

Human Behavior in Newsvendor Decisions: A Comparative Study with Experimental Results

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ABSTRACT

As decision makers do not make optimal decisions in practice despite the existence of optimal solutions in many models, there has been a rising interest in behavioral operations management recently. In this study, we aim for a comparative study to analyze the inventory decisions in Korea, America, and China, by conducting the same newsvendor experiment in Korea and compare the results with those of previous studies. From the comparative analysis, some national characteristics in decision-making processes have been observed but there is lowly significant difference in order quantities among the three groups. Korean students show lower level of understanding in demand distributions and tendencies of anchoring on the mean demand and being risk-averse. The finding that individuals make their own decisions differently based on their different behaviors suggests that we need to consider individual approach in analyzing human decision-making processes rather than adapting aggregate approach.

Keywords: Comparative Study, Inventory Decisions, Newsvendor Experiment, Behavioral Operations Management

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1. INTRODUCTION

Recently, researchers have shown rising interests in behavioral operations management (Gino and Pisano, 2008; Bendoly *et al.*, 2010, and many special issues of OM journals). Like other fields, traditional studies in operations management have searched for optimal solutions for efficient and effective operations. However, in reality, the decisions made in companies seem to deviate from the optimal ones and researchers have realized the importance of incorporating human factors into the analysis of decision-making processes in firms' operations.

Schweitzer and Cachon (2000) conducted newsvendor experiments to the MBA students in Duke University who have taken an operations management course containing the materials about the newsvendor model and found out that average order quantities lie between the mean demand and the optimal order quantity. Since the study pointed out human behavior that makes non-optimal decisions, many studies (Bolton and Katok, 2008;

Benzion *et al.*, 2010; Becker-Peth *et al.*, 2013, Ren and Croson, 2013, Lau and Bearden, 2013) have also observed non-optimal behaviors of decision makers in newsvendor settings.

Most operations of companies are not implemented based on theories in practice. Therefore, it is critical to study human behaviors in operations management, as the decision makers are human and they tend to make non-optimal decisions. Particularly, Gavirneni and Isen (2010) studied how decision makers decide order quantities by analyzing their decision-making processes from the verbalized protocols. As a following study, Cui *et al.* (2013) studied the difference between Americans and Chinese by conducting the same experiment as that of Gavirneni and Isen (2010). In their study, Chinese seem to be smarter in inventory decisions but still, most decision makers do not make optimal decisions in the newsvendor settings.

In this study, we aim for a comparative study to compare the decision-making processes of the three

groups-Korean, American, and Chinese-by conducting the same experiment as theirs except for the language with Korean subjects. Through the comparative study, we search for some characteristics of Koreans in inventory decisions and managerial implications about the human behavior in decision-making processes.

As a result of the experiment, we have observed that Korean subjects also were not able to find the optimal order quantity in most cases and they showed some characteristics that are different from those of Americans or Chinese. Korean subjects show relatively lower level of understanding of demand distribution and tend to anchor on some reference values or have risk-averse attitudes for inventory decisions. An important finding of this research is that individual decision makers show different decision-making processes regardless of national differences. This leads to the need to consider individual behaviors when analyzing management decisions.

2. EXPERIMENTS AND VERBAL PROTOCOL ANALYSIS

For a comparative study, we conducted the same experiment as in Gavirneni and Isen (2010) and Cui *et al.* (2013), but in the Korean language. As Gavirneni and Isen (2010) recruited 21 American subjects and Cui *et al.* (2013) recruited 21 Chinese subjects, we recruited 21 Korean subjects. We presented the newsvendor task with only the mean-demand information, and subjects are expected to request additional pieces of information that they thought they need for the inventory decision. If parts or all of the requested information is available, they had to determine an order quantity that maximizes the profit based on the available information. The subjects are undergraduate students, but they have taken the course "Operations Management" that contains the materials about newsvendor models. In the task instructions, there is a statement such as "If you order too much, you will incur costs associated with items leftover and if you order too little, you will be foregoing profits that you could have otherwise collected." Therefore, subjects may catch the clue that this problem can be solved by using the newsvendor model they learnt in class. Like in Gavirneni and Isen (2010) and Cui *et al.* (2013), ten pieces of information were available: (1) demand range (0~20,000), (2) demand distribution (uniform), (3) unit selling price (\$900), (4) unit purchasing cost (\$300), (5) unit salvage value (\$100), (6) loss of goodwill (zero), (7) quality problem (10% defective), (8) quantity discount (\$50 per-unit discount if order quantity is 20,000 or more), (9) demand management (investing \$250,000 to ensure demand is at least 5,000), and (10) rain checks (\$100 coupon guaranteed for unsatisfied customers to come back). If the subjects' requested information was not available, they were notified the unavailability. With the information on hand, subjects verbalized their deci-

sion-making processes to determine the order quantity. By audio-recording all these experiments, we were able to analyze the protocols to understand individual decision-making processes on the newsvendor problem. More details about experimental design can be found in Gavirneni and Isen (2010).

Verbal protocol analysis has been widely used in other areas of social sciences for analyzing individual decision-making processes (Isenberg, 1986; Anderson and Potter, 1998). Despite its powerful research capability, there are only two papers (Gavirneni and Isen, 2010; Cui *et al.*, 2013) using this methodology in operations management, as individual behaviors are usually not the focus of traditional operations management research. Gavirneni and Isen (2010) and Cui *et al.* (2013) used verbal protocol analysis to analyze individual decisions systematically by categorizing the protocol phases into information gathering and problem solving. This study also applies verbal protocol analysis methodology for analyzing Koreans' newsvendor inventory decisions and compares the results with the observations in the existing two studies.

3. COMPARATIVE STUDY

The results of the newsvendor experiments with the Korean subjects enable a comparative study to explore the similarities and differences in Koreans' inventory decisions in contrast to those of American or Chinese decision makers. We provide the analysis according to the two protocol phases (information gathering and problem solving) of the decision-making processes and discuss the managerial implications.

3.1 Information-Gathering Phase

Given only the information of the mean demand (10,000 units), the subjects were allowed to ask for any more information that they thought they need for the inventory decision. The experimental results show that Korean students requested obviously fewer information than American or Chinese students in regards to the available information that can be critical to the newsvendor inventory decision. Among the ten pieces of available information, Korean subjects asked for 3.10 pieces on average while Americans asked for 4.52 and Chinese asked for 4.86 on average respectively. Figure 1 illustrates the number of subjects who asked for the available information.

In all the three groups, the first five pieces of information were requested more frequently than the last five pieces. A notable difference is that Korean subjects requested much fewer for the information about demand distribution. According to the recorded protocols, many Korean students tend to assume that the future demand will be equal to the expected mean demand which is the given information. They seem to think that the optimal

inventory decision should be based on the mean demand because they believe, whether the future demand is more than or less than the expected demand, the “mean” is the average value. Some of those decision makers did not request the information about demand variance and made the decision assuming the demand is exactly 10,000 (the expected demand). In that case, it is highly likely that they can easily find the optimal order quantity (10,000), but we cannot conclude those decision makers are smart just because they found the right answer. If the demand has some variability as it usually does in reality, those decisions obviously will not be the optimum.

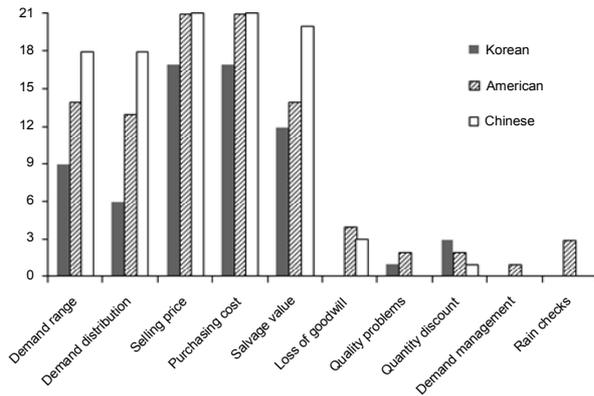


Figure 1. Number of Subjects Asking for the Available Information

Even though a few Korean students obtained the information about demand range (0~20,000), they were not able to use the information effectively for the decision. They calculated the profit when the demand was 15,000, 20,000, or etc., respectively to decide the order quantity. Most Korean students appear to be afraid of using probabilistic concepts for future uncertain demand though most of them have taken a basic statistics course with a passing grade (B+ or higher). Cui *et al.* (2013) explained that Chinese students are better at understanding probabilistic concepts as Chinese students are stronger in mathematics due the hard training. It is known that Korean students have also strong mathematical problem-solving skills, but in this experiment they failed to incorporate the probabilistic concepts into the inventory decisions. Korean math education may not focus on probability and students are known to be strong at solving “given” problems. We observe that many Korean students have hard time “seeking” the necessary information for the decision. These results give an insight on education of operations management in Korea (Kwak, 2014).

The summary of the unavailable information that Korean subjects asked for is given in Table 1.

Similarly to the two previous studies, Korean subjects asked for some unavailable information. Many subjects asked for the information about business settings such as selling season, product, competitors, and customers. It seems that they wanted to create a business

context for their order decisions. In addition, many subjects were interested in past demand. There may be a tendency to use the information about past demand for inventory decisions if available.

Table 1. Summary of the Unavailable Information that Korean Subjects Asked for

Information requested	Number of subjects who asked for the information
Is there a selling season?	14
Is there information about past demand?	11
What is the product?	10
Is there information about competitors?	9
How is the expected demand derived?	7
What are the other costs?	7
What are the characteristics of customers?	6
How accurate is the information about expected demand?	4
What is the maximum amount that can be ordered once?	4
Is the financing sufficient?	3
Is there an ongoing promotion?	2
What is the current inventory level?	2
What is the required labor?	1
Does the selling price change over time?	1
Is there an effort to reduce costs during production?	1
Is there a formula to compute the order quantity?	1
What is the location of the company?	1

3.2 Problem-Solving Phase

Average order quantities and average absolute deviations are compared in Table 2. An absolute deviation is defined as the absolute difference between the subject’s order quantity and the optimal order quantity with the information on hand.

Experimental finding 1: There is lowly significant difference in the decision of order quantities under a newsvendor setting among Koreans, Americans, and Chinese.

Table 2. Comparison of Average Order Quantity and Average Absolute Deviation

	Korean	American	Chinese
Average order quantity	11,986	12,376	14,291
Average absolute deviation	2,386	2,735	2,291

As a result of ANOVA test, there is lowly significant difference in three groups' decisions on order quantity with a p -value of 0.0843. As Cui *et al.* (2013) pointed out, there is significantly less difference in the effectiveness of the final decisions made by different subjects due to the large randomness in demand. However, detailed analysis of protocols show some differences in the decision-making processes among the three groups.

First of all, Koreans show obvious anchoring tendencies in their decisions. Among 21 subjects in each country, 10 Koreans, 10 Americans and 3 Chinese chose either the mean demand (10,000) or the extreme demands (0 or 20,000) as the order quantity. In addition to those 10 subjects, some Korean students chose the amount close to the mean demand. 3 students chose 9,000 and 2 students chose 10,500 after all of them anchor on the mean demand 10,000. Therefore, more than half of the Korean subjects show anchoring tendencies.

Experimental finding 2: Korean subjects show strong tendencies of anchoring on the mean demand, compared to American or Chinese subjects.

Table 3. Comparison of Number of Subjects Who Anchor on the Mean Demand

	Korean	American	Chinese
Number of subjects who anchor on the mean demand	14	9	3

As a result of chi-square test, we found that Korean subjects show strong anchoring tendencies with a p -value of 0.002581. The mean-anchoring behavior is explained by an anchoring and insufficient adjustment process in Schweitzer and Cachon (2000).

Regardless of whether they made a near-optimal decision for order quantity, we can observe a strong anchoring tendency of Koreans. This anchoring tendency may be related to the fact that many Korean subjects asked for past demand information. If the information about past demand were available, they might anchor on the past demand as well. From the protocol analysis, it also seems quite obvious that Korean subjects want to have some reference values when they make decisions rather than just computing the order quantity.

Experimental finding 3: Korean subjects show risk-averse attitudes rather than risk-neutral or risk-seeking.

Another tendency we may observe is a risk-averse attitude of Koreans. Among 21 Korean subjects, 9 chose smaller order quantities than the optimal one with on-hand information, 6 chose the optimal order quantity, and 6 chose larger order quantities than the optimal one (Refer to Table 4).

According to a prospect theory (Schweitzer and Cachon, 2000), a decision maker will be risk-averse over

the domain of gains. We can observe some risk-averse attitudes of Korean subjects and 3 students actually mentioned that they are risk-averse while verbalizing their decision-making processes.

Table 4. Order Quantities and Optimal Order Quantities for Korean Subjects

Subject #	Order quantity chosen	Optimal quantity for each subject	Difference
1	9,000	10,000	-1,000
2	9,000	10,000	-1,000
3	9,000	10,000	-1,000
4	10,000	10,000	0
5	10,000	10,000	0
6	10,000	10,000	0
7	10,000	10,000	0
8	10,000	10,000	0
9	10,000	11,111	-1,111
10	10,000	15,000	-5,000
11	10,000	15,000	-5,000
12	10,000	20,000	-10,000
13	10,500	10,000	+500
14	10,500	10,000	+500
15	13,333	15,000	-1,667
16	15,000	13,333	+1,667
17	15,000	13,333	+1,667
18	15,000	15,000	0
19	15,000	20,000	-5,000
20	19,999	10,000	+9,999
21	20,000	15,000	+5,000

This risk-aversion somewhat explains that average order quantity of Koreans is less than that of Americans or Chinese. Figure 2 describes the comparison of order quantities chosen by each subject in the three groups, in an increasing order.

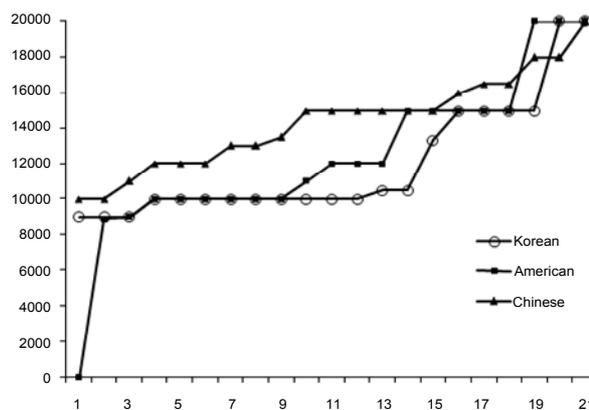


Figure 2. Comparison of Order Quantities Chosen by Subjects

One limitation of this study is that the subjects in the three countries are not demographically homogeneous. For example, the subjects in our experiment are

undergraduate students while the other two studies use MBA subjects. However, Bolton *et al.* (2012) found out that there is no significant difference among undergraduate students, graduates, and managers in newsvendor decisions. Moreover, VPA approach focuses on individual decision making processes and thus the demographical differences do not really matter in analyzing the results. Even the subjects in the existing two studies are not demographically identical. As mentioned in the next section, a related issue such as cultural attributes can be studied in a future study.

4. CONCLUSION

A Newsvendor experiment as a form of in-depth interview with individual subjects shows that there exist some differences among American, Chinese, and Korean subjects in Newsvendor inventory decisions. However, it is common that all the three groups failed to make optimal inventory decisions. This is quite a robust result, and we were able to analyze the decision-making processes leading to the wrong answers by verbal protocol analysis. In fact, failing to make optimal inventory decisions in newsvendor experiments is prevalent in many existing literatures, regardless of the subjects' intelligence or exposure to the relevant experience (Schweitzer and Cachon, 2000; Gavirneni and Isen, 2010; Bolton *et al.*, 2012).

One of the major causes of wrong inventory decisions among Korean subjects is lack of understanding the probabilistic concepts of demand distributions. Optimal order quantity must be derived by considering demand distributions, but most subjects tend to arbitrarily assume that demand is deterministic and many of them even did not request for the information about demand distributions. Other characteristics of Korean decision makers are anchoring tendencies and risk-averse attitudes. Many Korean subjects tend to anchor on the mean demand. It seems that they want to have some reference for their inventory decisions. We can observe some risk-averse attitudes of Korean subjects, leading to relatively less order quantities on average compared to Americans or Chinese. In fact, Hofstede (1980) rated Koreans' risk-averseness highly among many countries and Calhoun *et al.* (2002) measured uncertainty avoidance of Koreans by considering cultural differences from USA. What kinds of cultural attributes lead to the difference in the business decisions might be another important and interesting research topic.

Most experimental studies may not guarantee the same results for the replicated experiments with different subjects, but give the valuable insights about human decision-making processes. For the Newsvendor inventory decisions, the subjects in three different countries show different characteristics in decision-making processes and even in the same group, individual subjects show different decision-making processes. Inventory de-

isions clearly depend on individual behaviors such as what types of information they sought, whether they anchor on a certain reference, or whether they are risk-averse, etc. This study contributes to the behavioral research stream in operations management area by identifying the characteristics of Korean decision makers and by using verbal protocol analysis for detailed understanding in individual behaviors.

Though a well-established inventory theory exists, individuals make different inventory decisions according to their own decision-making processes. This is why behavioral study is needed to analyze the decision-making processes in business. Considering that most traditional researches adapt aggregate approach, we have to emphasize the importance of individual analysis in management decisions. For a future study, we may consider how we can incorporate individual differences in management decisions. Also, in order to claim national differences in decision making processes, extensive experiments with more various subjects may be needed, and this may merit another future study.

REFERENCES

- Anderson, M. J. and G. S. Potter, "On the use of regression and verbal protocol analysis in modeling analysts' behavior in an unstructured task environment: a methodological note," *Accounting, Organizations and Society* 23, 5/6 (1998), 435-450.
- Becker-Peth, M., E. Katok, and U. W. Thonemann, "Designing buyback contracts for irrational but predictable newsvendors," *Management Science* 59, 8 (2013), 1800-1816.
- Bendoly, E., R. Croson, P. Goncalves, and K. Schultz, "Bodies of knowledge for research in behavioral operations," *Production and Operations Management* 19, 4 (2010), 434-452.
- Benzion, U., Y. Cohen, and T. Shavit, "The newsvendor problem with unknown distribution," *Journal of the Operational Research Society* 61 (2010), 1022-1031.
- Bolton, G. and E. Katok, "Learning by doing in the newsvendor problem: a laboratory investigation of the role of experience and feedback," *Manufacturing and Service Operations Management* 10, 3 (2008), 519-538.
- Bolton, G. E., A. Ockenfels, and U. W. Thonemann, "Managers and students as newsvendors," *Management Science* 58, 12 (2012), 2225-2233.
- Calhoun, K. J., J. T. C. Teng, and M. J. Cheon, "Impact of national culture on information technology usage behavior: an exploratory study of decision making in Korea and the USA," *Behaviour and Information Technology* 21, 4 (2002), 293-302.
- Cui, Y., L. G. Chen, J. Chen, S. Gavirneni, and Q. Wang, "Chinese perspective on newsvendor bias: an exploratory note," *Journal of Operations Management*

- 31 (2013), 93-97.
- Gavirneni, S. and A. M. Isen, "Anatomy of a newsvendor decision: observations from a verbal protocol analysis," *Production and Operations Management* 19, 4 (2010), 453-462.
- Gino, F. and G. Pisano, "Toward a theory of behavioral operations," *Manufacturing and Service Operations Management* 10, 4 (2008), 676-691.
- Isenberg, D. J., "Thinking and managing: a verbal protocol analysis of managerial problem solving," *Academy of Management Journal* 29, 4 (1986), 775-788.
- Hofstede, G., *Culture's Consequences: International Differences in Work-Related Values*, Sage Publications, Inc., Beverly Hills, CA, 1980.
- Kwak, J. K., "Application of newsvendor experiments to education of operations management," *Korean Management Review* 43, 5 (2014), 1465-1474.
- Lau, N. and J. N. Bearden, Newsvendor demand chasing revisited, *Management Science* 59, 5 (2013), 1245-1249.
- Ren, Y. and R. Croson, "Overconfidence in newsvendor orders: an experimental study," *Management Science* 59, 11 (2013), 2502-2517.
- Schweitzer, M. E. and G. P. Cachon, "Decision bias in the newsvendor problem with a known demand distribution: experimental evidence," *Management Science* 46, 3 (2000), 404-420.