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Can Hexaco-100 Personality Inventory Predict Newsvendor Behavior?

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Abstract

It has been well established by a plethora of experimental and empirical studies that human decision makers deviate from the newsvendor optimal order quantity. In this study we try to predict newsvendor behavior through an out-of-experiment personality inventory, namely Hexaco-100. We consider a simple scenario of a perishable product with random consumer demand. The decision-makers determine the stock quantity for 40 consecutive periods. In this exploratory study we investigate if there is any correlation between order decisions or expected and realized profit and any of the personal characteristics measured by Hexaco-100. Our results show that order decisions are negatively correlated with social self-esteem and fairness. Sincerity and fairness are positively correlated with expected profit and realized profit values. Greed-avoidance is also positively correlated with realized profit. The experiment is based on low-profit margin setting and generally decision-makers order more than the optimal in this setting. Hence smaller order decisions are better and lead to better profit values. Combining this with the correlation results, we conclude that subjects with higher social self-esteem, sincerity, fairness and greed-avoidance scores make smaller order decisions and earn higher profit values. We also observe significant demand chasing behavior in the data and show that "dependence" and "sentimentality" have significant positive correlation with demand chasing behavior.

Keywords
Behavioral Operations, Supply Chain Management, Newsvendor Model, Personality Traits, Hexaco-100.

1. Introduction and Literature Review

Behavioral Operations as a field aims to understand human decision making under complex operations problems. The motivation behind the field is that many experimental and empirical studies have shown that human decision-makers do not follow the theoretical expectations. For instance Fisher and Raman (1996) have shown with Sport Obermeyer case that the order decisions are consistently below the optimal. On the other hand, with the Jeppesen Sanderson case Katok et al. (2001) show that the order decisions are systematically over the optimal. Corbett and Fransoo (2007) have conducted a survey study with small business owners and showed that the newsvendor logic is used for products with high profit margin but not for the best-selling products. The newsvendor model is one of the simplest inventory management models that has a wide range of applications. More importantly, the newsvendor model is in more complicated supply chain management models. As such, the human decision processes that affect the newsvendor ordering behavior have significant importance for a many business areas.

Newsvendor model is based on random consumer demand and a perishable product. Hence if there are any unsold product at the end of the selling period, the products lose their value and the inventory doesn't carry over to the following periods. The problem is to find the order quantity that will maximize the expected profit. The trade-off in this problem is that if the order quantity is more than the demand, then there will be unsold products at the end of the season, resulting in "cost of overage". On the other hand, if the order quantity is less than the demand, then potential profit would have been forsaken, resulting in "cost of underage". The optimal order quantity is computed using the costs associated with this trade-off. If *F(.)* is the demand distribution, then the expected profit will be maximized when the order quantity is equal to

$$F^{-1}\left(\frac{cost\ of\ underage}{cost\ of\ underage + cost\ of\ overage}\right)$$

Schweitzer and Cachon (2000) are the first to publish a Newsvendor experiment study. They show that when the "cost of underage" is higher than the "cost of overage" the subjects order less than the optimal, and when the "cost of overage" is higher, they order more than the optimal. Later studies also confirmed this systematic, too-low-too-high

suboptimal behavior. Researchers have tried to explain this deviation from the optimal in many studies. Schweitzer and Cachon (2000) argue that risk aversion, loss aversion or prospect theory don't explain the newsvendor ordering behavior. They suggest that minimizing ex-post inventory error might be an explanation. Su (2008) explains this behavior with bounded rationality.

Some researchers try to find a connection between personal factors and ordering decisions. Feng et al. (2011) demonstrate that extremeness aversion affects the ordering decisions by extending Bolton and Katok's (2008) study making sure the optimal is not one of the extreme options and showing an improvement over the newsvendor performance. De Vericourt et al. (2013) and Akbay (2016) show that gender of the subject affects their ordering behavior. Cui et al. (2011) and Feng et al. (2011) show that cultural differences also impact the ordering behavior of the decision makers. Moritz et al. (2013) show that cognitive reflection capabilities significantly affect the newsvendor performance. Akbay (2016) shows self-esteem and regret tendency also affect how subjects make ordering decisions.

In this exploratory study we aim to see if there is any correlation between the personality traits measured by Hexaco-100 personality inventory and the newsvendor order decisions. Hexaco-100 is a widely-used personality model that is developed by Ashton and Lee (2007). This model has 6 major facets, namely "Honesty-Humility", "Emotionality", "Extraversion", "Agreeableness", "Conscientiousness", and "Openness to Experience|. Each of these 6 facets contains 4 sub scales which are measured by 4 questions. In addition to the 6 facets, there are 4 questions related to altruism.

This study is the first in the literature to investigate the connection between Hexaco personality traits and the newsvendor ordering behavior. Any out-of-experiment data that can explain the ordering behavior will have meaningful impact on the improvement of the suboptimal ordering decisions. Hence, we believe this study has a rather small but significant contribution to the literature.

1.1 Objectives

Our objective in this exploratory study is to investigate any correlation between newsvendor order decisions and Hexaco-100 traits.

2. Experimental Design

We consider a simple newsvendor model where the selling price is $12, purchasing cost is $10 and there is no salvage value. The consumer demand is uniformly distributed between 51 and 150. According to the classical newsvendor optimal order quantity formula, the optimal is 67.

The participants of the experiment are recruited from the undergraduate student body with the incentive of 1% course credit as reward for participation. The sample size is 32 students. However one student's data is removed from the analysis due to missing answers in the survey. The experiment consisted of 40 periods after 3 periods-of warm up. The experiment lasted about 40 minutes including a brief tutorial at the beginning.

The experiment part of the study is conducted in the laboratory using MS Excel and Visual Basic. Figure 1 displays a sample experiment screen. Survey data is collected online and matched with experiment data later.

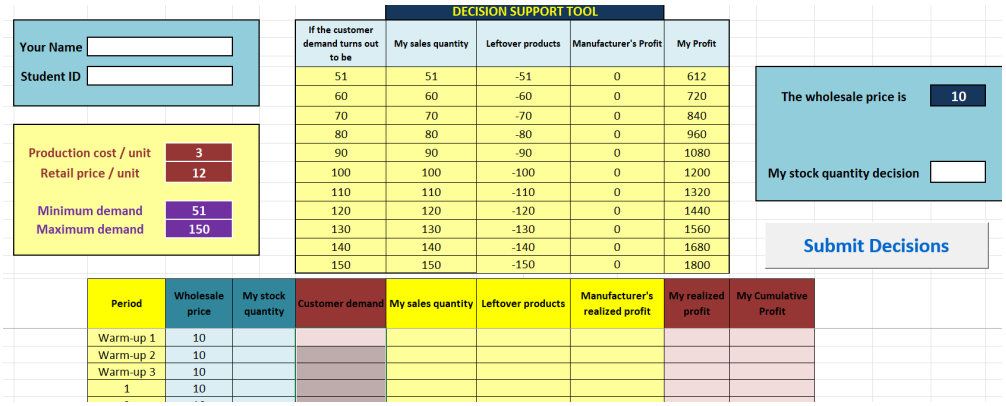

Figure 1: Sample decision screen

3. Experiment Results

We first present the analysis of the decision-making experiment, then we will present the survey results and the correlation analysis of the experiment results with the survey data.

3.1 Analysis of the experiment data

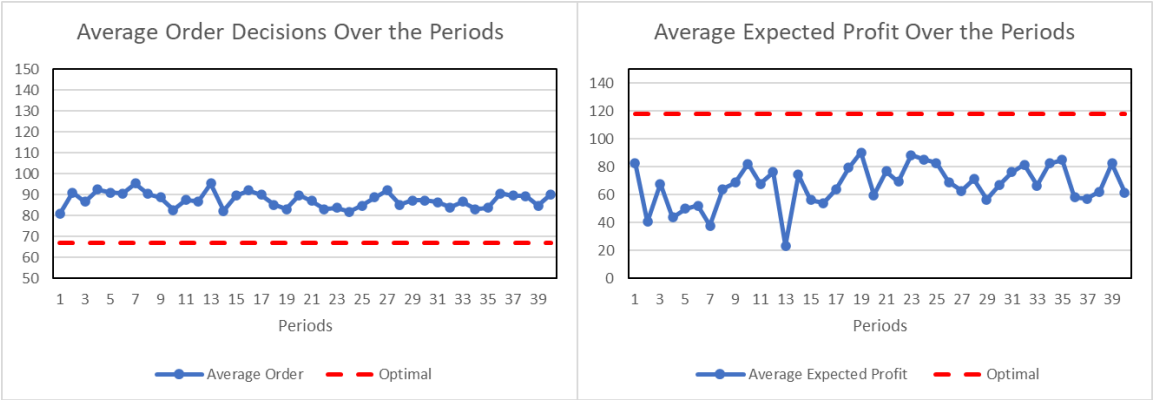

Figure 2: Evolution of the average order decision and average expected profit over the periods

Figure 2 displays the evolution of the average order quantity and average expected profit (averaged over the subjects) over the duration of the experiment. From these graphs we can clearly see that the average order quantities are well above the optimal and thus average expected profits are below the optimal. This phenomenon is parallel with the findings of earlier literature about the too-low-too-high phenomenon. These graphs also show that there is not salient learning effect over 40 periods.

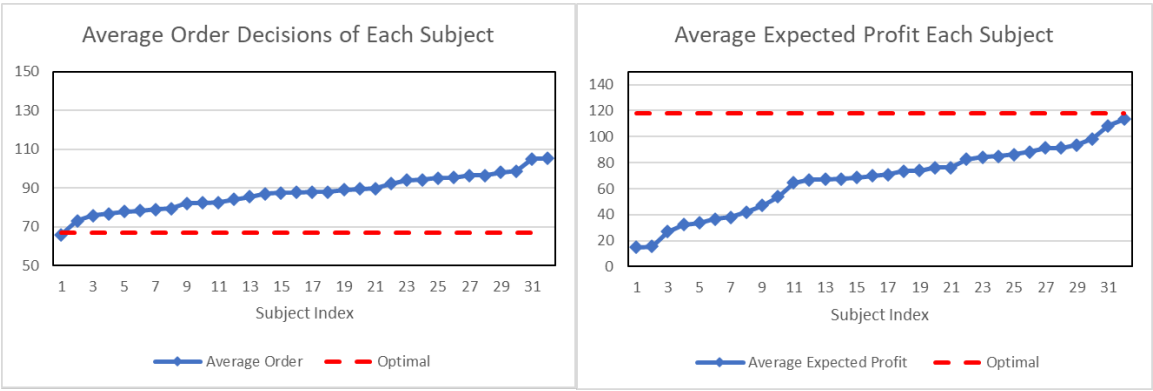

Figure 3: Average order quantity and expected profit of each subject in ascending order

Next, we plot the average order quantity and expected profit for each subject. Here, the data is averaged over the 40 periods. Figure 3 presents the graphs of these averages in ascending order. Clearly, majority of the subjects order above the optimal and earn below the optimal profit. When we compare these averages with the theoretical expectation, as presented in Table 1, as expected from the earlier graphical results, all comparisons yield significant p-values.

Table 1: Comparison with the theory

	Theory	Experiment Data			
	Optimal	Mean	Median	Std. Dev.	P
Order Quantity	67	87.46	87.84	9.16	**0.00**
Expected Profit	118	66.83	70.34	26.01	**0.00**
Realized Profit	118	60.48	65.15	30.08	**0.00**
Comparison is done with two-sided Wilcoxon test.					

What is also noteworthy is that there is a high level of variance or heterogeneity among the subjects. This can easily be seen in the individual order decision graphs presented in Figure 4. Here, we see that subject changed their order decisions quite frequently suggesting that subject decisions are highly affected by the demand realizations since from one period to the other demand realization is the only thing that changes. Hence, we next compare the demand chasing behavior.

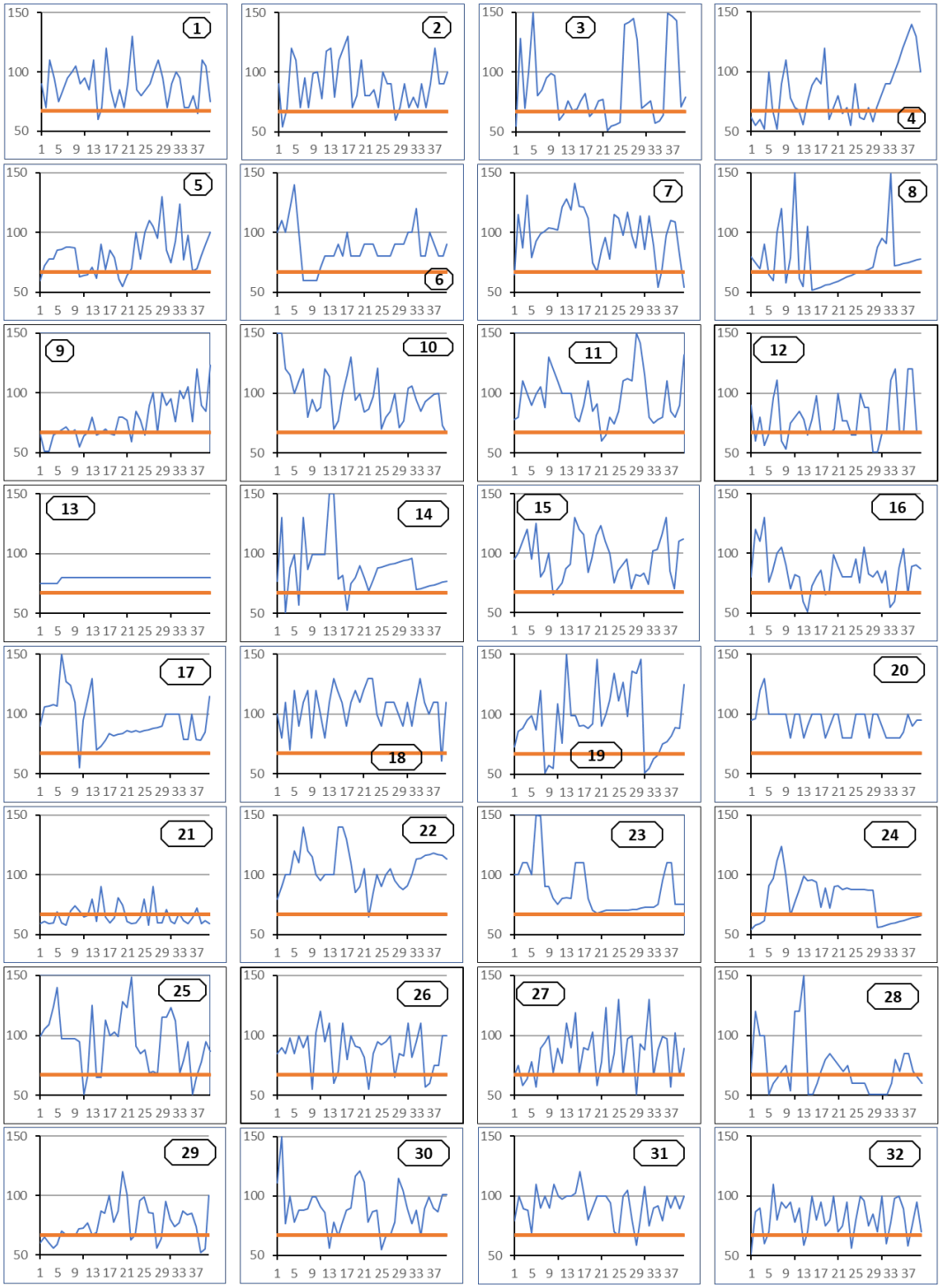

Figure 4: Individual order decisions graphs

Demand chasing behavior is an anchor-adjust type heuristics in which the decision makers anchor at their previous decision and adjust towards the previous demand realization. The behavior can be modeled by the following equation

$$Q_t = Q_{t-1} + \beta(D_{t-1} - Q_{t-1}) + \varepsilon$$

where ε is the error term that is normally distributed with mean 0. Table 2 presents the individual regression analysis results for the demand chasing heuristic. We observe that all coefficients are positive and more than 75% of them are significant. This implies that if the demand realization is greater than the order decision, in the following period the participants are more like to increase their order decision. And if the demand happens to be less than the order decision, then the participants tend to decrease their order decision.

Table 2: Demand-chasing heuristic individual regression results

Subject	Coeff	P-value	Subject	Coeff	P-value	Subject	Coeff	P-value	Subject	Coeff	P-value
1	0.199	**0.04**	9	0.165	**0.00**	17	0.281	**0.00**	25	0.262	**0.00**
2	0.364	**0.00**	10	0.214	**0.03**	18	0.098	0.38	26	0.251	**0.01**
3	0.367	**0.00**	11	0.147	**0.05**	19	0.374	**0.00**	27	0.281	**0.03**
4	0.094	0.20	12	0.134	0.20	20	0.237	**0.00**	28	0.397	**0.00**
5	0.195	**0.00**	13	0.019	0.17	21	0.099	**0.02**	29	0.122	**0.04**
6	0.120	0.06	14	0.271	**0.01**	22	0.240	**0.00**	30	0.317	**0.00**
7	0.282	**0.01**	15	0.366	**0.00**	23	0.149	**0.03**	31	0.232	**0.00**
8	0.208	**0.04**	16	0.340	**0.00**	24	0.069	0.24	32	0.308	**0.00**

3.2 Analysis of the survey data

Table 3: Survey scores of individual subjects

Subject ID	Honesty-Humility	Emotionality	Extraversion	Agreeableness	Conscientiousness	Openness to Experience	Altruism
1	3.50	3.00	3.88	2.75	3.75	3.69	4.75
2	4.06	2.94	4.06	3.00	3.63	4.00	4.50
3	2.38	3.38	3.44	3.13	3.50	3.88	4.00
4	4.44	2.94	4.44	3.88	3.00	4.88	3.00
5	3.25	3.25	3.38	2.81	3.63	3.63	4.25
6	3.63	3.88	3.00	2.88	3.50	4.06	5.00
7	3.38	3.75	3.13	2.94	2.81	4.06	5.00
8	3.06	2.94	4.25	3.44	3.44	4.25	3.75
9	3.81	3.94	3.69	4.06	4.31	4.31	4.50
10	2.94	2.75	3.88	2.50	4.00	3.56	2.75
12	2.75	2.94	3.13	3.25	3.13	3.44	3.00
13	3.13	2.81	3.88	2.25	3.50	2.81	3.25
14	2.56	4.19	4.38	2.63	3.88	4.56	5.00
15	3.81	3.56	3.25	3.81	2.56	2.88	4.25
16	3.81	2.13	3.69	3.31	3.13	4.19	3.75

Subject ID	Honesty-Humility	Emotionality	Extraversion	Agreeableness	Conscientiousness	Openness to Experience	Altruism
17	2.50	3.88	3.56	1.44	3.56	3.00	4.00
18	3.31	2.88	2.44	2.63	3.50	3.94	4.00
19	2.63	3.25	3.88	3.38	3.69	3.63	3.75
20	3.56	2.38	3.50	3.69	3.94	4.19	4.25
21	3.63	3.56	3.38	2.56	2.56	2.50	3.50
22	3.06	3.38	4.19	2.88	2.44	3.13	3.25
23	3.81	3.19	2.81	2.63	4.38	4.44	4.25
24	3.25	2.56	4.13	3.38	3.50	3.63	3.75
25	1.94	3.00	3.50	1.88	3.81	3.56	2.25
26	3.06	4.44	4.13	3.75	3.88	2.63	4.75
27	3.63	3.00	3.50	3.44	2.94	3.13	3.75
28	3.75	4.13	3.19	2.63	4.00	3.63	4.25
29	3.88	3.06	3.56	2.69	3.88	3.06	3.50
30	3.06	3.25	3.06	2.19	3.25	3.94	3.50
31	4.31	3.69	3.50	3.31	3.19	3.81	4.00
32	4.13	3.63	4.25	3.44	3.81	4.81	5.00

Here, we present the analysis of the survey results. Table 3 presents the survey scores of each decision maker while Figure 5 displays the average score of each subject for each facet of the survey. Similar to the experiment results there is a high level of heterogeneity in the subjects in survey answers, too.

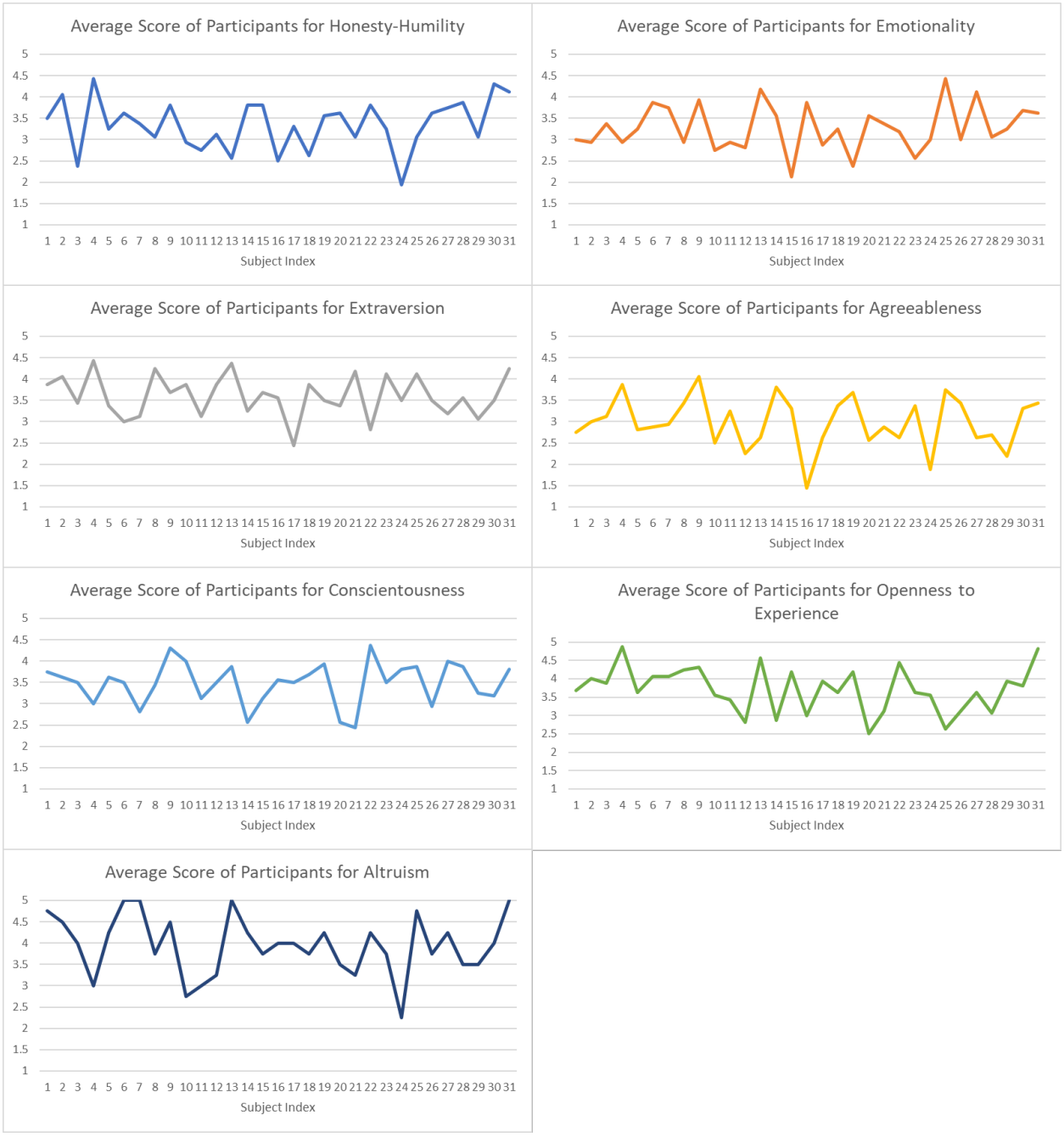

Figure 5: Average score for each facet of the survey

3.3 Correlation of the experiment data with the survey results

Here we analyze the correlation between experiment results and the survey data. Specifically, we check the correlation of the survey data with the average order quantity, average expected profit, realized profit and demand-chasing heuristic coefficients. These results are given in Table 4, Table 5, Table 6 and Table 7 respectively.

Table 4: Correlation of the order decisions with the survey results

	Sincerity	Fairness	Greed-avoidance	Modest, y	Honesty-Humility
Coeff.	-0.18	-0.32	-0.17	-0.08	-0.27
P-value	0.33	**0.08**	0.37	0.65	0.15
	Fearfulness	Anxiety	Dependence	Sentimentality	Emotionality
Coeff.	-0.13	0.18	-0.11	-0.05	-0.04
P-value	0.49	0.32	0.56	0.78	0.83
	Social Self-esteem	Social Boldness	Sociability	Liveliness	Extraversion
Coeff.	-0.32	-0.11	0.05	-0.07	-0.16
P-value	**0.08**	0.54	0.78	0.69	0.40
	Forgiveness	Gentleness	Flexibility	Patience	Agreeableness
Coeff.	-0.08	-0.27	0.05	-0.14	-0.15
P-value	0.67	0.15	0.80	0.44	0.43
	Organization	Diligence	Perfectionism	Prudence	Conscientiousness
Coeff.	-0.04	-0.24	-0.02	-0.02	-0.12
P-value	0.82	0.20	0.91	0.93	0.53
	Aesthetic App	Inquisitiveness	Creativity	Unconventionality	Openness to Experience
Coeff.	0.04	-0.06	0.27	-0.08	0.04
P-value	0.84	0.75	0.14	0.68	0.82

Since this is an exploratory study, we analyze the correlations without any hypotheses. For the average order quantity decisions, there are no significant correlations at 5% level. If we relax the significance constraint to be 10%, then "fairness" and "social self-esteem" have significant correlation with the average order decision. Their coefficients are both negative indicating that a higher score in these personality traits reduces the order decision.

Table 5: Correlation of the expected profit with the survey results

	Sincerity	Fairness	Greed-avoidance	Modesty	Honesty-Humility
Coeff.	0.33	0.51	0.26	0.06	0.41
P-value	**0.07**	**0.00**	0.16	0.76	**0.02**
	Fearfulness	Anxiety	Dependence	Sentimentality	Emotionality
Coeff.	0.06	-0.25	0.13	0.02	-0.01
P-value	0.76	0.18	0.50	0.89	0.95
	Social Self-esteem	Social Boldness	Sociability	Liveliness	Extraversion
Coeff.	0.27	0.15	0.03	0.05	0.17
P-value	0.15	0.43	0.87	0.80	0.37
	Forgiveness	Gentleness	Flexibility	Patience	Agreeableness
Coeff.	-0.09	0.26	0.05	0.19	0.14
P-value	0.63	0.16	0.78	0.31	0.44
	Organization	Diligence	Perfectionism	Prudence	Conscientiousness
Coeff.	0.10	0.22	0.00	0.08	0.15
P-value	0.59	0.23	1.00	0.66	0.42
	Aesthetic App	Inquisitiveness	Creativity	Unconventionality	Openness to Experience
Coeff.	-0.09	0.07	-0.27	0.02	-0.07
P-value	0.62	0.69	0.14	0.91	0.71

The experiment is set-up in low-profit margin setting. As per the findings of earlier literature, under low-profit margin, decision-makers tend to order more than the optimal. Hence, any factor that reduces the order decisions will be improving the expected profit. Table 5 confirms this expectation with positive correlation coefficients for "fairness" and "social self-esteem" with the average expected profit. The coefficient is significant only for "fairness". We also observe "sincerity" and the overall "honesty-humility" facet have significant correlations with the expected profit. Table 6 shows parallel results for the realized profit correlations. In addition to the scales that positively affect the expected profit, we see that "greed-avoidance" is positively and significantly correlated with the realized demand values.

Table 6: Correlation of the realized profit with the survey results

	Sincerity	Fairness	Greed-avoidance	Modesty	Honesty-Humility
Coeff.	0.36	0.52	0.31	0.04	0.44
P-value	**0.05**	**0.00**	**0.09**	0.82	**0.01**
	Fearfulness	Anxiety	Dependence	Sentimentality	Emotionality
Coeff.	0.06	-0.26	0.08	-0.08	-0.07
P-value	0.74	0.16	0.67	0.66	0.71
	Social Self-esteem	Social Boldness	Sociability	Liveliness	Extraversion
Coeff.	0.27	0.13	0.02	0.01	0.14
P-value	0.15	0.48	0.90	0.97	0.45
	Forgiveness	Gentleness	Flexibility	Patience	Agreeableness
Coeff.	0.00	0.29	0.06	0.19	0.18
P-value	0.99	0.12	0.76	0.30	0.33
	Organization	Diligence	Perfectionism	Prudence	Conscientiousness
Coeff.	-0.02	0.16	0.02	0.11	0.08
P-value	0.90	0.40	0.91	0.55	0.68
	Aesthetic App	Inquisitiveness	Creativity	Unconventionality	Openness to Experience
Coeff.	-0.09	0.16	-0.21	0.09	0.00
P-value	0.63	0.38	0.25	0.65	0.99

The demand chasing heuristic coefficients seem to be significantly correlated with “dependence” and “sentimentality” scales. These facets indicate a need for emotional support or emotional bond with others. Further analysis is required to check if high scores in these facets indicate attaching some meaning to the random demand realization and making decisions based on this meaning. Overall, this is an important observation.

Table 7: Correlation of the demand chasing heuristic coefficients with the survey results

	Sincerity	Fairness	Greed-avoidance	Modesty	Honesty-Humility
Coeff.	0.26	0.04	-0.01	-0.16	-0.13
P-value	0.16	0.82	0.96	0.39	0.48
	Fearfulness	Anxiety	Dependence	Sentimentality	Emotionality
Coeff.	0.20	0.00	0.38	0.38	0.23
P-value	0.27	0.99	**0.04**	**0.04**	0.21
	Social Self-esteem	Social Boldness	Sociability	Liveliness	Extraversion
Coeff.	0.25	-0.31	0.22	0.25	0.05
P-value	0.17	0.09	0.23	0.18	0.80
	Forgiveness	Gentleness	Flexibility	Patience	Agreeableness
Coeff.	0.18	0.03	0.03	-0.05	0.06
P-value	0.34	0.89	0.87	0.81	0.75
	Organization	Diligence	Perfectionism	Prudence	Conscientiousness
Coeff.	-0.13	0.18	0.23	-0.25	-0.02
P-value	0.48	0.33	0.22	0.18	0.91
	Aesthetic App	Inquisitiveness	Creativity	Unconventionality	Openness to Experience
Coeff.	0.15	-0.05	0.11	0.34	0.09
P-value	0.44	0.79	0.57	0.06	0.64

Due to space restrictions altruism correlation results are presented separately in Table 8. None of the correlations is significant and it seems altruism doesn’t have any effect on newsvendor ordering decisions when there is only one decision-maker.

Table 8: Correlation of the experiment results with altruism

	Order Quantity	Expected Profit	Realized Profit	Demand Chasing
Coeff.	0.02	0.10	0.06	0.11
P-value	0.94	0.60	0.73	0.56

4. Conclusion

In this study we explore the correlation between newsvendor ordering behavior and Hexaco personality inventory. We show that order decisions are negatively correlated with fairness and social self-esteem scales. Expected profit is positively correlated with fairness, social self-esteem and additionally sincerity and honesty-humility as a whole facet. When we check the results for realized profit, we see that similar to expected profit it is positively correlated with sincerity, fairness, social self-esteem and honesty-humility facet. Additionally, greed-avoidance also positively impacts realized profit. Demand chasing behavior is prominent in the ordering decisions. And we see that there is significant and positive correlation between dependence and sentimentality scales and demand chasing behavior.

Though small, we believe these findings are significant for the future research. A bigger study with larger sample sizes and both low and high profit margin settings can further investigate these connections we have revealed in this study and make an important contribution to the literature.

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Biography

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