

Effect of Personality on Newsvendor Decisions

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Abstract

We present the results of a newsvendor experiment and out-of-experiment personality trait surveys. Our study is based on a simple scenario where the decision maker determines the stock quantity for a perishable product with stochastic consumer demand. We explore the predictive power of self-esteem and regret tendency on ordering behavior in newsvendor setting. We find that subjects with higher self-esteem scores place larger orders and earn more profit under low purchasing cost setting, whereas the difference is not salient under high purchasing cost setting. Moreover, decision-makers with higher regret tendency place orders with smaller variability and closer to the demand mean under high purchasing cost setting.

Keywords

Behavioral Operations, Inventory Management, Newsvendor, Personality Traits.

1. Introduction

Owing to its intuitive problem structure; elegant and simple optimal solution; and applicability to a wide range of operations decision, the newsvendor model is one of the most common theoretical inventory control models. In this model a decision maker faced with stochastic consumer demand determines the order quantity of a perishable product that will maximize the expected profit over one selling season. Any products that are unsold at the end of the selling period lose their value and any unmet demand translates to lost sales. Hence the trade-off here is to order too much and risk leftovers or to order too little and lose potential profit. The optimal solution is obtained using the critical fractile, which is the ratio of unit cost of under-ordering to the sum of unit cost of under-ordering and over-ordering.

Recently the theory of the classical newsvendor model has been challenged by various case studies and experimental investigations exhibiting that ordering decisions made by humans do not follow the theoretical expectations. On the contrary, there seems a systematic deviation in actual decisions from the theoretical optimal. This phenomenon has been investigated by Behavioral Operations researchers. Behavioral Operations is the field that studies human behavior under complex operations problems. Although lab experiments are not new to the field of operations management thanks to the famous beer distribution game, behavioral operations field gained a dramatic momentum with the experimental paper of Schweitzer and Cachon (2000) on newsvendor ordering behavior. This milestone article shows that even with formal training on the newsvendor model, human decision makers remarkably and consistently diverge from the optimal order decision. Specifically, the order decisions lay in between the optimal and the demand average. This pattern is named as “the pull-to-center effect” by Schweitzer and Cachon (2000). When purchasing cost is low, order decisions are lower than the optimal. Conversely, when purchasing cost is high decision makers order more than the optimal. Obviously, these deviations result in a significant suboptimality.

As the newsvendor model is used in many more complicated supply chain coordination theory in the literature, these findings have severe implications on the practical efficiency of the inventory management and supply chain coordination theory. That is to say, if in practice the simplest model doesn't perform as expected, then the whole supply chain coordination theory is in serious trouble. For this reason, since 2000 many researchers investigated the newsvendor behavior with the aim of uncovering the factors and conditions affecting the order decisions and what interference can be performed in order to move the decisions back to the optimal.

In this paper we explore the correlation between newsvendor decisions and two different personality traits, namely self-esteem and regret tendency. We show that there is significant correlation between order decisions and self-esteem score low purchasing cost setting. Also under high purchasing cost setting, regret tendency affects newsvendor behavior significantly. Though, the results are not uniform over the different treatments and the magnitude of the said correlation is not high, we believe our findings constitute valuable contribution to the behavioral operations literature.

The study presented in this paper is derived from Akbay's (2016) doctoral dissertation with never-before-published analyses and figures. Akbay (2016), and thus the current paper, is the first and to this day only authentic research to consider the behavioral effects of self-esteem and regret tendency on newsvendor decisions and to investigate the relationship between these traits and newsvendor behavior using an out-of-experiment survey.

1.1 Objectives

In this paper, we are looking for the answers of the following research questions:

1. Is there a correlation between self-esteem of the subjects and their newsvendor orders? Can the self-esteem of a subject predict their ordering behavior and their ordering performance?
2. Is there a correlation between regret-tendency of the subjects and their newsvendor orders? Can the regret-tendency of a subject predict their ordering behavior and their ordering performance?

2. Literature Review and Research Hypotheses

Following Schweitzer and Cachon (2000), the pioneering studies investigating newsvendor behavior focused on aggregate behavior and disregarded individual heterogeneity in the decision processes. Later the individual factors and decision processes that might affect the newsvendor ordering behavior came into the spotlight. For instance, de Vericourt et al. (2013) study gender effects on ordering behavior and show that female subjects make significantly smaller order decisions than male subjects due to, as revealed by a mediation analysis, higher risk aversion. Cui et al. (2013) and Feng et al. (2011) study cultural differences and compare American subjects and Chinese subjects in terms of inventory decisions. Cui et al. (2011) show that Chinese subjects try to collect more data by asking more questions before making a decision, which indicates mistake-aversion behavior. Feng et al. (2011) show that Chinese subjects are more prone to fall victim to the pull-to-center effect.

Moritz et al. (2013) consider several personal factors and demonstrate that subjects with higher cognitive reflection scores perform better in the experiment, i.e., place better orders and make more profit. In a more complex inventory setting Strohhecker and Größler (2013) investigate the effect of four different personal factors and find that there is a strong connection between inventory performance and intelligence of the subjects. They also show that personality of the subject has a weak effect on the performance.

In a more general economics context, Rustichini et al. (2016) show that personal characteristics are closely related to economic preferences. Bucciol and Zarri (2017) investigate various personality traits and investment decisions and identify that three personality traits have significant anticorrelation with financial risk taking.

As demonstrated by this tiny portion of the literature mentioned above, there is a significant connection between behavior of subjects and their personality traits. In this paper we fill the gap in the literature about the effect of self-esteem and regret tendency on inventory decisions.

3. Methods

3.1 Analytical Background

We consider a standard newsvendor model. Before the random consumer demand is realized the decision maker determines the stock quantity. If the demand turns out to be less than this stock quantity, any unsatisfied demand will be lost. If on the other hand the demand is less than the stock quantity, any unsold products will be discarded. The model is based on maximization of the expected profit. With unit cost c , retail price p , and demand probability distribution function $f()$, the expected profit can be written as:

$$E[\pi(Q)] = \int_0^Q (px - cQ)f(x)dx + (p - c)Q \int_Q^\infty f(x)dx$$

Taking the derivative of the above function with respect to Q yields the following result for the optimal order quantity:

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

where $F^{-1}()$ is the inverse of the cumulative distribution function of the demand.

3.2 Experimental Design

Earlier literature has shown that the newsvendor behavior exhibits different patterns under different purchasing costs. (Schweitzer and Cachon 2000). Hence to capture these differences our study is based on a low purchasing cost-high purchasing cost 2x1 experimental design. The retail price in our scenario is \$90, unit cost is either \$35 or \$55 depending on the purchasing cost setting. Demand is uniform between 50 and 150. With these assumptions the optimal order quantity is computed as 111 and 89 for low and high purchasing cost settings respectively.

Participants of the study are students of undergraduate inventory management course in Sabanci University. The experiments are conducted after the newsvendor model is covered in the course. The experiment is conducted using MS Excel and VBA.

The experiment consisted of 40 periods in addition to 3 warm-up periods. The participants are asked to make ordering decisions considering that each period is independent of the previous ones. Including the brief tutorial at the beginning of the session, the experiment lasted about 40 minutes. The only incentive provided to the participants in the experiment is 1% participation bonus.

Due to the experiment being conducted over several semesters and difficulty in collecting out-of-experiment surveys the sample sizes for each treatment and each personality trait are different. These sample sizes are given in Table 1.

Table 1: Sample sizes for each treatment and personality trait

	Self-Esteem	Regret Tendency
Low Purchasing Cost	57	57
High Purchasing Cost	148	148

4. Experiment Results

4.1 Self-Esteem vs Newsvendor Behavior

Self-esteem is a person's subjective evaluation of their self-worth. In literature there are many studies connecting self-esteem of the subject and their various behavior; various aspects of their life such as academic propensity, professional success, happiness and interpersonal relations. (For an example see de Araujo and Lagos 2013). In this respect, Josephs et. al. (1992) show that low self-esteem subjects exhibit risk and ambiguity aversion behavior in order to avoid negative outcomes that may damage self-image and self-esteem. A more recent study by Sekścińska et al. (2021) demonstrates that subjects with high self-esteem undertake more financial risk.

In newsvendor context risk stems from the random consumer demand and the difficulty of matching order with demand. A higher order decision constitutes higher risk as it carries higher possibility of actual loss due to stock quantity being larger than the demand as any leftovers will lose their value. Although the other side of the trade-off,

i.e., ordering too little, also constitutes a cost to the decision problem, this cost is a hypothetical cost and less salient than over-ordering cost. Hence we hypothesize the following for the behavior of the newsvendors:

Hypothesis 1a: Under low purchasing cost setting, subjects will place larger orders and earn higher profit values.

Hypothesis 1b: Under high purchasing cost setting, subjects will place larger orders and earn lower profit values.

For the study we use the Turkish version of Rosenberg's (1965) self-esteem scale. This scale consists of 5 positive and 5 negative questions each scored between 0 and 3. We average the score of the 10 questions and obtain an overall self-esteem score between 0 and 3 for the subjects. A higher score indicates higher self-esteem.

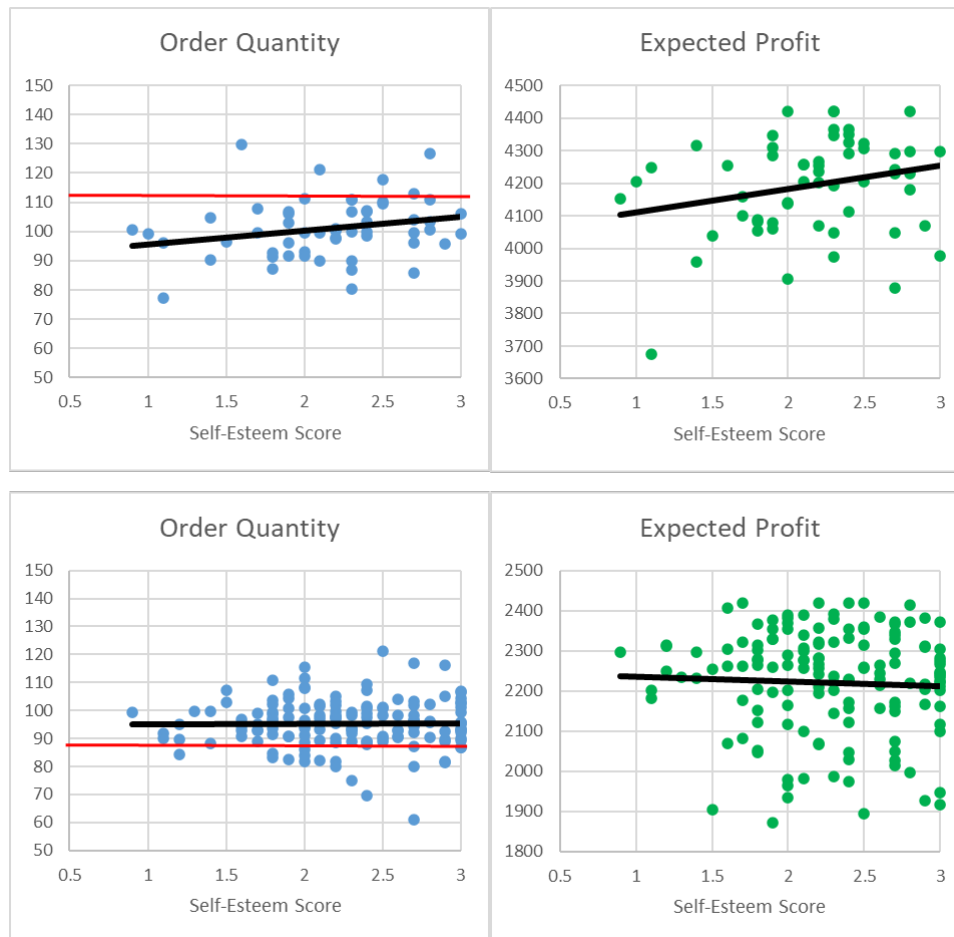


Figure 1: Scatter Plot of Various Performance Measures vs Self Esteem Scores. (The black line in the graphs is the trendline. The red line in the first graph is the optimal order. Top low purchasing cost, bottom high purchasing cost.)

For the experiment analysis, 40 period order decisions of the subjects are averaged to obtain a single data point for each subject. Figure 1 displays average order quantity, average expected profit and average distance from the demand mean scatter plots against the self-esteem score of the subjects. For the low purchasing cost setting, we observe a salient correlation in the experiment performance and self-esteem scores. However, for the high purchasing cost setting, the relationship is not as salient. What is also striking in Figure 1 is the high level of individual heterogeneity in the data.

When we check the simple regression results presented in Table 2 we observe a parallel result. The correlation between self-esteem and experiment performance is significant for only the low purchasing cost setting. Yet, high purchasing cost setting results support the hypothesis in the sign of the coefficient of the self-esteem score.

Table 2: Simple regression results for self-esteem scores

Dep. Var.	Indep. Var.	High Purchasing Cost Setting				Low Purchasing Cost Setting			
		Coeff.	Std. Dev.	P-value	R ²	Coeff.	Std. Dev.	P-value	R ²
Order Quantity	Intercept	94.98	3.29	0.00	0.00	91.00	5.79	0.00	0.05
	Self-esteem	0.14	1.41	0.92		4.67	2.62	0.08	
Expected Profit	Intercept	2247.37	53.43	0.00	0.00	4038.40	87.29	0.00	0.06
	Self-esteem	-11.61	22.95	0.61		71.41	39.47	0.08	

Here we must note that the average order quantity under high purchasing cost setting is significantly above the optimal order quantity, which is 89. Therefore, the impact of self-esteem may be lessened by this excessiveness. As subjects increase their orders, they realize a decline in their profit values and avoid placing larger orders. On the other hand, for low purchasing cost setting the average order quantity is significantly less than the optimal, which is 111. So, in order to achieve better profit values, the subjects need to increase their order decisions. High self-esteem may help subjects fight the aversion to place larger orders to avoid inventory errors and realize better profit values in this setting.

Overall, the data supports Hypothesis 1a significantly, whereas Hypothesis 1b is weakly supported.

4.2 Regret Tendency vs Newsvendor Behavior

Regret is feeling sad and disappointed in the results of one's decisions or actions. It is one of the emotions that affect human behavior according to scientific studies. It can affect human behavior in two ways; as in realized actual regret or anticipated potential regret. For the first case, subjects may take actions to negate their previous actions that caused regret. (Gilovich and Medvec 1995). For the second case, subjects take actions to minimize anticipated future regret. (Bell 1982). Josephs et al. (1992) argue anticipated regret can cause the subjects to prefer risk avoidance. On the other hand, Zeelenberg et al. (1996) show that anticipated regret leads to regret-aversion rather than risk-aversion.

In our newsvendor context, the only source of uncertainty is the random consumer demand. In this setting regret can only be associated with inventory error. Specifically, the subjects may regret ordering too little or too much compared to the consumer demand. They may regret inventory errors after the order decision is made and random consumer demand is revealed and try to negate this inventory error in the future decisions. Another possibility is that the subjects may anticipate regret due to future inventory error and place orders to avoid this error. In either case, the order decisions will be pulled towards the demand mean as that is the order quantity that minimizes expected inventory error. Hence we hypothesize the following:

Hypothesis 2: Under both purchasing cost settings, subject with higher regret tendency place orders closer to the demand mean.

In order to measure regret tendency of the subjects we used Schwarz et al. (2002)'s regret scale which consists of 5 positive and negative questions scored from 0 to 7. We average the scores of the five questions in order to obtain a regret tendency score between 0 and 7. A higher score indicates higher regret tendency. In other words, a higher score indicates subjects that the subject has a higher potential to regret their actions after taking them.

Figure 2 displays scatter plot of order standard deviation and order's distance to the demand mean averages for each subject against their regret tendency score. For both purchasing cost conditions we see a downward trend in the distance to the demand mean graphs supporting our hypothesis. We also observe a decline in the order standard deviation as regret tendency increases, suggesting that as subject's regret tendency increases they avoid changing their order decisions too much.

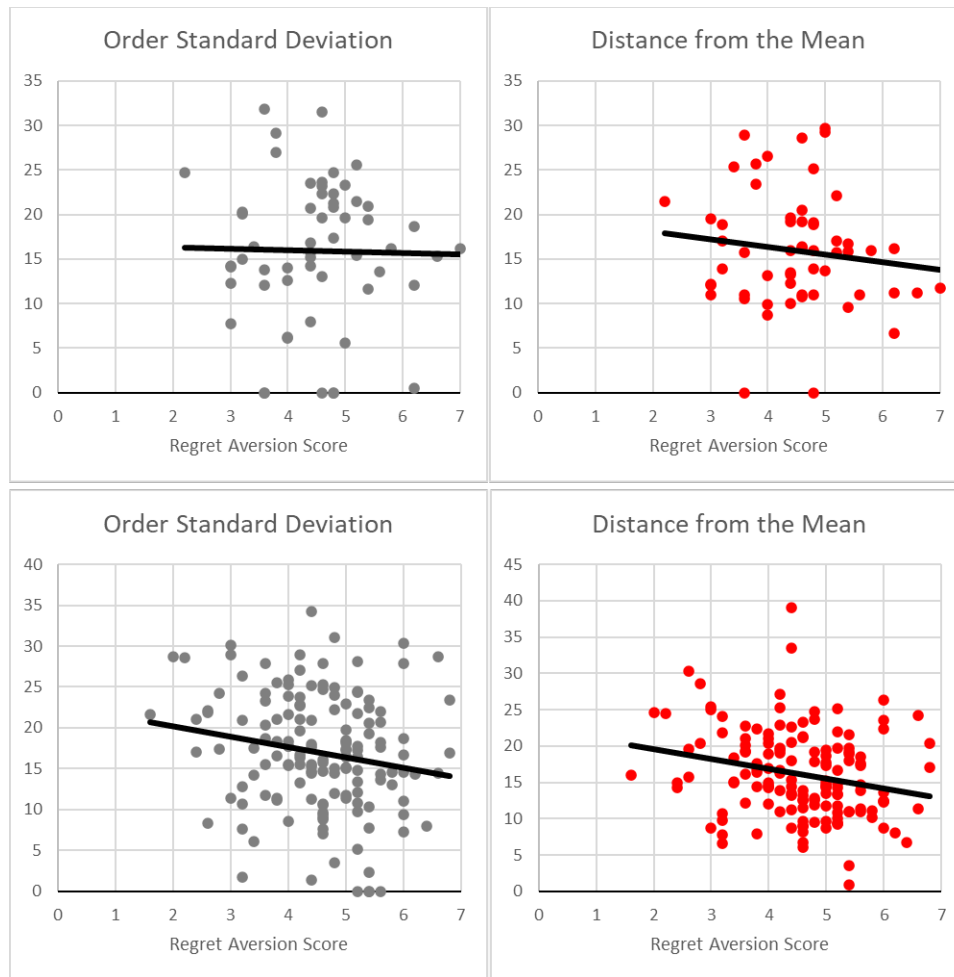


Figure 2: Scatter Plot of Various Performance Measures vs Regret Tendency Scores. (The black line in the graphs is the trendline. Top low purchasing cost, bottom high purchasing cost.)

Table 3: Simple regression results for regret tendency scores

Dep. Var.	Indep. Var.	High Purchasing Cost Setting				Low Purchasing Cost Setting.			
		Coeff.	Std. Dev.	P-value	R ²	Coeff.	Std. Dev.	P-value	R ²
Order Std. Dev.	Intercept	22.77	2.68	0.00	0.03	16.66	5.05	0.00	0.00
	Regret Tendency	-1.28	0.58	0.03		-0.17	1.10	0.88	
Distance from the Mean	Intercept	22.20	2.21	0.00	0.05	19.83	4.07	0.00	0.02
	Regret Tendency	-1.35	0.47	0.01		-0.86	0.89	0.33	

The regression results presented in Table 3 support the hypothesis significantly for high purchasing cost setting. The sign of the coefficients of regret tendency in low purchasing cost setting support the hypothesis but the coefficient however, the coefficients are not significant. This may be due to the asymmetry in regret in high and low purchasing cost settings. As mentioned earlier, the cost of over-ordering and cost of under-ordering are asymmetrical as one is an actual realized cost and the other is counterfactual. And under high purchasing cost setting, the cost of over-ordering is \$55 as opposed to \$35 in low purchasing cost setting. Hence the regret that will result from over-ordering and

incurring the loss due to unsold products is expected to be stronger under high purchasing cost setting. Therefore under high purchasing cost setting, subjects may be more prone to regret their ordering decisions or make ordering decisions that will minimize future regret.

Overall, we can conclude that Hypothesis 2 is partially supported by the data.

5. Conclusion

Recent studies in behavioral operations and various case studies have revealed that despite formal training human subjects do not make the optimal order decision in practical newsvendor scenarios. This deviation results in significant suboptimality and profit loss for the companies. Hence, it is of crucial importance to identify the factors affecting ordering decisions and, if possible, to predict their effect and correct it.

In this paper we explore the correlation between certain personality traits and newsvendor ordering decisions. We show that both self-esteem and regret tendency affect subject decisions significantly. The effect is asymmetrical with respect to the purchasing cost and hence our research hypotheses are partially supported by the data. However, it is worth noting that in our analysis 40 ordering decisions of each subject are averaged to obtain a single data point, which truncates the effects of personal factors. Additionally, subjects' decisions are affected by the random consumer demand that is revealed after every ordering decision. Moreover, there are other factors which are not yet identified but still affect the ordering behavior. Hence the R^2 values of the regression analyses are very low. As these other factors are identified and included into the analyses, it may be easier to detect the effect of personality traits.

All in all, we believe we filled an existing gap in the behavioral operations literature by investigating the effects of self-esteem and regret tendency using out-of-experiment surveys.

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Biographies

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Murat Kaya is currently working as an assistant professor at the Industrial Engineering Program of Sabancı University, İstanbul, Turkey. He received his BSc degree in industrial engineering from the Middle East Technical University (METU), Ankara, Turkey and his M.S. and Ph.D. degrees in Management Science and Engineering (MS&E) from Stanford University. During his Ph.D. study, Dr. Kaya has worked for several projects at Hewlett Packard Research Laboratories in Palo Alto, USA. Dr. Kaya's research is concerned with strategic decision analysis in supply chains. Having worked with traditional supply chains in apparel, FMCG, automotive and pharma industries, Dr. Kaya's recent interest is directed towards applied decision & optimization problems in energy supply chains. His research has been supported by an EC Marie Curie International Reintegration Grant (IRG). At Sabancı University, Dr. Kaya has been the academic director of the Energy Technologies and Management (ETM) graduate program since 2018. He served as the Vice Dean of the Faculty of Engineering and Natural Sciences (FENS) between 2019-2020. Dr. Kaya is also affiliated with Sabancı University İstanbul International Center for Energy and Climate (IICEC). He is a recipient of numerous teaching awards of the University.