

A Cross-National Examination of the Newsvendor Behavior

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Abstract

Previous Behavioral Operations studies have revealed that there is a significant amount of individuality and heterogeneity in the ordering decisions made by human decision makers. Several studies investigated the effect of personal factors such as cognitive capabilities, personality traits and cultural norms on these decisions. In this study we conduct a simple lab experiment under newsvendor setting and investigate the effect of national differences in Turkish and American decision makers. The experiment scenario is based on two different settings, namely buyback setting and an equivalent revenue sharing setting. Specifically, under the buyback setting any leftovers are sold back to the supplier (which is represented by the computer) and under the revenue sharing setting for each sale made a revenue share is paid to the supplier. The data of the American subjects is obtained from the study conducted by Katok and Wu (2009) with the courtesy of the authors. The data of the Turkish subjects is obtained through a new experiment designed to match the setting of the American study. Our analysis shows that both groups of decision-makers under both settings place orders that are significantly lower than the optimal. For both cultural groups, under revenue sharing setting the subjects place lower orders than under buyback setting. Though, the difference is on average. When we compare Turkish and American decisions, we see that Turkish subjects place lower orders than American subjects, yet the difference is again on average. We also compare both groups in terms of decision heuristics and find that demand chasing behavior is more prevalent in the Turkish subjects.

Keywords

Behavioral Operations, Newsvendor Model, Mean Anchor, Demand Chasing, and Cultural Differences.

1. Introduction and Literature Review

Over the last 20 years, Behavioral Operations studies have been investigating which factors could be affecting decision making behavior under operations management contexts. A significant number of these studies have been focused on the newsvendor behavior. The focus on the newsvendor ordering behavior originates from the study contacted by Schweitzer and Cachon in 2000. This study revealed that there is a consistent deviation from the optimal that can't be explained by the existing theories of risk-aversion, loss-aversion or prospect theory. Thereafter, many studies are conducted in order to find an explanation to this suboptimal behavior. Lau et al. (2014) express that there is a high level of heterogeneity among the decisions of each participant. Wu and Chen (2014) attribute this individual heterogeneity to the bounded rationality of the subjects. De Vericourt et al. (2001) associate part of this individual difference to gender and they show that female subjects place lower order decisions compared to male subjects. After a mediating study, they reveal that the reason behind the lower order decisions made by female subjects is due to higher risk-aversion. Moritz et al. (2013) show that newsvendor performance is significantly affected by the cognitive capabilities of the decision makers. Akbay (2016) demonstrates that self-esteem and regret tendency can also affect order decisions. Specifically, decision-makers with higher self-esteem place higher orders, and decision-makers with higher regret tendency make orders closer to the demand mean.

Although few, there are also studies focused on cultural differences in newsvendor behavior. Feng et al. (2011) is the first of these studies investigating differences between Chinese and American decision makers. They show that Chinese order decisions are closer to the demand mean under both high profit and low profit margins which the authors attribute to the Doctrine of the Mean and extremeness aversion that is prevalent in the Chinese culture. Another study conducted by Li et al. (2019) find parallel results, again, in comparison of American and Chinese decision-makers. They show that Chinese order decisions are more prone to demand chasing and mean anchor heuristics, have higher

standard deviation and result in lower profit values. Though, when groups of similar cognitive reflection scores are compared, the differences are not significant.

In an interview-like study, Cui et al. (2011), yet again, compare American and Chinese decision-makers and find partially parallel and partially conflicting results. The authors find that the Chinese ask more questions to obtain more information before making the order decisions, and they explain this behavior by the Chinese being more anxious about making a wrong decision. The authors also find that anchoring to one of the demand distribution parameters (minimum, maximum or mean) is more prevalent in the American subjects and Chinese subjects are more aware of the salvage values. Kwak (2015) replicate this study with Korean decision-makers and compare Korean findings with the Chinese and the American. This study demonstrates that the comprehension of the demand distribution is lower in the Korean, which the author attributes to Korean education system. Other findings include the Korean exhibiting higher anchoring behavior to the demand mean and avoiding high order quantities which may be explained by risk-aversion.

In addition to the studies mentioned above, there are few cross-cultural studies comparing trust and trustworthiness in a supply chain information sharing setting. However, these studies are based on a more complex setting and include strategic interaction between decision-makers. Hence their findings are not relevant to the current study.

This study is the first to compare Turkish and American newsvendor decisions. The trade between the United States and Turkey has a significant contribution to the Turkish economy. The US ranks the second highest country in terms of Turkish exports and fifth highest in terms of imports. Hence investigation of cross-national differences between Turkish and American decision makers in terms of inventory decisions will have valuable insights for the business conducted between these two countries.

Our study consists of a standard Newsvendor scenario under buyback and revenue sharing settings with uniform consumer demand. Both of these settings are based on high profit margin.

Following the findings of Akbay (2016), we build our research hypotheses on the cultural differences in terms of self-esteem. Yigiter (2014) compares Turkish and American students in terms of the effect of participation in sports activities on the self-esteem. For both groups (participating in sports activities and not participating) Turkish students have significantly lower self-esteem values. Hence, we hypothesize that:

Hypothesis 1a: Turkish subjects will make lower order decisions than American subjects.

Hypothesis 1b: Turkish subjects will have lower expected profit values than American subjects.

Moreover, Turkish culture can be accepted more similar to Chinese culture rather than the American culture in terms of individuality, extremeness aversion and anchoring behavior. Hence we hypothesize that extremeness aversion or mean anchoring behavior will be more prevalent in Turkish subjects. We also expect to see Turkish subjects being more prone to demand chasing behavior.

Hypothesis 2: Number of orders that fall in between the demand mean and the optimal will be more in Turkish subjects

Hypothesis 3: Turkish subjects' orders will be affected by the demand realization more.

1.1 Objectives

The objectives of this study is the investigate the differences between Turkish and American decision makers in the context of

- Newsvendor order decisions
- Decision heuristics such as demand chasing and mean anchoring

2. Experimental Design and Procedures

We consider a Newsvendor problem under two mathematically equivalent settings namely, buyback setting and revenue sharing setting. All subjects undertake the role of the retailer and determine the order quantity of a certain perishable product with random demand. In other words the decision-makers face the newsvendor model. In all

treatments the parameters including the prices are predetermined and fixed throughout the experiment. Under the buyback setting, the retailer purchases the product from the supplier at the wholesale price w . If at the end of the selling period there are any leftovers, they are sold back to the supplier at the buyback price b . Assuming $F(\cdot)$ is the cumulative distribution of the demand, using the Newsvendor solution, the optimal order quantity is derived as $F^{-1}\left(\frac{p-w}{p-b}\right)$.

Under the revenue sharing setting, again the retailer purchases the product from the supplier at the wholesale price w . At the end of the selling period, for any sale the retailer makes a revenue share r is paid to the supplier. Under these conditions, the optimal order quantity is derived as $F^{-1}\left(\frac{p-r-w}{p-r}\right)$

Below are the parameters of the experimental setup.

- Selling price $p=\$12$
- Consumer demand \sim Discrete Uniform (51,150)
- Buyback setting: wholesale price (w) = 9, buyback price (b) = 8,
- Revenue sharing setting: wholesale price (w) =1, revenue share (r) =8
- Experiment duration: 40 periods

In Turkish and American studies two different demand streams are used. When compared, the two streams are not different from each other ($p=0.42$).

With these parameters the buyback setting is equivalent to the revenue sharing setting. That is to say, for both setups the optimal order quantity is 125.

American subjects

The data for the American subjects is taken from Katok and Wu (2009) study. Specifically, the data is from “Retailer Game- High Demand – Inexperienced” treatments for the buyback and revenue sharing settings. This study originally consists of 100 decision periods, therefore for comparison the first 40 periods are taken into analysis. The subjects in this study are recruited from the university student body and motivated by monetary reward based on experiment performance.

Turkish subjects

The participants are recruited from sophomore Industrial Engineering students of a Turkish university with the incentive of course credit between 1-2% proportional to experiment performance. The experiment is conducted using MS Excel and Visual Basic.

Table 1 shows the number of participants in each treatment. The sample sizes Turkish study is determined to be comparable to the American study.

Table 1. Sample sizes of the treatments

	Buyback setting	Revenue sharing setting
Turkish participants	10	14
American participants	10	10

3. Experiment Results

Now we present the experiment results. Here, the order decisions of the subjects over 40 periods is averaged and one data point for each subject is obtained. All hypothesis tests are conducted using nonparametric tests, namely Wilcoxon test for comparison with the theoretical benchmarks and Mann Whitney U for comparison of two samples.

Table 2 shows the results of the comparison with the theoretical benchmarks. Turkish subjects seem to order significantly less than the optimal order quantity and as a result make significantly less than optimal profit under both settings. Similarly, American subjects’ order decisions are also less than the optimal, but the difference is significant

only under revenue sharing setting. As a result, American subjects as well, earn significantly less than optimal expected profit under both settings.

Table 2. Comparison of experiment results with theoretical expectations

			Theory	Experiment Data			
			Optimal	Mean	Median	Std. Dev.	P-value
Buyback Contract	Turkish	Order Quantity	125	109.99	108.96	12.49	0.01
		Expected Profit	264	246.00	246.13	10.64	0.01
		Realized Profit	264	244.48	244.26	11.61	0.01
	American	Order Quantity	125	119.02	118.71	11.36	0.13
		Expected Profit	264	255.27	258.44	7.97	0.01
		Realized Profit	264	268.20	269.96	11.04	0.31
Revenue Sharing Contract	Turkish	Order Quantity	125	103.54	100.74	8.93	0.00
		Expected Profit	264	246.39	245.60	8.27	0.00
		Realized Profit	264	247.91	250.24	9.34	0.00
	American	Order Quantity	125	101.61	102.85	14.68	0.01
		Expected Profit	264	242.31	245.64	15.25	0.01
		Realized Profit	264	252.29	252.55	17.93	0.10
<i>P-values are obtained from two-tailed Wilcoxon test.</i>							

When we compare the buyback and revenue sharing settings, as shown by the results in Table 3, we see that under the revenue sharing setting both Turkish and American subjects make smaller order decisions and earn smaller profit values compared to the buyback setting. The differences are significant for the American subjects except for the expected profit values. This suggests that there is evidence for the failure of the equivalence of the two settings in practice as earlier studies such as Akbay (2016) have demonstrated.

Table 3. Comparison of buyback and revenue sharing settings

		Buyback			Revenue Sharing			
		Mean	Median	Std. Dev.	Mean	Median	Std. Dev.	P
Turkish	Order Decision	109.99	108.96	12.49	103.54	100.74	8.93	0.15
	Expected Profit	246.00	246.13	10.64	246.39	245.60	8.27	1.00
	Realized Profit	244.48	244.26	11.61	247.91	250.24	9.34	0.62
	Order Std. Dev.	22.14	22.66	6.86	17.43	16.52	5.57	0.10
American	Order Decision	119.02	118.71	11.36	101.61	102.85	14.68	0.02
	Expected Profit	255.27	258.44	7.97	242.31	245.64	15.25	0.09
	Realized Profit	268.20	269.96	11.04	252.29	252.55	17.93	0.04
	Order Std. Dev.	14.48	11.05	9.19	12.64	9.66	9.23	0.43
<i>Comparison is done with two-sided Mann Whitney U test.</i>								

Next, we compare Turkish and American subjects' decisions. The results are shown in Table 4. We see that in terms of order quantity, Turkish subject place smaller orders than American subjects under the buyback settings, but the p-values for the one-sided comparisons are not small enough. We conclude that there is partial weak support for *Hypothesis 1a*. We see that Turkish subjects make less profit than American subjects with the difference being significant under buyback setting suggesting that *Hypothesis 1b* is partially supported by the data.

Table 4. Comparison of Turkish and American subjects' order decisions

		Turkish			American			
		Mean	Median	Std. Dev.	Mean	Median	Std. Dev.	P
Buyback Contract	Order Decision	109.99	108.96	12.49	119.02	118.71	11.36	0.08
	Expected Profit	246.00	246.13	10.64	255.27	258.44	7.97	0.03
	Realized Profit	244.48	244.26	11.61	268.20	269.96	11.04	0.00
Revenue Sharing Contract	Order Decision	103.54	100.74	8.93	101.61	102.85	14.68	0.38
	Expected Profit	246.39	245.60	8.27	242.31	245.64	15.25	0.40
	Realized Profit	247.91	250.24	9.34	252.29	252.55	17.93	0.20
<i>Comparison is done with one-sided Mann Whitney U test.</i>								

Figure 1 graphically depicts the cross-cultural differences in order decisions and expected profit values. These graphs are generated by sorting the average order decisions and average expected profit values of the subjects in ascending order. Under the buyback setting, the experiment performance of the American subjects dominates that of the Turkish subjects. Yet, the revenue sharing setting paints a different picture. Basically, we can't talk about a clear dominance under this setting.

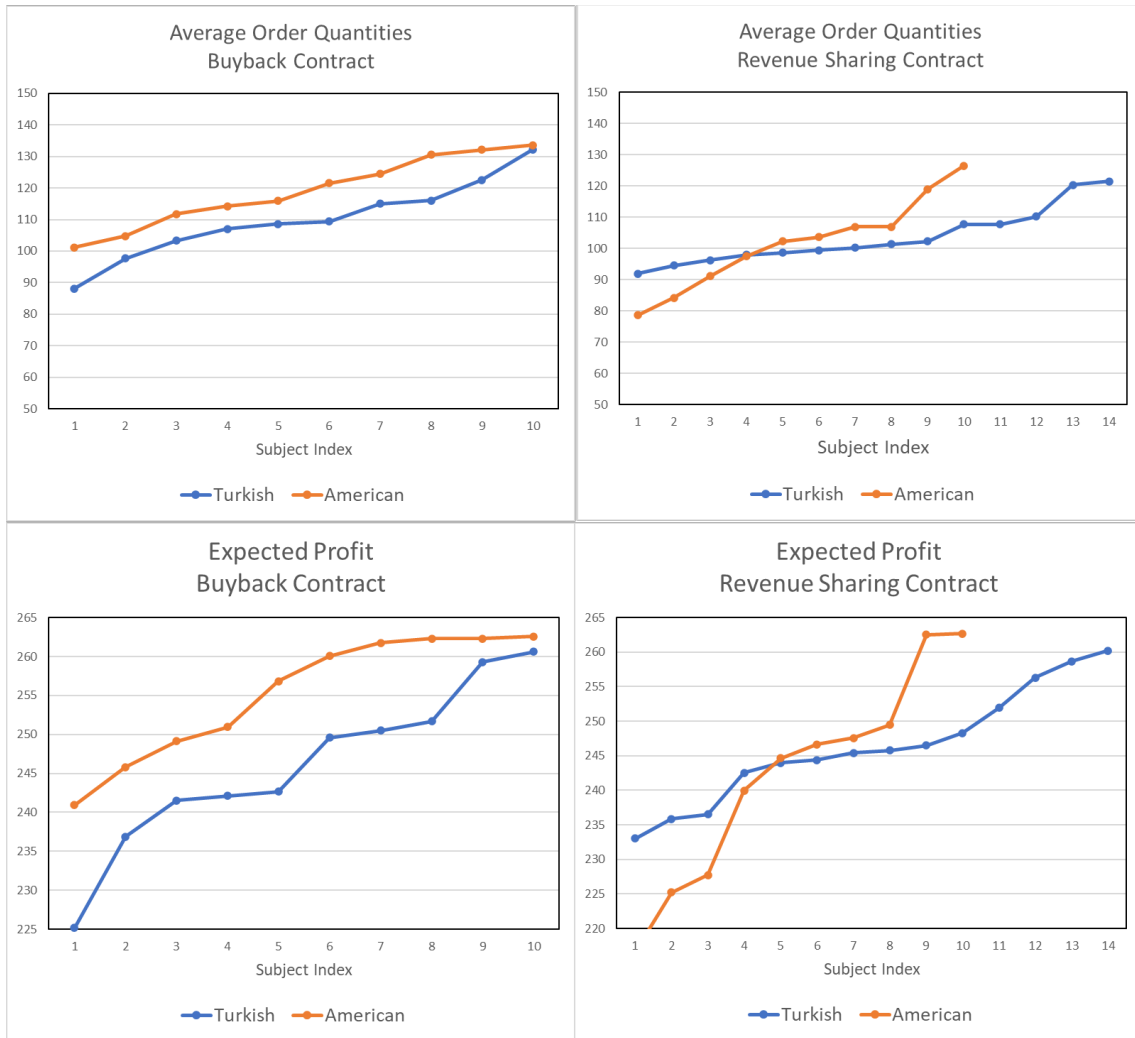


Figure 1. Cross-national comparison of order quantities and expected profit values

Finally, we compare the decisions of Turkish and American subjects in terms of decision heuristics, namely the mean anchor heuristic and demand chasing heuristic.

Table 5. Comparison of the mean-anchor heuristic

		Turkish			American			P
		Mean	Median	Std. Dev.	Mean	Median	Std. Dev.	
Buyback Contract	# orders in [100-125]	13.30	13.00	5.36	16.80	13.50	11.06	0.32
	# orders in [51,100)	13.10	12.00	7.99	6.30	6.00	5.91	0.04
	# orders in (125,150]	13.60	11.50	8.78	16.90	15.50	12.74	0.31
Revenue Sharing Contract	# orders in [100-125]	21.43	23.50	7.73	18.10	18.00	10.98	0.16
	# orders in [51,100)	13.57	14.50	7.98	15.50	13.50	11.88	0.45
	# orders in (125,150]	5.00	4.00	4.40	6.40	6.00	6.70	0.50
<i>Comparison is done with one-sided Mann Whitney U test.</i>								

The mean-anchor heuristic is the behavior of anchoring order decision to the mean of the demand distribution and adjusting towards the optimal order quantity. As a result, the order decisions will fall in between the mean and the

optimal. We compare this behavior in Table 5 and in Figure 2 by the number of ordering decisions out of the total periods 40 that fall onto the interval between 100 and 125 in our setting. There is no significant difference in the number of orders that fall onto the interval between the demand mean and the optimal. We conclude that there is *Hypothesis 2* is not supported by the data.

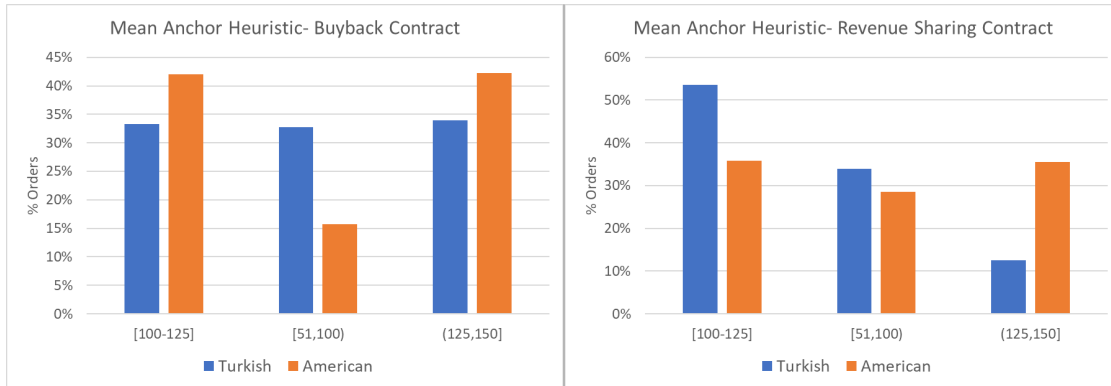


Figure 2. Cross-national comparison of the mean anchor heuristic

Under both settings, the number of orders less than the demand mean are higher for Turkish subjects, and number of orders that are greater than the optimal is less. The difference is significant only for [51,100) interval under the buyback setting. These observations can be regarded as partial weak support for *Hypothesis 1a*, that is Turkish decision-makers placing smaller orders.

Table 6. Comparison of the demand-chasing heuristic

		Turkish			American			P
		Mean	Median	Std. Dev.	Mean	Median	Std. Dev.	
Buyback Contract	Towards D_{t-1}	21.80	21.50	4.94	16.80	18.00	9.91	0.13
	Opposite D_{t-1}	12.10	11.00	2.92	5.90	5.00	3.73	0.00
	No Change	4.90	3.50	4.65	16.10	13.00	12.21	0.01
Revenue Sharing Contract	Towards D_{t-1}	20.86	22.00	6.68	19.00	19.50	8.91	0.28
	Opposite D_{t-1}	10.86	12.00	3.48	8.40	6.00	6.08	0.09
	No Change	7.00	5.00	7.64	11.60	10.00	10.81	0.11

Comparison is done with one-sided Mann Whitney U test.

The demand chasing heuristic is the behavior of anchoring at the previous order decision and adjusting towards the demand realization. Table 6 and Figure 3 compare the the number of order decisions that are changed towards or in the opposite direction of the demand realization of the previous period. Under both settings, on average Turkish subjects change their order decisions more towards the most recent demand realization. In addition, the number of Turkish order decisions that were changed in the opposite direction of the demand realization is also higher with significant difference under the buyback setting. These differences can be more clearly seen in Figure 3. We conclude that there is partial support for *Hypothesis 3*.

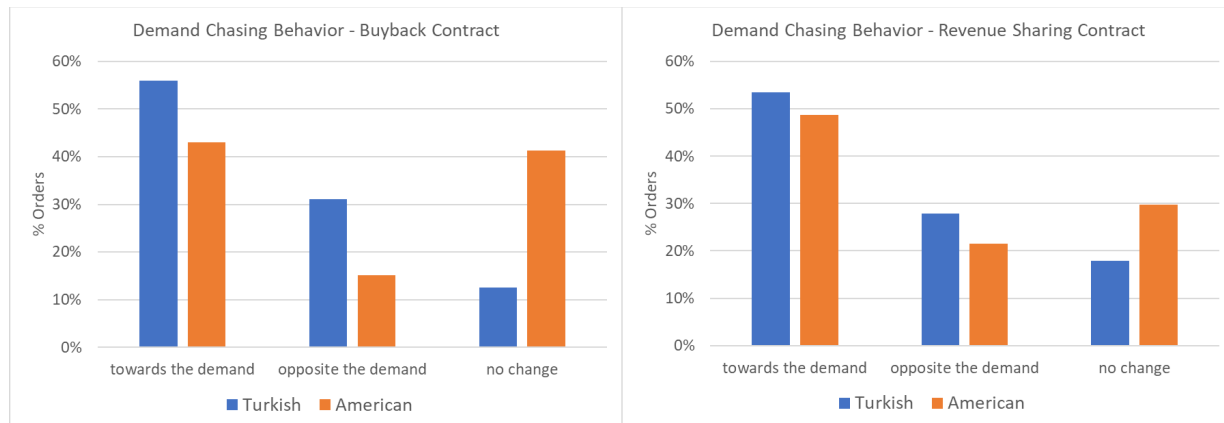


Figure 3: Cross-national comparison of demand-chasing heuristic

4. Conclusion and Discussion

In this study we compare the cross-national differences between Turkish and American decision makers under the newsvendor problem. Our analysis shows that there is in fact a significant cultural difference between the two nations that affect their ordering behavior. Considering Turkish culture is more conservative, and individualism is more prevalent in American culture, we conjecture that Turkish subjects would order smaller quantities and would be affected by decision heuristics more and we have found partial support for our hypotheses.

Here, we must note that the two studies that are compared are conducted by different researchers following different procedures. Hence some of the results observed in the data can be attributed to the differences in the experimental procedures. What is equally likely is that the procedural differences may have hindered some other differences in the ordering behavior. Furthermore, the sample sizes are considerably smaller than the ones that are preferred by the most recent studies. This paper should be regarded as an exploratory call for further research into cross-cultural examination of the newsvendor behavior.

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Biography

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