katrina bought 19 generators and hauled them to Mississippi in order to earn a profit thus increasing the number of generators in Mississippi.⁶

However, the practice of price gouging is often viewed as being morally and ethically questionable. As a result, many locations pass have enacted laws to prohibit sellers from charging higher prices, especially in states of emergency. Thirty four US states and the District of Columbia have anti-price gouging laws. For instance, according to §17.46(b) of the Texas Deceptive Trade Practices-Consumer Protection Act provides that it is a “*false, misleading or deceptive act or practice to take advantage of a disaster declared by the Governor under Chapter 418, Government Code, by (1) Selling or leasing fuel, food, medicine or another necessity at an exorbitant or excessive price; or (2) Demanding an exorbitant or excessive price in connection with the sale or lease of fuel, food, medicine or another necessity.*” Sellers who are found to have engaged in price gouging often face stiff fines. The aforementioned gentlemen from Kentucky was arrested. Thus sellers in such settings face the following optimization problem. The seller can raise the price of her inventory and thus earn a larger profit so long, as she is not deemed to be engaging in price gouging. However, if she raises her price too much and is deemed to be price gouging then she will have to

³ See <http://time.com/money/4928955/hurricane-irma-florida-price-gouging/>

⁴ See <https://www.montgomeryadvertiser.com/story/news/2018/10/12/hurricane-michael-victims-price-gouging-florida-alabama-georgia-north-carolina-virginia/1599888002/>

⁵ See <http://fortune.com/2017/09/06/price-gouging-florida-irma/>

⁶ See <https://abcnews.go.com/2020/Stossel/story?id=1954352&page=1>

pay penalties thus lowering her profit. Thus, the seller’s profit problem is to charge the highest price possible without price gouging.

Before continuing, we want to emphasize that our focus is on understanding behavior in the news vendor game and not on price gouging per se. Although price gouging as it relates to supply chain responses to catastrophic events is an important issue and worthy of detailed study, especially from a behavioral perspective as personal views on raising prices may conflict with efficient market reactions, that is not the focus of the current paper. Hence, we omit many features such as seller reputation and consumer backlash that may be relevant in actual price gouging settings. This is akin to newsvendor studies ignore the reputation effects of a vendor regularly not having sufficient inventory. Further, we only consider a specific penalty structure that was designed to align the price gouging game with the newsvendor’s problem.

2.3 The Price Gouging Game

To model price gouging, we assume that a seller has a fixed inventory of θ units available and must set her price, π . The seller knows all of the units can be sold regardless of the price charged. What the seller does not know is the threshold price, τ , at which regulators will penalize her for engaging in price gauging. The seller does know that the threshold is distributed according to $\phi(\cdot)$, with cumulative distribution function $\Phi(\cdot)$.⁷ The penalty for price gouging is assumed to be a multiple of the difference between the threshold price and the price set by the seller as given by the following equation. With $\gamma > \theta$ this penalty means the seller has to forgo the revenue from charging a price above the threshold and has to pay a fixed fine of $\gamma - \theta$ for each dollar amount the price exceeds the threshold.⁸

$$penalty = \begin{cases} \gamma(\pi - \tau) & \text{if } \pi > \tau \\ 0 & \text{otherwise} \end{cases}$$

⁷ For the sake of comparison with the newsvendor, the support of $\phi(\cdot)$ starts at 0. Without loss of generality, the lower bound can be viewed as the normal (pre-emergency) price and higher bound with viewed as the (post-emergency) mark-up in naturally occurring price gouging setting.

⁸ This penalty structure was chosen because it can generate a one-to-one correspondence with the newsvendor problem in terms of choices and profits. Other penalty structures such as the addition of a fine that is invariant to the degree of price gouging may be more reflective of penalties in some jurisdictions.

The price gouger's objective is thus to select π , so as to maximize expected profit, which is given by the following.

$$Expected Profit = (1 - \Phi(\pi))\pi\theta + \int_0^\pi (\pi\theta - \gamma(\pi - x))\phi(x) dx$$

This objective function is similar to that of the newsvendor. A low price limits the upside profit potential but also limits downside losses, similar to a low inventory selection by the newsvendor. Likewise, charging a high price creates the potential for a large payoff but also exposes the seller to a large potential loss just as selecting a high inventory level does for the newsvendor. The solution to the price gouger's problem is to set a price of π^* such that $\Phi(\pi^*) = \frac{\theta}{\gamma}$.

Careful choice of γ , θ and $\phi(\cdot)$ can make the newsvendor and price gouging games equivalent in the sense of there being a one-to-one correspondence between choices and payoffs. Consider a newsvendor facing a demand, $d \sim U[0, M]$ with $M > c$ where c denotes the per unit inventory cost of the newsvendor. Figure 1 shows the revenue and inventory costs to the newsvendor who has a set price of p . The left panel is for a realized demand in excess of the ordered inventory level and the right panel is for a realized demand less than the inventory level. Figure 2 shows the same situations in a price gouging game with $\gamma = p$, $\theta = p - c$ and $\tau \sim U[0, M]$. The left panel shows a set price below the realized threshold and the right panel shows the case when the price exceeds the threshold. With these constraints, the two tasks become identical in terms of the equivalent action yielding the same payoff for the corresponding draws from the relevant distribution. That is, for each choice in the newsvendor game, a price gouger has a choice that will generate the say payoff distribution and hence the actions have the same expected payoff and risk.

The figures also highlight the sense in which price gouging and news vending are distinct rather than a pure framing difference. In the newsvendor game, the seller's cost is fixed by their decision. Thus, the cost of inventory (the hashed boxes) in Figure 1 are identical. What is uncertain is the revenue. By contrast, in the price gouging game revenue is determined by the seller's choice and it is cost that is uncertain. Thus, the revenue from sales (the dark bordered boxes) in Figure 2 are identical.

Figure 1. Newsvendor Problem with Uniform Demand

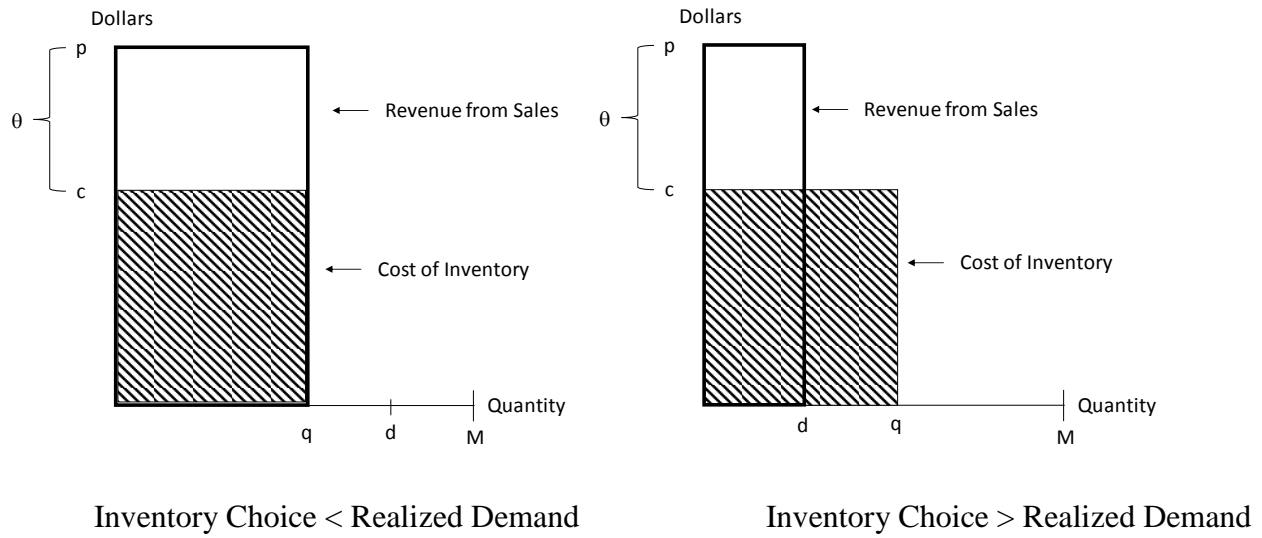
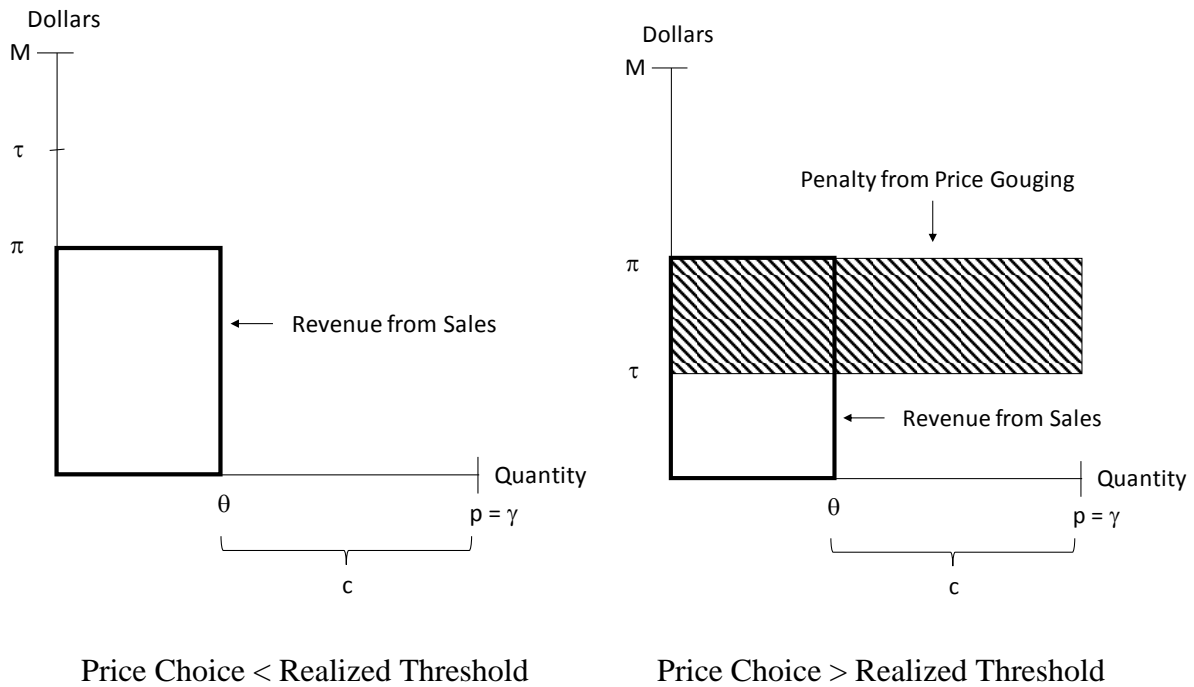


Figure 2. Price Gouging Problem with Uniform Price Threshold



3. Experimental Design

We conducted a 2×2 experimental between subjects design. The first dimension is the structure of the game: news vending or price gouging. The second dimension is the cost (c in the news vending game) or the inventory level (θ in the price gouging game): either low or high.

For the news vending game, $p = 100$ and $d \sim U[0,100]$. In the low cost treatment, $c = 25$ and thus $q_{Low}^* = 75$. In the high cost treatment, $c = 75$ and thus $q_{High}^* = 25$. To maintain an isomorphism between game structures, $\gamma = 100$ and $\tau \sim U[0,100]$ in the price gouging game. For the low inventory treatment, $\theta = 25$ and thus $\pi_{Low}^* = 25$. For the high inventory treatment, $\theta = 75$ and thus $\pi_{High}^* = 75$.

The expected profits from optimal decision making differ between the low cost/inventory and high cost/inventory treatments. Further, it is possible that participants could lose money depending on their choice and the realization of demand/threshold. To account for these potential incentive issues, we follow Katok, Stangl, and Thonemann (2017) providing treatment specific endowments. For the low cost / high inventory treatments, the endowment was set at 300. For the high cost / low inventory treatments, the endowment was set at 2,000. Although the cost levels in Katok, Stangl, and Thonemann (2017) differ from ours, the endowments are set so that the nominal payoffs are similar in all treatments in the two studies.

After reading computerized instructions, subjects were required to correctly answer comprehension questions before being allowed to proceed to the experiment.⁹ While subject participants are unlikely to bring preconceived views of inventory ordering with them into the lab, they may bring ideas about price gouging which is often portrayed in the news as unethical or immoral despite it often being welfare improving. Thus, the instructions for the price gouging treatments intentionally do not mention price gouging and simply parallel the news vending directions. In the experiment, subjects completed 100 decision periods in the assigned treatment. The realized demand or the price gouging threshold was randomly drawn for each subject each period. All payoff amounts are

⁹ Copies of the instructions, which closely follow Katok, Stangl, and Thonemann (2017), and the comprehension questions are available in the appendix.

denoted in Experimental Currency Units (ECUs). Subjects were paid their cumulative earnings, which were converted into \$US at the rate 12,500 ECU = 1 \$US. After completing the 100 decision periods and before receiving their payoff, subjects also completed a short survey that included sex, a cognitive reflection task (CRT), and a non-incentivised risk assessment (Risk).¹⁰

A total of 105 subjects completed the study at The University of Alabama’s TIDE Lab. Fifty two percent of the subjects were male. The average number of CRT questions answered correctly was 2.63 and the average amount invested in the risk assessment was 38%. Table 1 compares these characteristics by treatment. We note that there is marginal evidence in our data that males are more willing to take risks (p-value = 0.087 for two sided test that correlation = 0) and strong evidence that males score higher on the cognitive reflection questions (p-value = 0.001 for two sided test that correlation = 0). We observe no evidence the risk taking and cognitive reflection score are correlated (p-value = 0.490 for two sided test that correlation = 0).

Table 1. Participant Characteristics by Treatment

	News Vending		Price Gouging	
	Low Cost	High Cost	Low Inventory	High Inventory
Participants	26	26	27	26
Percent Male	46%	62%	56%	46%
Average Cognitive Reflection Score	2.15	2.73	2.74	2.88
Average Amount Invested in Risky Asset	38%	35%	38%	40%

One subject in the Low Inventory Price Gouging Treatment entered a price of 0 in every period. An additional observation was collected for this treatment to balance the design. In the data analysis in the next section, the person who entered a price of zero every period has been excluded although the results remain qualitatively similar if that observation is included.

The participants were drawn from the lab’s standing pool of subjects. None of the participants had completed a related study. The average earnings for the 30 minute sessions was \$23.40 including a \$5.00 participation payment.¹¹

¹⁰ The cognitive reflection test consisted of six question drawn from Frederick (2005) and Toplak, West and Stanovich (2014). The risk assessment is due to Dohmen, Falk, Huffman, Sunde, Schupp, and Wagner (2005). The question is “Suppose that you earned 100 000 EUR in lottery winnings. How much of the 100 000 EUR would you be willing to invest in an asset to either HALVE or DOUBLE in two years time with equal probability?”.

¹¹ Initially participants were recruited for a 60-minute session, but after it became apparent that 30 minutes was sufficient, the time of subsequent sessions was reduced.

4. Behavioral Results

For both the low inventory cost news vending game and the high inventory level price gouging game, the optimal quantity and price choice is 75, respectively. For the high inventory cost and low inventory level games the optimal price and quantity choice is 25, respectively. Table 2 gives the descriptive statics for each treatment. For none of the four treatments is the observed means statistically equal to the optimal values and in each case the observed mean exhibits a pull-to-center effect. This is our first finding.

Finding 1. Both newsvendor inventory choices and price gouging price choices differ from the optimal behavior and exhibit a pull-to-center effect.

Table 2. Descriptive Statistics of Inventory and Price Choices

	Optimal	Average Inventory or Price	Within Subject Standard Deviation	Percent Demand or Price Chasing
News Vending				
Low Cost	75	53.92*** (19.79)	9.87 (5.91)	50%
High Cost	25	42.67*** (17.03)	10.37 (6.69)	65%
Price Gouging				
High Inventory	75	51.56*** (16.60)	13.45 (6.47)	46%
Low Inventory	25	41.30*** (16.59)	9.74 (7.00)	27%

Unit of observation is a single participant and thus each average and standard deviation is based on 26 observations. Standard deviation of measurement given in parentheses. *** denotes difference from optimal behavior at 0.01 significance level based on two-sided t-test. Power analysis for the average inventory (price) being different from the optimal level indicates that N=26 subjects ensure a power > 0.99% in all four treatments when using the standard value of $\alpha = 0.05$.

To examine subject choices in more detail, Table 3 reports regression analysis of the average choice by a subject for each treatment controlling for individual characteristics: sex, CRT score, and Risk assessment. Because each subject accounts for a single observation, we rely upon ordinary least squares regression. The analysis is conducted separately for the entire experiment and only the last quarter as one might expect experience to mute or enhance the effects of individual characteristics. The results are consistent with Bolton and Katok (2008) who find that experience improves

performance. In all treatments, subjects tend to make choices closer to the optimal price or quantity in last 25 rounds than they do earlier in the experiment. However, no individual characteristic¹² is found to have a consistently significant effect on behavior across specifications although there are a few cases where risk attitude and CRT score have significant coefficients, as one would expect given the number of tests being conducted.¹³

Table 3. Analysis of Individual Characteristics on Average Choice

Periods	News Vending				Price Gouging			
	Low Cost		High Cost		High Inventory		Low Inventory	
	1-100	75-100	1-100	75-100	1-100	75-100	1-100	75-100
<i>Constant</i>	46.57*** (4.80)	50.58*** (9.13)	34.06*** (4.55)	28.65** (7.61)	40.49*** (5.73)	47.01*** (10.13)	43.02*** (4.49)	40.56*** (7.38)
<i>Male</i>	-4.05 (0.38)	-3.27 (6.03)	0.92 (4.09)	2.95 (4.40)	-7.32 (4.92)	-8.66 (5.80)	2.76 (4.18)	3.46 (4.65)
<i>CRT</i>	1.78 (0.18)	1.70 (2.86)	2.74+ (1.42)	3.51* (1.53)	4.24* (1.98)	5.82* (2.33)	-0.12 (1.37)	-0.85 (1.53)
<i>Risk</i>	0.19* (0.09)	0.23+ (0.13)	0.07 (0.10)	0.04 (0.11)	0.19+ (0.10)	0.29* (0.11)	-0.07 (0.08)	-0.08 (0.09)
Observations	26	26	26	26	26	26	26	26

Dependent variable represents defined number of choices of subjects on process or quantity based in the Price gouging/ Newsvendor game. Standard errors are in parentheses. +, *, **, *** denote significance at the 10%, 5%, 1% and 0.1% level, respectively.

Figure 3 plots average behavior over the course of the experiment by treatment in blocks of ten periods. In addition to pull-to-center effect mentioned above, the figure reveals two other important patterns. First, there is little difference in average choices between isomorphic versions of the newsvendor and price gouging games although subjects are slower to raise their prices in the high inventory price gouging game than they are to increase inventory in the low cost newsvendor game. Second, there is an asymmetry in the strength of the pull-to-center effect with those subjects predicted to select a high inventory level or price being closer to the mean demand or threshold. These two patterns are examined in more detail below.

¹² In contrary to De Vericourt, Jain, Bearden and Filipowicz (2013), we do not observe systematic differences in males' and females' choices neither in low cost/inventory nor high cost/inventory settings.

¹³ This finding differs from Moritz, Hill, and Donohue (2013) who find that higher CRT scores are correlated with better performance in the news vendor game.

Figure 3. Inventory and Pricing Decisions over the Experiment

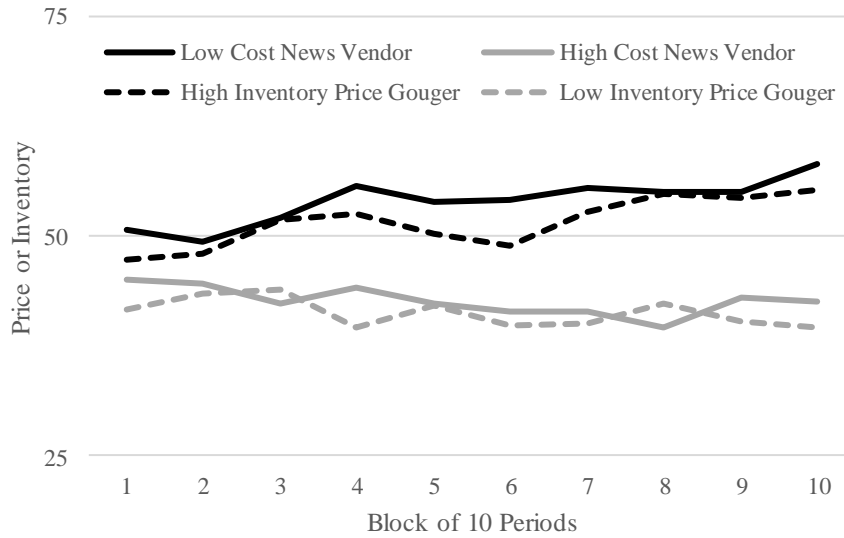


Table 4 reports the results of panel regression analysis with random effects for each subject that compares theoretically isomorphic news vending and price gouging games. For both pairs, the coefficient on *PriceGouging*, which is an indicator function for observations from the price gouging game, is not significantly different from zero. This pattern also hold when controlling for a time trend in the data as shown in the second and fourth specifications in Table 4. This result provides the basis for our main finding.

Finding 2: Isomorphic versions of the newsvendor and price gouging games yield similar average behavior.

Table 4. Analysis of Inventory and Choice Difference between New Vending and Price Gouging

	Low Inventory Cost & High Inventory Level		High Inventory Cost & Low Inventory Level	
<i>Constant</i>	53.9219*** (2.314)	50.1798*** (2.405)	42.6712*** (1.973)	44.3135*** (2.068)
<i>PriceGouging</i>	-2.3581 (3.272)	-2.8604 (3.401)	-1.3742 (2.790)	-1.5645 (2.925)
<i>Period</i>		0.0741*** (0.013)		-0.0325** (0.012)
<i>Period × PriceGouging</i>		0.0099 (0.018)		0.0038 (0.017)
Observations	5,200	5,200	5,200	5,200

Dependent variable represents hundred choices of subjects on process or quantity based in the Price gouging/ Newsvendor game. Standard errors are in parentheses. +, *, **, *** denote significance at the 10%, 5%, 1% and 0.1% level, respectively. Our results are based on panel regression with random effects of subjects.

We now turn to the question of asymmetry in the pull-to-center effect. We follow Bostian, Holt and Smith (2008) and Katok, Stangl and Thonemann (2017) in defining an anchoring score as $(q_{itc} - q_c^*) / (50 - q_c^*)$ for the newsvendor game where q_{itc} denotes the inventory quantity choice of subject i in period t experiencing cost c . The analogous anchoring score for the price gouging game is $(\pi_{jt\theta} - \pi_{\theta}^*) / (50 - \pi_{\theta}^*)$ where $\pi_{jt\theta}$ denotes the price choice of subject j in period t with inventory level θ . The 50 in each measure is the mean of the relevant distribution and a * denotes the expected payoff maximizing choice of the given treatment.

Table 5 reports the results of regressing the anchoring measure on *HighOptimal*, which is an indicator variable for an observation in which the optimal choice exceeds the mean of the relevant distribution and is zero otherwise. Given that behavior is similar in theoretically isomorphic games, we combine the data to examine the question of asymmetry in the degree to which prices are pulled-to-center for the first pair of specifications. In both cases, the results indicate that the pull-to-the-center effect is greater when the optimal choice exceeds the mean of the relevant distribution. The second and third pair of specifications in Table 5 repeat this analysis for each game separately. Again, the results are consistent with an asymmetric pull-to-center effect. This is the basis for our next finding.

Finding 3: The pull-to-center effect is stronger when the optimal choice exceeds the mean of the demand or threshold distribution.

Table 5. Analysis of Asymmetric Pull-to-Center Effect

	Combined data		News Vending		Price Gouging	
<i>Constant</i>	0.6794*** (0.060)	0.7413*** (0.063)	0.7068*** (0.079)	0.7725*** (0.084)	0.6519*** (0.092)	0.7100*** (0.095)
<i>HighOptimal</i>	0.2109* (0.085)	0.3088*** (0.089)	0.1363 (0.112)	0.2203+ (0.118)	0.2856* (0.130)	0.3973** (0.135)
<i>Period</i>		-0.0012*** (0.000)		-0.0013* (0.001)		-0.0012* (0.000)
<i>Period</i> × <i>HighOptimal</i>		-0.0019*** (0.001)		-0.0017* (0.001)		-0.0022** (0.001)
Observations	10,400	10,400	5,200	5,200	5,200	5,200

Dependent variable represents anchoring score for the newsvendor game and for the price gouging game. Standard errors are in parentheses. +, *, **, *** denote significance at the 10%, 5%, 1% and 0.1% level, respectively. Our results are based on panel regression with random effects of subjects.

The second column of Table 2 reveals that there is considerable heterogeneity in behavior within subject. Table 6 reports the results of ordinary least squares regression that relates the standard deviation of a subject's choices to the subject's characteristics from the post experiment survey. The table considers behavior from the entire experiment as well as separately for the beginning, middle, and ending parts of the experiments. Interestingly, better performance on the cognitive reflection task is associated with reduced within-subject variation in choices. This result is intuitive since a subject who always makes the optimal decision would have no variation in her responses.

Table 6. Analysis of the Within Subject Variation of Choices

	Periods 1-100	Periods 1-25	Periods 25-75	Periods 75-100
<i>Constant</i>	21.6370*** (1.596)	20.8595*** (1.666)	22.0059*** (1.859)	21.6894*** (2.015)
<i>High costs/ low inventory</i>	-0.8385 (1.231)	0.4199 (1.286)	-1.0670 (1.434)	-0.9419 (1.555)
<i>PriceGouging</i>	-1.7222 (1.226)	-1.3126 (1.280)	-1.9904 (1.428)	-2.1627 (1.548)
<i>CRT</i>	-1.3863** (0.472)	-1.0844* (0.492)	-1.5124** (0.549)	-1.9205** (0.595)
<i>Male</i>	-1.8271 (1.277)	-1.8150 (1.333)	-2.2215 (1.488)	-2.6172 (1.613)
<i>Risk taking</i>	0.0154 (0.026)	-0.0052 (0.027)	0.0096 (0.030)	-0.0096 (0.033)
Observations	104	104	104	104

Dependent variable represents standard deviation on defined number of choices of subjects in defined number of periods on process or quantity based in the Price gouging/ Newsvendor game. Standard errors are in parentheses. +, *, **, *** denote significance at the 10%, 5%, 1% and 0.1% level, respectively.

One potential explanation for the variation is what Bolton and Katok (2008) refer to as demand chasing where newsvendors in period t are responding to the realized demand in period $t-1$ even though demand is independent each period.¹⁴ Following Katok, Stangl, and Thonemann (2017),

¹⁴ There are multiple statistics used in extant literature to assess demand chasing. However, as noted by Lau and Bearden (2013, p. 1248) “a simple measure of the correlation between the previous demand and the current order quantity does not suffer from [inflated Type I errors], and it is also a reasonably powerful test (when there is true demand chasing).”

we classify a newsvendor as a demand chaser if the correlation between the subject’s inventory choice and the realized demand from the previous period is significant at the 0.05 level. For price gougers, the analogous price chaser is defined as a subject whose price choice is significantly correlated at the 0.05 level with the penalty threshold in the previous period. The final column of Table 2 gives the percentage of demand and price chasing subjects by treatment. From the table, it appears that demand chasing is more prevalent than price threshold chasing and indeed a chi-squared test indicates that the frequency of this behavior is not independent of treatment (p-value = 0.050). This serves as the basis for our final finding. This difference may be driven by understocking and overstocking being natural measures of performance whereas there is no natural notion of overpricing and underpricing. This may make regret more salient in the newsvendor game and thus lead to greater demand chasing.

Finding 4: Demand chasing in the newsvendor game is more prevalent than the analogous behavior in the price gouging game.

Given that an increased CRT score is associated with a reduced variance in choice behavior, one might suspect that subjects with higher CRT are less likely to chase demand or the price threshold. However, Katok, Stangl, and Thonemann (2017) report no relationship between chasing and CRT, but do find evidence that women are more likely to chase. They also report that neutral framing of the newsvendor game reduces chasing behavior relative to the framed version of the game. Table 7 reports the results of probit regressions that examine how individual characteristics impact the chance an individual chases demand or the price threshold. Our results support the findings of Katok, Stangl, and Thonemann (2017) as we do not find a statistically significant relationship between the CRT and other individual characteristics on chasing behavior.

Table 7. Probit Analysis of Chasing Behavior

	Combined Data	News Vending		Price Gouging	
		Low Cost	High Cost	High Inventory	Low Inventory
<i>Constant</i>	0.6841* (0.316)	0.9553 (0.696)	0.8644 (0.600)	-0.0658 (0.605)	0.5692 (0.792)
<i>PriceGouging</i>	-0.5285* (0.254)				
<i>Male</i>	-0.3250 (0.263)	-0.5889 (0.550)	-0.0243 (0.560)	-0.4421 (0.525)	-0.5290 (0.589)

<i>CRT</i>	-0.0461 (0.096)	-0.1742 (0.269)	-0.2919 (0.198)	0.1022 (0.211)	-0.0736 (0.197)
<i>Risk</i>	-0.0065 (0.006)	-0.0128 (0.013)	0.0050 (0.013)	0.0009 (0.010)	-0.0239 (0.016)
Observations	104	26	26	26	26

Dependent variable is binary and equals to 1 if the subject is classified as demand/price chaser. Otherwise, it is 0. Standard errors are in parentheses. +, *, **, *** denote significance at the 10%, 5%, 1% and 0.1% level, respectively. Our results are based on probit regression. Power analysis for the model with combined data indicates that N=104 subjects ensure a power > 0.85% for identifying the effect of game type on chasing behavior using the standard level of $\alpha = 0.05$.

5. Discussion

We introduce a price gouging game in which a seller faces a penalty from charging a price above some unknown threshold. In this game, increasing price increases profits up to point but only serves to increase costs beyond that point. This trade-off is mathematically similar to that faced by a newsvendor whose profit in increasing in inventory up to some unknown level of demand, is only increasing costs when ordering excess inventory. In fact, the news vending and price gouging games are isomorphic under certain restrictions. But the framing of the problems is distinct: in the newsvendor game the seller's choice determines costs and revenues are random whereas in the price gouging game the seller's choice determines revenue and it is costs that are random.

Using controlled laboratory experiments, we compare news vending and price gouging behavior. For both games, we find clear evidence of a pull-to center effect. Further, the pull-to-center is stronger when the optimal choice is above the mean of the distribution for demand (in the case of news vending) or for the penalty threshold (in the case of price gouging). The experimental results also reveal that average choices are similar across the theoretically isomorphic games. This suggests that the behavior commonly observed in newsvendor experiments more are representative of a broader class of games and not driven by the standard operations framing. We also find little evidence that behavior is influenced by personal characteristics such as sex, risk attitude, or cognitive reflection.

We hope that by considering the newsvendor as a special case of a larger family of games, scholars are able to gain more insight into the drivers of news vendor behavior. Such information should help lead to identifying methods for debiasing suboptimal behavior. In particular, our results suggest that observed behavioral patterns have more to do with people understanding how their

choices impact the conditional distribution of outcomes rather than concerns about wasted inventory, stock out aversion, or other operations specific notions per se. We also hope that our research will help encourage others scholars to consider ways in which established newsvendor results may be applicable to other settings.

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Appendix: The instructions and the comprehension questions for each treatment

Instructions (News Vending, cost of 25)

Your task is to make a number of decisions under uncertainty. You have to decide how much inventory to order.

You will play 100 rounds with identical activities:

1. At the beginning of each round you receive a fixed endowment of 300 ECU.
2. You place an order, which should be from 0 to 100.
3. Once you place your order, the computer randomly generates a customer demand from a range of 0 to 100, with each number in that range equally likely. The customer demand drawn for any one round is independent of the customer demand from earlier rounds. So a small or large customer demand in earlier rounds has no influence on whether the customer demand is small or large in later rounds.
4. The profit for the round is computed. There are two different cases:

- The customer demand is less than or equal to your order quantity:

$$\text{Profit} = \text{Customer Demand} \cdot 100 \text{ ECUs} - \text{Order Quantity} \cdot 25 \text{ ECUs} + 300 \text{ ECUs}$$

- The customer demand is greater than your order quantity:

$$\text{Profit} = \text{Order Quantity} \cdot 100 \text{ ECUs} - \text{Order Quantity} \cdot 25 \text{ ECUs} + 300 \text{ ECUs}$$

Thus, your profit in each round is the minimum of your order quantity and the customer demand times the selling price of 100 ECU, minus your order quantity times the purchase cost of 25 ECU, plus 300 ECU.

At the end of the experiment you will be paid your cumulative earnings at the rate of \$1 = 12,500 ECU.

Instructions (News Vending, cost of 75)

Your task is to make a number of decisions under uncertainty. You have to decide how much inventory to order.

You will play 100 rounds with identical activities:

1. At the beginning of each round you receive a fixed endowment of 2,000 ECU.
2. You place an order, which should be from 0 to 100.
3. Once you place your order, the computer randomly generates a customer demand from a range of 0 to 100, with each number in that range equally likely. The customer demand drawn for any one round is independent of the customer demand from earlier rounds. So a small or large customer demand in earlier rounds has no influence on whether the customer demand is small or large in later rounds.

4. The profit for the round is computed. There are two different cases:

- The customer demand is less than or equal to your order quantity:

$$\text{Profit} = \text{Customer Demand} \cdot 100 \text{ ECUs} - \text{Order Quantity} \cdot 75 \text{ ECUs} + 2,000 \text{ ECUs}$$

- The customer demand is greater than your order quantity:

$$\text{Profit} = \text{Order Quantity} \cdot 100 \text{ ECUs} - \text{Order Quantity} \cdot 75 \text{ ECUs} + 2,000 \text{ ECUs}$$

Thus, your profit in each round is the minimum of your order quantity and the customer demand times the selling price of 100 ECU, minus your order quantity times the purchase cost of 75 ECU, plus 2,000 ECU.

At the end of the experiment you will be paid your cumulative earnings at the rate of \$1 = 12,500 ECU.

Instructions (Price Gouging, quantity of 25)

Your task is to make a number of decisions under uncertainty. You have to decide what price to charge.

You will play 100 rounds with identical activities:

1. At the beginning of each round you receive a fixed endowment of 2,000 ECU.
2. You set a price, which should be from 0 to 100.
3. Once you place your price, the computer randomly generates a maximum allowed price from a range of 0 to 100, with each number in that range equally likely. The maximum allowed price drawn for any one round is independent of the maximum allowed price from earlier rounds. So a small or large maximum allowed price in earlier rounds has no influence on whether the maximum allowed price is small or large in later rounds.

4. The profit for the round is computed. There are two different cases:

- The maximum allowed price is greater than or equal to your price:

$$\text{Profit} = 25 \text{ Price in ECUs} + 2,000 \text{ ECUs}$$

- The maximum allowed price is less than your price:

$$\text{Profit} = 25 \text{ Price in ECUs} - 100 (\text{Price in ECUs} - \text{Maximum Allowed Price}) + 2,000 \text{ ECUs}$$

Thus, your profit in each round is your price in ECU times 25, minus 100 ECUs for each ECU you charge above the maximum allowed price, plus 2,000 ECU.

At the end of the experiment you will be paid your cumulative earnings at the rate of \$1 = 12,500 ECU.

Instructions (Price Gouging, quantity of 75)

Your task is to make a number of decisions under uncertainty. You have to decide what price to charge.

You will play 100 rounds with identical activities:

1. At the beginning of each round you receive a fixed endowment of 300 ECU.
2. You set a price, which should be from 0 to 100.
3. Once you place your price, the computer randomly generates a maximum allowed price from a range of 0 to 100, with each number in that range equally likely. The maximum allowed price drawn for any one round is independent of the maximum allowed price from earlier rounds. So a small or large maximum allowed price in earlier rounds has no influence on whether the maximum allowed price is small or large in later rounds.

4. The profit for the round is computed. There are two different cases:

- The maximum allowed price is greater than or equal to your price:

$$\text{Profit} = 75 \text{ Price in ECUs} + 300 \text{ ECUs}$$

- The maximum allowed price is less than your price:

$$\text{Profit} = 75 \text{ Price in ECUs} - 100 (\text{Price in ECUs} - \text{Maximum Allowed Price}) + 300 \text{ ECUs}$$

Thus, your profit in each round is your price in ECU times 75, minus 100 ECUs for each ECU you charge above the maximum allowed price, plus 300 ECU.

At the end of the experiment you will be paid your cumulative earnings at the rate of \$1 = 12,500 ECU.

Comprehension Questions (News Vending)

Q1. Suppose you ordered 50 units and the computer generated a customer demand of 10 units.

What is your profit (in ECUs) in this round?

- -750 (correct if cost is 75)
- 50 (correct if cost is 25)

Q2. Suppose you ordered 50 units and the computer generated a customer demand of 90 units.

What is your profit (in ECUs) in this round?

- 3250 (correct if cost is 75)
- 4050 (correct if cost is 25)

Q3. How many rounds will you complete?

- 1
- 25
- 100 (correct)

Comprehension Questions (Price Gouging)

Q1. Suppose you set a price of 50 and the computer generated a maximum allowed price of 10.

What is your profit (in ECUs) in this round?

- -750 (correct if quantity is 25)
- 50 (correct if quantity is 75)

Q2. Suppose you set a price of 50 and the computer generated a maximum allowed price of 90.

What is your profit (in ECUs) in this round?

- 3250 (correct if quantity is 25)
- 4050 (correct if quantity is 75)

Q3. How many rounds will you complete?

- 1
- 25
- 100 (correct)