

HOW TO SELECT AND USE A KOREAN CHECK CARD TO MAXIMIZE THE BENEFITS THAT FIT CUSTOMERS' LIFESTYLE

SANG-IK NA, HYUK-JOONG JANG AND JAE-DONG SON*

Department of Industrial and Information Systems Engineering
Soongsil University

511 Sangdo-Dong, Dongjak-Gu, Seoul 06978, Korea

{ nasi0221; ky48k }@naver.com; *Corresponding author: son88@ssu.ac.kr

Received September 2022; accepted December 2022

ABSTRACT. *Although check cards are gaining great popularity among young Koreans, research on check cards itself is still lacking, and studies on optimizing the benefits of check cards have not been conducted so far. In this study, we formulate a mathematical model that maximizes the benefits of check cards mainly used by college students. Based on this, a numerical experiment will be conducted to validate the model and propose the best way to select and use a check card in order to maximize the benefits that fit each user's lifestyle.*

Keywords: Check card, Credit card, Debit card, Benefits maximization, Linear programming, Optimal policy, Consumption behavior

1. Introduction. The check card was derived from VISA Check Card, an offline debit card developed by VISA card to respond to debit cards issued by US banks, and it was introduced by BC Card in 1999. After then, it appeared as a payment method under the name of 'check card' in LG Card in 2000 [1]. A check card is a kind of debit card that is linked to a bank account and can be freely used at credit card merchants within the account balance. In other words, it can be said to be a combination of the two advantages of a one-time payment of debit card and a wide range of merchants of credit card [2]. A debit card and a check card have the same method of withdrawing from the bank account at the time of payment, but the debit card uses the financial network, whereas the check card uses the computer network of the credit card. Therefore, unlike check card networks that operate 24 hours a day, debit cards cannot be used during the check-up of the financial network, and since the affiliates stores of banks and their payment networks are not well established, credit and check cards are mainly used in Korea. In addition, as various simple payment services such as Kakao Pay, Samsung Pay, and Naver Pay are being commercialized in Korea, the possibility of using debit cards seems low in the future.

According to the Bank of Korea's economic statistics system, the cumulative number of check cards issued as of 2019 is over 130 million. Moreover, in 2019 alone, the number of transactions and total transaction amount reached about 660 million and 11 trillion won, respectively, and are steadily increasing. This is because a check card has the convenience of a credit card as a payment method, and at the same time can freely pay within the deposit balance, thereby eliminating the side effect of overconsumption [3-5]. Especially, the rate of use of check cards in their 20s was 76.7%, which is the highest in all age groups. The reason why the ratio of people in their 20s is so high seems to be the result of the difficulty of issuing credit cards and the easy living using pocket money linked with their account [6]. Although it is called pocket money, they experience quite independent

decision-making in consumption, and their spending is relatively large [7]. In addition, since he/she will be employed in the next few years and act as a leading consumer in the future, their consumption behavior will be more important than anything else. In fact, the analysis of consumption behavior of young people is currently being conducted steadily in various ways [8]. However, despite this trend, not many previous studies on check cards have been conducted. Not only is there a lack of research conducted from the perspective of consumers on how check cards are recognized and used by modern consumers, but it is difficult to find the research itself because the history of check cards is not long compared to the credit card introduced in 1968 in Korea [9,10]. In addition, since most of foreign young people own the debit card, which is different from the Korean check card as mentioned above, there has been little research on check cards abroad [11].

In this paper, we study how to select and use Korean check cards with different discount rates according to the types of benefits for each card company in order to maximize the benefits (discount amount). There are relatively many studies examining the relationship between price discounts and customers' shopping behavior or payment methods when using debit/credit cards, but, to the best of the authors' knowledge [12-14], no studies have been conducted on how to maximize overall discounts/benefits using check cards from a consumer's point of view. Furthermore, most of the studies on Korean check cards mentioned above are also related to card usage behavior. Therefore, this study proposes a mathematical model maximizing the benefits of Korean check cards from the perspective of customers and proves the validity of the mathematical model by deriving the optimal check card use policies through numerical experiments that reflect the spending behavior of college students.

The rest of this paper is organized as follows. Section 2 presents a mathematical model that maximizes the benefits of check cards from the perspective of check card users. Section 3 conducts some numerical experiments with three scenarios to verify the mathematical model established in the previous section. Section 4 concludes and discusses some topics to be tackled in the future.

2. Model Formulation. In this section, we formulate a mathematical model that maximizes the benefits from the point of view of a check card user. To begin, we define the symbols used in the model below.

- i : Type of check card, $i = 1, 2, \dots, c$
- j : Type of benefits, $j = 1, 2, \dots, b$
- $X_{i,j}$: Payments to benefit type j of card i , $i = 1, 2, \dots, c$, $j = 1, 2, \dots, b$
- $\beta_{i,j}$: Discount rate for the amount paid to benefit type j of card i , $i = 1, 2, \dots, c$, $j = 1, 2, \dots, b$
- $n_{i,j}$: Number of payments to benefit j of card i ($n_{i,j} = 1, 2, \dots, n_{\max}$), $i = 1, 2, \dots, c$, $j = 1, 2, \dots, b$
- $\gamma_{i,j}$: Maximum discount for benefit type j of card i , $i = 1, 2, \dots, c$, $j = 1, 2, \dots, b$
- $u_{i,j}^+(u_{i,j}^-)$: Upper (lower) bounds of payment to receive discount for benefit type j of card i , $i = 1, 2, \dots, c$, $j = 1, 2, \dots, b$
- $d_{i,k}$: k th ($k = 1, 2$) threshold when monthly total payments to card type i ($i = 1, 2, \dots, c$) is divided into three interval values, where $d_{i,1} < d_{i,2}$
- $s_{i,k}$: k th ($k = 1, 2, 3$) maximum discount amount when monthly total payments to card type i ($i = 1, 2, \dots, c$) is divided into three interval values by $d_{i,1}$ and $d_{i,2}$, where $s_{i,1} < s_{i,2} < s_{i,3}$
- h : Maximum monthly expendable amount
- m : Number of cards a customer holds, $1 \leq m \leq c$
- p_j : Weight for benefit type j ($j = 1, 2, \dots, b$), $\sum_{j=1}^b p_j = 1$

Now, from the customer’s point of view, we can formulate a mathematical model that expresses which type of check card to choose and how much to spend on which benefits in order to maximize his/her benefits, with the following relevant constraints:

$$\max \sum_{i=1}^c \sum_{j=1}^b (p_j \beta_{i,j} n_{i,j} X_{i,j} (1 - Z_{i,j}) + p_j \gamma_{i,j} Z_{i,j}) \tag{1}$$

$$u_{i,j}^- \leq X_{i,j} \leq u_{i,j}^+ \text{ for } i = 1, 2, \dots, c, j = 1, 2, \dots, b \tag{2}$$

$$\sum_{j=1}^b (\beta_{i,j} n_{i,j} X_{i,j} (1 - Z_{i,j}) + \gamma_{i,j} Z_{i,j}) \leq s_{i,1} W_{i,1} + s_{i,2} W_{i,2} + s_{i,3} W_{i,3} \text{ for } i = 1, 2, \dots, c \tag{3}$$

$$\sum_{i=1}^c \sum_{j=1}^b n_{i,j} X_{i,j} \leq h \tag{4}$$

$$\sum_{i=1}^c V_i \leq m \tag{5}$$

$$\sum_{i=1}^c n_{i,j} \leq n_{\max} \text{ for } j = 1, 2, \dots, b \tag{6}$$

$$Z_{i,j} = \begin{cases} 1, & \text{if } \beta_{i,j} n_{i,j} X_{i,j} \geq \gamma_{i,j} \\ 0, & \text{otherwise} \end{cases} \text{ for } i = 1, 2, \dots, c, j = 1, 2, \dots, b \tag{7}$$

$$V_i = \begin{cases} 1, & \text{if } \sum_{j=1}^b X_{i,j} > 0 \\ 0, & \text{otherwise} \end{cases} \text{ for } i = 1, 2, \dots, c \tag{8}$$

$$W_{i,1} = \begin{cases} 1, & \text{if } \sum_{j=1}^b n_{i,j} X_{i,j} < d_{i,1} \\ 0, & \text{otherwise} \end{cases} \text{ for } i = 1, 2, \dots, c \tag{9}$$

$$W_{i,2} = \begin{cases} 1, & \text{if } d_{i,1} \leq \sum_{j=1}^b n_{i,j} X_{i,j} < d_{i,2} \\ 0, & \text{otherwise} \end{cases} \text{ for } i = 1, 2, \dots, c \tag{10}$$

$$W_{i,3} = \begin{cases} 1, & \text{if } d_{i,2} \leq \sum_{j=1}^b n_{i,j} X_{i,j} \\ 0, & \text{otherwise} \end{cases} \text{ for } i = 1, 2, \dots, c \tag{11}$$

(1) represents an objective function that maximizes benefits. The first term is a case where the amount of benefits does not reach the maximum amount, which can be expressed as a product of weight, discount rate, number of uses, and total payment amount, while the second term is a case where the discount amount reaches the cap and no further discount is offered, so the benefit is provided at the maximum discount. (2)-(6) show the constraints. (2) means that in order to receive benefits provided by card companies, the amount used must fall within the range of the amount set by the card company. (3) represents a constraint that the sum of the benefits provided by a single card company cannot exceed the maximum value of the benefits provided by the card. The amount of benefits offered changes depending on the total monthly payment, which is classified into three ranges. (4) restricts the maximum amount a customer can spend for month. In (5), the number of cards a customer can hold is limited. (6) represents that the number

of uses for any one particular benefit cannot be used indefinitely. (7)-(11) represent an indicator function whose value is 1 if the condition is satisfied and 0 otherwise.

The purpose of this study is to propose the best way to select and use a check card by determining the payment amount $X_{i,j}$ for the benefits provided by credit card company in (1) in order to maximize the total benefits under the given constraints.

3. Numerical Experiments. In this section, we conduct some numerical experiments to verify the mathematical model established in the previous section, and based on the numerical results we derive the best way to select and use check cards to maximize the benefits. Five types of check cards, thirteen types of benefits for each card, and the maximum discount amount depending on the monthly payment amount is introduced in the numerical experiment, the details of which are shown in Table 1. The numerical experiments are conducted for the following three scenarios with two different types of card that a customer can hold.

Scenario 1: Monthly payment amount is less than 500,000 won.

Scenario 2: Monthly payment amount is less than 700,000 won.

Scenario 3: Customer's preference for the benefits (primary public transport, secondary shopping) when monthly payment amount is less than 500,000 won.

The numerical results obtained by the optimization software 'LINGO10.0' for each scenario are shown in Table 2.

The meanings of the results in Table 2 are as follows.

1) Scenario 1. It is best to use two cards to pay 300,000 won with a Kookmin Bank check card to receive a benefit of 20,000 won, and for 200,000 won to receive a benefit of 10,000 won by using a Woori Bank check card; as a result, the total benefit of 30,000 won can be received.

2) Scenario 2. When the monthly usage amount is 700,000 won, it is best to pay 500,000 won with Kookmin Bank's check card to receive a benefit of 30,000 won and 200,000 won with Woori Bank's check card to receive a benefit of 10,000 won; as a result, the total benefit of 30,000 won can be received. Card payment is made for 11 kinds of benefits, which are two more benefit compared to Scenario 1. Except for the two types of benefits, music streaming app and the delivery app, the card payment is made for all benefits. This means that as the total spendable amount increases, the card must be used for various types of benefits in order to receive greater benefits.

3) Scenario 3. Unlike Scenarios 1 and 2, the most preferred benefit is assumed to be the benefit of public transportation with the weight of 0.9. In this case, it is the best to use Kookmin and Shinhan Bank's check card. The reason why the Shinhan card is chosen over Woori card is that Shinhan Bank's 3,000 won discount has a comparative advantage over Woori Bank's 2,000 won discount. In addition, Woori Bank's check card and Kookmin Bank's check card have the same discount on public transportation of 2,000 won, but Kookmin Bank's check card seems to have been selected because the maximum discount amount is larger than Woori Bank's check card. Therefore, Scenario 3 can benefit from 25,000 won, which is 5,000 won less than Scenario 1, but the most preferred benefit from the public transportation increases by 1,000 won.

4. Conclusions and Considerations. Although check cards are gaining great popularity among young Koreans, research on check cards itself is still lacking, and studies on optimizing the benefits of check cards have not been conducted so far. In this study, we formulated a mathematical model that maximizes the benefits of check cards mainly used by college students. Based on this, a numerical experiment was conducted to verify our model and the best way of using a check card in order to maximize the discount benefits according to the benefits preference and the monthly usage amount was suggested. From the results of the numerical experiment, we have the following. 1) Using 500,000 won or

TABLE 1. The details of benefits for five check cards

Benefits	Kookmin Bank	Woori Bank	Nonghyup Bank	Shinhan Bank	IBK Bank
1. Shopping	X	Using more than 20,000 won, 2,000 won discount (maximum 6,000 won) (Additional) Using Naver, Kakao, Payco Pay for more than 10,000 won, 1,000 won discount (maximum 2,000 won)	Using more than 20,000 won, 2,500 won discount (maximum 8,000 won)	Using more than 20,000 won, 1,000 won discount on large supermarket (maximum 5,000 won)	Using more than 10,000 won, 10% discount on COUPANG (maximum two times)
2. Delivery app	X	X	Using more than 10,000 won, 1,000 won discount (maximum 6,000 won)	X	X
3. Convenience store	Using more than 10,000 won, 5% discount on GS25	Using more than 10,000 won, 1,000 won discount on CU, GS25 (maximum 2,000 won)	Using more than 10,000 won, 1,000 won discount (maximum 3,000 won)	Using more than 10,000 won, 1,000 won discount (maximum 5,000 won)	5% discount (maximum 10,000 won)
4. Music streaming	X	X	Using less than 1,000 won, maximum 1,000 won discount	X	X
5. Family restaurant	20% discount using between 30,000 won to 50,000 won	X	X	X	X
6. Cafe	Using more than 10,000 won, 20% discount on Starbucks coffees	Using more than 10,000 won, 2,000 won discount on Starbucks coffees (maximum 8,000 won)	Using more than 10,000 won, 20% discount on Starbucks Ediya coffees (maximum 3,000 won)	Using more than 10,000 won, 1,000 won discount on Starbucks coffees (maximum 5,000 won)	10% discount (maximum 10,000 won)
7. Cinema	Using more than 10,000 won, 35% discount on CGV ticket prices	Using more than 15,000 won, 5,000 won discount on CGV, Lotte Cinema ticket prices	Using more than 10,000 won, CGV 2,000 won discount	Using more than 20,000 won, 5,000 won discount on CGV ticket prices	Using more than 10,000 won, 4,000 won discount
8. Amusement park	50% discount using between 30,000 won to 50,000 won	X	50% discount	X	50% discount
9. Bookstore	50% discount using between 20,000 won to 50,000 won	X	Using more than 20,000 won, 2,500 won discount (maximum 8,000 won)	X	X
10. Language test	X	Using more than 30,000 won, 3,000 won discount on YB-M, Hackers Academy (maximum 6,000 won)	Using more than 20,000 won, 2,500 won discount on TOEIC, TEPS, JPT, KPE examination fee	X	X
11. Phone bill	Using more than 50,000 won, 2,500 won discount	X	Using more than 50,000 won, 2,500 won discount	Using more than 50,000 won, 2,000 won discount	X
12. Public transport	10% discount on total public transportation, up to 20,000 won	Using more than 50,000 won, 2,000 won discount	X	5% discount (maximum 3,000 won)	Discount of 100 won per use (maximum 1,000 won)
13. etc.	X	X	X	Using more than 20,000 won by Samsung Pay and Shinhan Pay, 1% discount (maximum 5,000 won)	X
Monthly usage/total maximum discount	Over 200,000 won/10,000 Over 300,000 won/20,000 Over 500,000 won/30,000	200,000~500,000/8,000 Over 700,000 won/28,000 (Additional discounts are not included in the limit)	200,000~400,000/4,000 400,000~600,000/13,000 600,000~1,000,000/22,000 Over 1,000,000 won/35,000	200,000~500,000/5,000 500,000~800,000/10,000 800,000~1,000,000/20,000 Over 1,000,000 won/30,000	300,000~500,000/5,000 Over 500,000 won/10,000

TABLE 2. Numerical experiment results

Scenarios Benefits	Scenario 1		Scenario 2		Scenario 3	
	Kookmin	Woori	Kookmin	Woori	Kookmin	Shinhan
Selected card						
1. Shopping	X	40,000 * 2 = 80,000	X	20,000 * 3 = 60,000	X	35,000 * 4 = 140,000
2. Delivery app	X	X	X	X	X	X
3. Convenience store	18,000 * 3 = 54,000	10,000 * 1 = 10,000	20,000 * 3 = 60,000	10,000 * 2 = 20,000	20,000 * 3 = 60,000	-
4. Music streaming	X	X	X	X	X	X
5. Family restaurant	47,000 * 2 = 94,000	X	50,000 * 1 = 50,000	X	50,000 * 1 = 50,000	X
6. Cafe	10,000 * 2 = 20,000	-	20,000 * 4 = 80,000	10,000 * 2 = 20,000	13,500 * 1 = 13,500	-
7. Cinema	-	30,000 * 1 = 30,000	20,000 * 2 = 40,000	-	20,000 * 1 = 20,000	-
8. Amusement park	-	X	50,000 * 1 = 50,000	X	-	X
9. Bookstore	-	X	50,000 * 2 = 100,000	X	23,800 * 1 = 23,800	X
10. Language test	X	30,000 * 2 = 60,000	X	40,000 * 2 = 80,000	X	X
11. Phone bill	82,000	X	70,000	X	83,700	-
12. Public transport	50,000	-	50,000	-	50,000 (2,000)	60,000 (3,000)
13. etc.	X	10,000 * 2 = 20,000	X	10,000 * 2 = 20,000	X	-
Payment amount/ total benefits	300,000/ 20,000	200,000/ 10,000	500,000/ 30,000	200,000/ 10,000	300,000/ 20,000	200,000/ 5,000

700,000 won per month can receive 30,000 won and 40,000 won per month, respectively, using two check cards from Kookmin Bank and Woori Bank. 2) In a situation where college students put the high priority on the public transportation benefits, using Shinhan Card instead of Woori Bank's check card reduces the total benefits, but maximizes the benefits from public transportation.

If the check card benefit optimization model proposed in this study is used as a basic algorithm for developing personalized applications, it could help check card users with various usage behaviors to make reasonable consumption decisions.

In this study, since the mathematical model was formulated based on only the check card benefits provided by five card companies, considering credit card benefits or check card benefits from more than five card companies can be an interesting topic to be tackled in the future.

REFERENCES

- [1] H. J. Cho, *Electronic Payment Theory*, Keimyung University Press, 2004.
- [2] D.-Y. Jung, *Research and Development of Check Card Design Reflecting the Life-Style of Youth*, Master Thesis, Ewha Womans University, 2010.
- [3] M. R. Kim and K. O. Kim, Consumers' attitudes and perceptions on credit and check cards and determinants of card usages, *Sungkyunkwan University*, vol.15, pp.53-78, 2012.
- [4] D. P. Hoang and T. H. Vu, Debit card usage as a rational choice: The moderating effect of cash habit, *Journal of Economic Development*, vol.45, no.1, pp.159-183, 2020.

- [5] L. Hernandez, N. Jonker and A. Kosse, Cash versus debit card: The role of budget control, *The Journal of Consumer Affairs*, vol.51, no.1, pp.91-112, 2017.
- [6] K. Kang, H. Lee, M. Jin, Y. Choi and C. Park, Study on actual status and influential factors on satisfaction of college students' use of check card, *Journal of Korean Data and Information Science Society*, vol.31, no.2, pp.365-374, 2020.
- [7] Y.-S. Kim, A path analysis of attitudes toward credit cards, financial management practices, and sound credit card use among college students, *Journal of Korean Home Management Association*, vol.23, no.5, pp.15-26, 2005.
- [8] Financial Services Commission, *Comprehensive Plan for Data Utilization and Information Protection in the Financial Sector, Meeting for Data Utilization and Information Protection in the Financial Sector*, <http://125.61.91.238:8080/SynapDocViewServer/viewer/doc.html?key=000000007f2a25c70186978352473c3e&convType=img&convLocale=ko&contextPath=/SynapDocViewServer>, 2018.
- [9] J. B. Guk, A study on the use patterns and the importance of brand design for check card by university students, *Design Research*, vol.4, no.3, pp.268-279, 2019.
- [10] H. Yoon, M. Shin and S. Jung, A study on college students' credit cards and check card usage, financial management attitudes and behaviors, *Financial Planning Review*, vol.5, no.3, pp.59-88, 2012.
- [11] S.-H. Joo, J. E. Grable and D. C. Bagwell, Credit card attitudes and behaviors of college students, *College Student Journal*, vol.37, no.3, pp.405-419, 2005.
- [12] C.-Y. Lee, C. K. Morewedge, G. Hochman and D. Ariely, Small probabilistic discounts stimulate spending: Pain of paying in price promotions, *Journal of the Association for Consumer Research*, vol.4, no.2, pp.160-171, 2019.
- [13] T. Bringlevics and O. Shy, Why don't most merchants use price discounts to steer consumer payment choice?, *Review of Industrial Organization*, vol.44, pp.367-392, 2014.
- [14] C. Arango, K. P. Huynh and L. Sabet, Consumer payment choice: Merchant card acceptance versus pricing incentives, *Journal of Banking & Finance*, vol.55, pp.130-141, 2015.