경영학석사 학위논문

The effect of discount coupons on lead time driven cancellations

2021년 8월

서울대학교 대학원

경영학과 생산관리전공

이 재 상

The effect of discount coupons on lead time driven cancellations

지도교수 양 홍 석

이 논문을 경영학 석사학위논문으로 제출함
2021년 8월

서울대학교 대학원
경영학과 생산관리전공
이 재 상

이재상의 석사학위논문을 인준함
2021년 8월

위 원 장 ________ 남 익 현 ________
부위원장 ________ 박 상 욱 ________
위 원 ________ 양 홍 석 ________

Abstract

Delivery is one of the key success factors in operations management. However, firms may be difficult to deliver products to customers on time because of meagre production system if there is an increase of orders due to popularity. This may cause customers to cancel their orders, which are a loss in profit. Therefore, this paper by providing discount coupon, tries to minimize firms' loss. The aims of this study are: 1) to examine how helpful coupon is to the profit in order cancellation situation; 2) to determine the optimal level of discount coupon; and 3) when should firms introduce coupons. This paper, therefore, first find the expected number of order cancellations by using nonhomogeneous Poisson process. Second, by introducing discount coupon with multivariate probability function, profit function will be structured. Then, analysis on the optimal level of discount coupon and point when to introduce discount coupon will be carried out. In addition, by numerical analysis, a trend of optimal level change by time period will be looked. In conclusion, offering coupon to the customers helps a firm to minimize its loss of profit. However, if popularity does not settle down, discount coupon loses its advantage because lead time keep increasing. This paper gives insight of how managers should respond to the situation where order cancellations occur due to the long lead time by considering discount coupon to maximize their profit. For academic insight, this paper offers a broader research on profit maximization by jointly thinking coupon and order cancellation due to lead time.

Keyword : *Sale Promotion; Coupon, Profit Maximization, Order Cancellation, lead time*

Student Number : 2019-21062

Table of Contents

List of Tables

List of Figures

Chapter 1. Introduction

It is important to align sales and operation planning since better balance of supply and demand brings benefits to firms (Wagner et al., 2014). Good balance will allow the firm to deliver the product to customer at promised time. This is important in operations management since delivery is one of the key success factors in operations management. As technology improves, expected and promised lead time gets shorter. In 2021, Amazon offers products to be delivered to the customers within 2 hours by Amazon prime service. This requires advanced knowledge not only in forecasting demand but also in establishing production systems to meet such demand.

However, not all companies have an established production system in place. Problems arise because of not well established production system. For instance, an online fashion commerce company may not able to deliver a product to consumers on time due to sudden product popularity. Consumers, who do not get their products at promised time may get frustrated and therefore cancel their orders. Losing customers because of order cancellations shows that the ability to reduce the total lead time for product customization is important (Jiao et al., 2008). This can be a critical issue and therefore bring a huge loss in industry. Order Cancellation also means loss in profits.

There are mainly two solutions for this problem. First, firms can improve the production system. However, this process costs high and takes time. Second, the firms can persuade people who cancelled the order by offering discount coupon. For situations when the firms cannot meet their demands at the present moment, the latter solution can be considered to be more ideal.

In this circumstances, providing discount coupon is not a perfectly good solution. It is because consumers can receive discount in price, but from the retailer's point of view, retailers try to minimize losses while reducing their own potential profits. Therefore, whether firms should introduce discount coupon to minimize their losses in profit or not is what this research aims to address. Specifically, the optimal level point of discount coupon will be found by modeling and numerical analysis.

This paper provides insights academically and to managerial level. From academic point of view, this paper extends study related with discount coupon and order cancellation. It considers the relationship and effects between discount coupon and order cancellation on profit. Whereas, from managerial view, this paper provides directions of what reactions have to be done when managers encounter a situation where order cancellations occur due to increased lead time.

This paper is organized as follow. First, previous works related with order cancellation and discount coupon will be reviewed. Second, a model, investigating the effect of discount coupon will be structured. Third, by assuming a special given situation, the model will be numerically analyzed and the value of optimal coupon level will be shown. Last, conclusion and discussion will be drawn.

Chapter 2. Literature Review

Literature review related with this paper is essential since discount coupon and order cancellation with lead time are one of key topics in marketing and operations management respectively. Thus, by literature review, this chapter will explain how this paper is distinctive compared to past studies and how this paper contributes to such field. Review will be done by looking at two areas, which are discount coupon and order cancellation. Overview of review can be shown as a figure below:

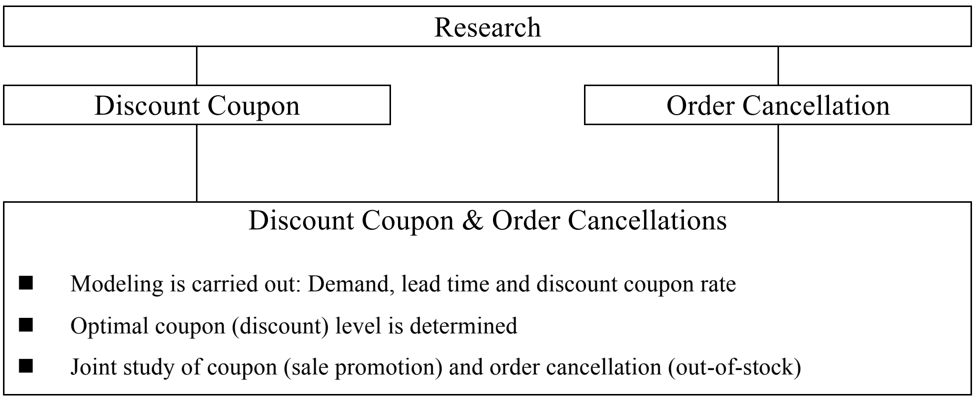

Figure 1. Overview of literature

2.1. History of discount coupon

Study on coupons has a long history. It has been kept investigated more than 40 years. The ultimate goal of the coupon is to increase and to maximize the profit of a firm like other types of sale promotion. Scholars investigated whether the coupon promotion actually helped the firms or not. Procedures of how to estimate the net profit coupon brings to firms were modeled (Neslin and Shoemaker, 1983). Later Leone (1996) evaluated impact of coupon on brand sales.

It has been found that coupon played a vital role in maximizing profit for firms. Despite the researchers' efforts to structure model for the profit maximization, number of algorithms and models for profit maximization are still insufficient. Reviews on increase in profit maximization by considering other factors of coupon include Raghubir (2004), Su et al. (2014) and Liu et al. (2020). Dark sides of the coupon sale promotion Davis et al. (1992) and Neslin and Shoemaker (1989) were tested to check actual usefulness of coupon. There was no decrease in profit and no devaluation on the brand

Beside studies related with profit maximization, many studies looked into the general broad concept of coupons. Yin and Dubinsky (2004) found coupon face value in different forms. Those forms are cents off, percentage off and reduced price. In this paper, the form with percentage off is handled. Furthermore, the relationship between consumer and coupon has been explored. One of the widely known terms is coupon redemption studies exist Bawa et al. (1997), Reibstein and Traver (1982), Swaminathan and Bawa (2005), Clark et al. (2013) and Nayal and Pandey (2020). Construction from psychological view also exist (Lichtenstein et al., 1990).

Although many studies exist related with coupon, studies considering coupon and order cancellations are limited. Optimal level of discount coupon has been analytically determined by Jiang and Jiang et al. (2012) and Shaffer and Zhang (1995). However, order cancellation has been considered. This paper differentiates from determining the level of coupon considering coupon and order cancellations together analytically.

2.2. Order cancellation and lead time related studies

Unlike discount coupon, history of cancellation is not very long. Many studies trying to find why cancellations occur and what factors lead customers to change their decision. However, yet studies focusing on consumer cancellation behavior are limited. Since, cancellations occur in many various industries, it can be thought an important topic in academic. For example, Li et al. (2019) predicted number of cancellations and no-shows in hospital by constructing an algorithm. Similar study was carried out by Zhang et al. (2018) but in different situations, cancellations and return order in Omni-channel. This paper deals with only order cancellations, not other forms of order cancellation like returning product. Since cancellations directly affect the profit of a firm, studies related with profit management/maximization exist. Wang and Truong (2018) introduced online scheduling considering consumer cancellation. In addition, Dai et al. (2019) structured optimal profit management system for airline industries by considering no shows and cancellations.

Researches on order cancellation due to lead time also exist separately from coupon considering supply chain systems (Treville, 2014 and So and Zheng, 2003). Negative relationship between wanting to buy items with increase in delivery time has been studied by Milkman et al. (2010), Lin et al. (2020) and Wang et al. (2020). Similar to delivery time, out of stock situation with order cancellations were done Son et al. (2019) and Xu et al. (2021). Further extension about the penalty cost due to long lead time was analytically investigated by Lim et al. (2012) applying Poisson process, which is a similar approach to this paper. However, again, factor of coupon was not included in the model and the order cancellations were calculated random size.

This research plans to extend by jointly considering two important factors determining profit: sales promotion and order cancellation due to lead time by analytic modeling. It aims to concentrate on the optimal level of discount coupon to maximize firm's profit in a situation where order cancellations occur because of failures in promised delivery time.

Although, factors such as return, initial coupon cost, information cost and cancellation due to simple change of mind, which brings changes to profit, are not considered in order to determine the optimal level of discount coupon rate, this paper has meaningful contribution to the literature by extending studies related with profit maximization and collapsing a barrier by jointly thinking two topics together

Summary of Relevant Discount Coupon Literatures

Author	Year	Finding	Relevant	Missing / Limit
Neslin and Shoemaker	1983	Direct mail coupon was effective in profit increase Promotions have immediate impact on the market.	Coupon helps profit to increase	Order Cancellation missing Coupon Level missing
Lichtenstein et al.	1990	Coupon proneness on the value consciousness (Studied from psychological view)	Understanding of coupon	
Inman	1992	No decreases in the test score for brand. No devaluation on brand	Coupon has positive effect	
Shaffer and Zhang	1995	Analytic work to examine the effect of targeting on firm profits and coupon face values Media and targeted coupons were complementary	To think about game strategy How coupon appeals to consumers	Game Theory not considered Order Cancellation missing Coupon Level missing
Leone and Srinvasan	1996	Coupon played a vital role in maximizing profit for firms	Coupon helps profit to increase	Order Cancellation missing Coupon Level missing
Raghubir,	2004	Information brings positive impacts	Understanding of coupon	
Yin and Dubinsky	2004	Coupon face value exist in three forms (cents off, % off, reduced price)		
Reistein and Traver Bawa et al. Swaminathan and Bawa Clark et al. Nayal and Pandey	1982 1997 2005 2013 2020	Coupon proneness considering individuals' characteristics Factors motivating consumers to use coupons Electric coupon redemption		
Jiang and Liu	2012	Optimal discount price using probability model	Discount level/ Profit maximization	Order Cancellation missing Substitution considered
Su et al.	2014	Coupon trading increase in the profit	Understanding of coupon	Coupon trading not considered Order Cancellation missing Coupon Level missing
B.Liu et al.	2020	Price to initiate considered in profit maximization Profit function cannot be always be monotone function	Coupon helps profit to increase	Initiate cost set as 0 Order Cancellation missing Coupon Level missing

Table 1. Summary of discount coupon related Literatures

Summary of Relevant Order Cancellation/Lead Time Literatures

Author	Year	Finding	Relevant	Missing / Limit
Milkman et al.	2010	Delivery increases, the lower percentage of want item	Long lead time negative effect	Concept of Coupon is missing
So and Zheng	2003	Analytical model on two factors; order quantity and lead time	Order demand and lead time	
Treville et al.	2014	Optimizing production considering volatility and lead time	Importance of Lead time	
Lim et al.	2012	determine the penalty cost of long lead time in system with stochastic demand and order cancellation returns of random size	Long lead time brings order cancellation Poisson Process used in the model	
Zhang et al.	2018	Omni channel with order cancellations before payment and return after payment strategy is not always beneficial to the retailer. Conditions under which retailer benefit from the Omni channel retailing strategy.	Order cancellations occurs Number of order cancellations	Omni-channel is not dealt Return of product not dealt Concept of Coupon is missing
Li et al.	2019	Predicted number of cancellations and no shows at hospitals by setting up an algorithm		
Son et al.	2019	Out-of-stock amounts have a negative impact	Order cancellations occurs because of out-of-stock	Concept of Coupon is missing Delivery time not modeled
Lin et al.	2020	Delivery increases, the lower percentage of want item	Delivery times get longer, wanting to buy product decreases	
Wang et al.	2020	Study of customer confirmed-order cancellation behavior on couple ride-sourcing and taxi markets	Order cancellations occurs Number of order cancellations	Concept of Coupon is missing
Xu et al.	2021	Empirical test form an on-demand service platform on cancellation concentrating on waiting time	Long lead time brings order cancellation	Concept of Coupon is missing

Table 2. Summary of Order cancellation/Lead Time related Literatures

Chapter 3. Model Development

In this chapter, the model will be developed step by step. First, the basic profit function, π_1, will be set. Second, new profit function considering order cancellations, π_2, will be developed. Third, profit function with introduction of discount coupon, π_3, will be constructed. For better understanding, situation which this paper deals with will be specifically explained with an overview of notations and assumptions used in developing a model.

3.1 Case dealing in the model

Suppose make-to-order company launches a product. Before, launching such product, the company would have forecasted the demand. However, for whatever reason, such product may gain popularity. Due to popularity, the company may face a problem. A company cannot meet the orders at the right time as shown below:

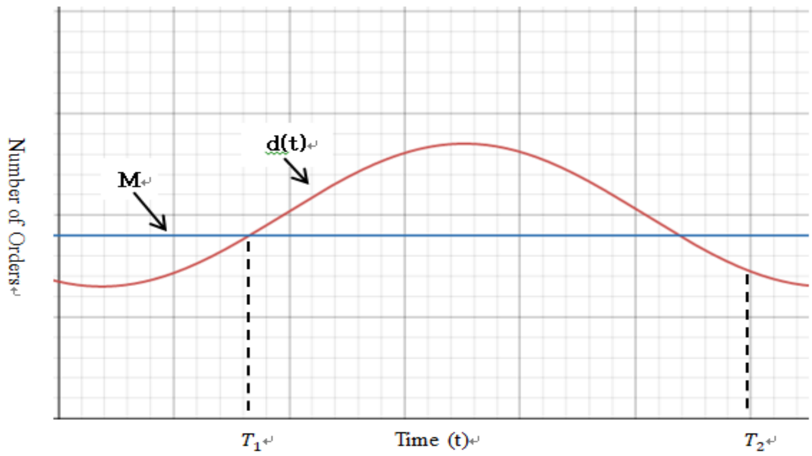

Figure 2. Picture of Case dealing in the Model

From the figure 2, T_1 represents the start point where orders hit the maximum capacity and T_2 represents the point where popularity starts to fade away but lead time is still not met at promised time due to back logging. The point, T_2, where popularity starts to fade away is when orders go under the maximum capacity. Therefore, T_2 has following two characteristics. First, $d(T_2) < \mathrm{M}$. Second, due to back logging, $\int_{T_1}^{T_2}[d(t) - M]dt > 0$. With the demand function, $d(t)$, point T_2 satisfying such conditions can be determined.

Therefore, from to T_1 to T_2, demand orders exceeds the maximum amount of productions thus firm cannot meet the promised lead time. This leads to increase in lead time. Popularity will disappear eventually and thus the situation will get under controlled. However, from T_1 to T_2, where lead time is longer than customers have expected, order cancellations might occur because customers get frustrated waiting too long.

Discount coupon will be introduced to people who are announced to wait in order to persuade people who decide to cancel their orders thus increase the profit. This paper considers the situation where total number of orders are over the capacity. Therefore, T_1, the start point where orders hit the maximum capacity can be considered as 0 without loss of generality. T_2, can be considered as T. Therefore, T denotes $T_2 - T_1 = T - 0$. For tractability, in setting the model, T_1 and T_2 will be denoted as 0 and T respectively.

Though the situation this model is dealing has specific setting, it is not abnormal. This situation can occur in real life. For example, a company which produces a customized product, which can be made after the order has been placed, has maximum number of productions each day. Such product gained popularity because of many reasons such as social networking service, which many people use nowadays. Therefore, the company could not meet the orders at their general promised time. However, after certain time, the popularity declined. There are many similar situations thus not abnormal.

By applying this specific situation, assumptions and settings could be structured in order to develop a model for this paper. The settings can be organized as following with notation and assumption tables:

3.1.1 Notation

Notation	Description
$d(t)$	Demand at t
p	Price of the product
c	Production cost
π	Profit of the firm
F	Fixed cost
$l(d(t), M)$	Lead time at t
T	$T_2 - T_1 = T - 0$
M	Maximum number of products firm can produce at t
$\lambda(l(d(t), M))$	Rate of order cancellations due to lead time at t
$N(T)$	Number of order cancellation by T
$prob(\beta, l(d(t), M))$	Probability function of acceptance of discount coupon
β	Level of discount coupon
$w(t)$	Number of waiting customer at t

Table 3. Notations for the model

Demand function, $d(t)$, in this paper will be a continuous function for t. $d(t)$ shows the number of orders at t. Therefore, demand function in this paper denotes the relationship between number of orders and the time. The curve of the function explains the trend or cycle of the popularity.

Unlike product life cycle (Levitt, 1965), yet popularity cycle of a product is not completely established. There are many factors which affect popularity of a certain product. Therefore, demand function in this paper is not dealt stochastically but will be given by considering the trend of popularity. It can be quadratic, exponential or logistic function. In numerical analysis, demand function will be set by past literature and trend will be looked.

Lead time function is determined by demand function and constant M. Lead time function is automatically found after demand function is set. Using demand function and M, lead time function can be expressed as function for t. Therefore, composition of function that takes d, M and l and produces lead time function, $l(d(t), M)$, will be done. Therefore, it is notated as $l(d(t), M)$.

Order cancellations in this paper occur because customers get frustrated waiting too long. Therefore, order cancellations intensity function is for $l(d(t), M)$. Again, composition of function that takes two functions l and λ and produces a function $\lambda(l(d(t), M))$ will be done. Therefore, it is notated as $\lambda(l(d(t), M))$.

Lastly, β, level of discount coupon, states the discount coupon level as a fraction of margin. For example, if $\beta = 0.9$, the price of the product with the discount coupon is $0.9 \times p$.

3.1.2 Assumption

In order to structure the model for the situation dealt in this paper, some assumptions were needed for logical explanations. Assumptions were made with comprehensive consideration of situations that can occur in nature and assumptions were organized as following table:

No	Assumptions
1	$\int_0^T [d(t) - M]dt > 0$
2	$d(t)$, $l(d(t), M)$, $\lambda(l(d(t), M))$ are continuous functions
3	When product is delivered at promised time, customers do not cancel their orders
4	$prob(\beta, l(d(t), M)) = k\frac{1-\beta}{l(d(t),M)}$ where range of k is from 0 to $\frac{l(d(t),M)}{1-\beta}$
5	Number of order cancellations is rational number. Does not have to be integer
6	Discount coupon initiating cost is set as 0
7	Discount coupon trading not considered. Only customers who are to wait can use coupon
8	Discount coupon is given once with same value

Table 4. Assumptions for the model

3.2. Basic profit function

Given that there is no order cancellation, basic profits function of a firm (Cowling and Waterson, 1976) with a product from 0 to T can be expressed as:

$$\pi_1 = \int_0^T d(t)dt \cdot p - \int_0^T d(t)dt \cdot c - F$$

Since $d(t)$ denotes the number of orders at t, $\int_0^T d(t)dt$ represents the total number of orders from 0 to T. Integrating function from 0 to T with respect to t represents the area below the function from 0 to T. Such area represents the total number of orders from 0 to T. Thus, if the firm did not have any order cancellations then the profit would have been π_1.

3.3. Profit with order cancellation

When the orders exceed the firm's capacity due to popularity, consumers have to wait longer than they have expected or were promised, the delivery time. To find the loss of profit due to order cancellation, the expected number of order cancellations has to be found.

In this paper, order cancellations follow nonhomogeneous (non-stationary) Poisson process with rate $\lambda(l(d(t), M))$ (Ross, 2007). Order cancellations satisfy the definitions and conditions for Poisson process. First, number of order cancellations at $l(d(t), M) = 0$ is zero. Second, order cancellations have independent increments. Homogeneous Poisson process could not be used in this paper since longer the customer's waiting time, more likely to cancel the order (Xu et al., 2021). Therefore, for nonhomogeneous Poisson process with rate $\lambda(l(d(t), M))$, the number of order cancellations from 0 to T, $N(T) - N(0)$, is a Poisson random variable, which can be written:

$$N(T) \sim \text{Pois}\left(\int_0^T \lambda(l(d(t), M))dt\right)$$

By using properties of Poisson distributed random variable, expected number of order cancellations can be derived as follow:

$$E[N(T)] = \int_0^T \lambda(l(d(t), M))dt$$

where, the maximum number of $E[N(T)]$, expected number of cancellations, cannot be larger than the number of waiting orders .

Like mentioned above, $l(d(t), M)$ is automatically found after demand function is set. Using demand function and M, lead time function can be expressed as function for t. $l(d(t), M)$ can be found by dividing numbers of waiting customers with the maximum capacity a firm can make (M). Therefore, it can be expressed as follow:

$$l(d(t), M) = \frac{\int_0^t [d(x) - M] dx}{M}$$

From the expression, we can derive the number of waiting customer:

$$w(T) = \int_0^T [d(t) - M] dt$$

This expression will be used when showing the trend of optimal discount coupon level in numerical analysis in Chapter 4. With expressions above, a new profit function, π_2, can be derived by extending π_1. From existing equation of π_1, we will subtract the expected number of order cancellations due to the long lead time. This can be expressed as follow:

$$\pi_2 = \int_0^T [d(t) - \lambda(l(d(t), M))] dt \cdot p - \int_0^T [d(t) - \lambda(l(d(t), M))] dt \cdot c - F$$

3.4. Profit with discount coupon

To investigate the aim of this study, the profit function when discount coupon is introduced to solve the problems of order cancellations due to lead time has to be structured. Discount coupons will be distributed so that customers do not cancel theirs orders. This will therefore decrease the loss in profit. For the fairness, discount coupons will be given to all customers who are announced to wait with the same amount of value.

Customers who are to wait more than they have expected have two choices after discount coupon is offered. They can either accept the discount coupon then wait for their products to arrive or they can cancel their order by refusing to accept discount coupon. Whether they accept or not, can be expressed in probability function. Thus, probability function of acceptance given discount coupon level β and lead time $l(d(t), M)$ can be expressed as:

$$prob(\beta, l(d(t), M)) = k \cdot \frac{1-\beta}{l(d(t), M)}$$

The probability function has been expressed as multivariate since the probability changes by both lead time and the amount of discount coupon customers are offered. Considering the factors given above, new profit function with such situation is structured. Figure 3 shows the overview of the situation:

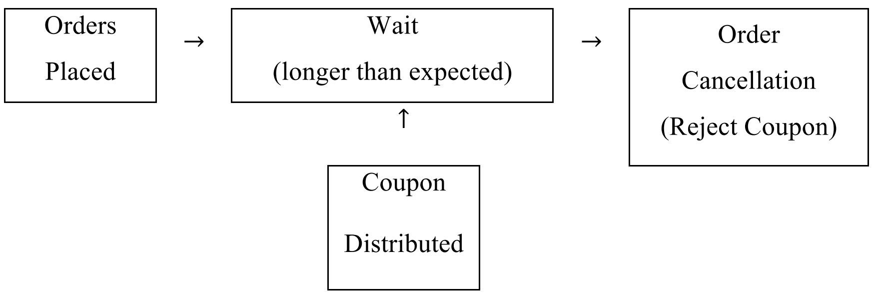

Figure 3. General picture of situation π_3

Therefore, by considering this new factor, the profit equation after the introduction of discount coupon can be expressed as follow:

$$\pi_3 = \int_0^T [d(t) - \lambda(l(d(t), M)) \cdot (1 - prob(\beta, l(d(t), M)))]dt \cdot (p - c) - \left(\int_0^T [d(t) - M]dt\right)(1 - \beta)p + \int_0^T [\lambda(l(d(t), M)) \cdot (1 - prob(\beta, l(d(t), M))]dt \cdot (1 - \beta)p - F \text{ where } 0 \leq \beta \leq 1$$

π_3 represents the profit after discount coupon is introduced. $\int_0^T [d(t) - \lambda(l(d(t), M)) \cdot (1 - prob(\beta, l(d(t), M)))]dt$ is the total number of customers who decided to buy the product from 0 to T. Number of customers who decided to reject the offered discount coupon and cancel their orders has been subtracted from the total demand. $\left(\int_0^T [d(t) - M]dt\right)(1 - \beta)p$ indicates the total value of discount coupons given out to people who are announced to wait. It includes customers who decide not to buy in the final. $\int_0^T [\lambda(l(d(t), M)) \cdot (1 - prob(\beta, l(d(t), M))]dt \cdot (1 - \beta)p$ is added since customers, who do not buy the product in the final, the discount coupon has not been distributed. Thus, such amount of loss should be recovered.

This studies tries to find at what discount coupon level of β, π_3 gets maximized. Without any doubts, it is clear that π_3 is smaller than π_1 because of order cancellations. However, whether π_3 is smaller or bigger than π_2 depends on the role of discount coupon introduction. If $\pi_3 < \pi_2$, then role of discount coupon is useless. However, if it is the opposite case, then it is clear that discount coupon is economically beneficial thus adoption of discount coupon is mandatory.

In chapter 4, an analysis will be carried out at what point is the optimal level of β which maximizes the profit. Thus managers can minimize their loss.

Chapter 4. Model Analysis

In this chapter, analysis on the model structured from Chapter 3, $\pi_3 = \int_0^T [d(t) - \lambda(l(d(t), M)) \cdot (1 - prob(\beta, l(d(t), M)))]dt \cdot (p - c) - \left(\int_0^T [d(t) - M]dt\right)(1 - \beta)p + \int_0^T [\lambda(l(d(t), M)) \cdot (1 - prob(\beta, l(d(t), M))]dt \cdot (1 - \beta)p - F$, will be carried out. For the convenience of the model analysis, the paper will assume that $prob(\beta, l(d(t), M)) = k \cdot \frac{1-\beta}{l(d(t),M)}$. Thus, $\pi_3 = \int_0^T \left[d(t) - \lambda(l(d(t), M)) \cdot \left(1 - k \cdot \frac{1-\beta}{l(d(t),M)}\right)\right] dt \cdot (p - c) - \left(\int_0^T [d(t) - M]dt\right)(1 - \beta)p + \int_0^T \left[\lambda(l(d(t), M)) \cdot \left(1 - k \cdot \frac{1-\beta}{l(d(t),M)}\right)\right] dt \cdot (1 - \beta)p - F$.

First, the optimal discount coupon level β will be determined and expressed. Then, second, for ease of understanding the model, a numerical analysis will be done. In the process of numerical analysis, this paper will establish specific settings, and look for trends by seeing how the value changes in T.

4.1. Optimal level of β

This paper examines at what discount coupon level, β^*, maximizes π_3. Thus, before investigating the optimizing level of β, checking whether π_3 has maximum point or not in a given condition has to be checked.

Lemma 1: π_3 (profit when coupon is introduced) has Maximum point

Proof) We need to show that π_3 is a continuous function and is defined in closed bounded set. Elements of π_3, $\int_0^T d(t)dt$, $\int_0^T \lambda(l(d(t), M))dt$ and

$prob(\beta, l(d(t), M))$, are continuous. Thus π_3 is a continuous function. Furthermore, π_3 is one variable (β) function with the closed interval $0 \leq \beta \leq 1$. Thus π_3 has Maximum point level by extreme value theorem.

■

From Lemma 1, the need for close look in this investigation is satisfied. Therefore, process to find at what point π_3 becomes maximized can be and should be carried out. Where π_3 becomes maximized can be found by using differentiation. Differentiating π_3 at β should be carried out. Probability function $prob(\beta, l(d(t), M))$ will be assumed to follow $prob(\beta, l(d(t), M)) = k \cdot \frac{1-\beta}{l(d(t),M)}$.

$$\frac{d\pi_3}{d\beta} = -(p-c)k\int_0^T \frac{\lambda(l(d(t),M))}{l(d(t),M)}dt + p\left(\int_0^T [d(t) - M]dt\right) + p\int_0^T \lambda(l(d(t),M))dt$$
$$- 2(1-\beta)kp\int_0^T \frac{\lambda(l(d(t),M))}{l(d(t),M)}dt$$

The optimal point of β, β^*, can be found by solving $\frac{d\pi_3}{d\beta} = 0$. Therefore, the optimal point of β can be expressed as:

$$\beta^* = 1 + \frac{p-c}{2p} - \frac{\int_0^T [d(t) - M + \lambda(l(d(t),M))]dt}{2k\int_0^T \frac{\lambda(l(d(t),M))}{l(d(t),M)}dt}$$

4.2. Decision to adopt discount coupon

Discount coupon should not be introduced just because the optimal point of β has been found. Indeed, a simple test should be carried out. The simple test finds the turning point where π_3 gets greater than π_2. That is point where $\pi_3 > \pi_2$. If $\pi_3 < \pi_2$, it indicates to us that no reaction should be taken. Letting order cancellations happen is the best way to maximize one's profit. This point is important since it shows the real problems firms face. For example, let's assume the price of a product A is 100 and the production cost for it is 70. If optimal discount coupon level, β^*, is 0.6 then the firm should sell the product with discount coupon of 40% thus the selling price is 60. This is below the production cost thus rather a loss-making business. In this case, not introducing discount coupon, but letting order cancellations occur is the best option. The turning point can be found easily by finding a point where:

$$\pi_3 > \pi_2$$

When simplified,

$$\beta > 1 - \frac{p-c}{p} \cdot \frac{\int_0^T [\lambda(l(d(t),M)) \cdot (prob(\beta, l(d(t),M))]dt}{\int_0^T [d(t) - M - \lambda(l(d(t),M)) \cdot (1 - prob(\beta, l(d(t),M))]dt}$$

Thus proposition 1 can be drawn to find the effectiveness of discount coupon.

Proposition 1: Coupon is always economically beneficial when

$$\beta^* > 1 - \frac{p-c}{p} \cdot \frac{\int_0^T [\lambda(l(d(t),M)) \cdot (prob(\beta, l(d(t),M))]dt}{\int_0^T [d(t) - M - \lambda(l(d(t),M)) \cdot (1 - prob(\beta, l(d(t),M))]dt}$$

Proof) From above, it is explained that discount coupon should be proposed when $\pi_3 > \pi_2$, $\beta > 1 - \frac{p-c}{p} \cdot \frac{\int_0^T [\lambda(l(d(t),M)) \cdot (prob(\beta, l(d(t),M))]dt}{\int_0^T [d(t) - M - \lambda(l(d(t),M)) \cdot (1 - prob(\beta, l(d(t),M))]dt}$. In addition, we need to show the concavity of π_3. Checking for concavity, the second derivative should have negative value. $\frac{d^2\pi_3}{d\beta^2} = -2kp \int_0^T \frac{\lambda(l(d(t),M))}{l(d(t),M)} dt < 0$. Thus discount coupon is economically beneficial when $\beta^* > 1 - \frac{p-c}{p} \cdot \frac{\int_0^T [\lambda(l(d(t),M)) \cdot (prob(\beta, l(d(t),M))]dt}{\int_0^T [d(t) - M - \lambda(l(d(t),M)) \cdot (1 - prob(\beta, l(d(t),M))]dt}$

■

From proposition 1, three main insights can be implied. First, when $\beta^* > 1 - \frac{p-c}{p} \cdot \frac{\int_0^T [\lambda(l(d(t),M)) \cdot (prob(\beta, l(d(t),M))]dt}{\int_0^T [d(t) - M - \lambda(l(d(t),M)) \cdot (1 - prob(\beta, l(d(t),M))]dt}$, optimal level of discount coupon always exist. Second, given such condition, discount coupon is economically beneficial. Last, therefore, managers should set the discount coupon level as β^*.

It can be noticed that the optimal level of discount coupon is found. One might wonder whether there is any situation where coupon is less effective or even useless. Thus, proposition 2 explaining the relation between optimal discount coupon level and such condition is derived.

Proposition 2: If popularity does not end, if $d(t)$ is strictly increasing function, discount coupon is less effective

Proof) We need to show that as $T \to \infty$, optimal level of discount coupon and point where $\pi_3 > \pi_2$ decrease. If optimal level of discount coupon decreases, then selling price decreases. If $lim\ T \to \infty$, then $\int_0^T [d(t) - M - \lambda(l(d(t), M)) \cdot (1 - prob(\beta, l(d(t), M))]dt$ converges to 0 where as $\int_0^T [\lambda(l(d(t), M)) \cdot (prob(\beta, l(d(t), M))]dt$ increases. Therefore, $1 - \frac{p-c}{p} \cdot \frac{\int_0^T [\lambda(l(d(t),M)) \cdot (prob(\beta,l(d(t),M))]dt}{\int_0^T [d(t)-M-\lambda(l(d(t),M)) \cdot (1-prob(\beta,l(d(t),M))]dt}$ gets closer to or smaller than 0. In addition, for $\beta^* = 1 + \frac{p-c}{2p} - \frac{\int_0^T [d(t)-M+\lambda(l(d(t),M))]dt}{2k \int_0^T \frac{\lambda(l(d(t),M))}{l(d(t),M)} dt}$, if $lim\ T \to \infty$, then $\frac{\int_0^T [d(t)-M+\lambda(l(d(t),M))]dt}{2k \int_0^T \frac{\lambda(l(d(t),M))}{l(d(t),M)} dt}$ increases thus β^* decreases.

■

From proposition 2, an important insight can be earned. If $d(t)$ is strictly increasing function, as T increases then β^* does not exist. β is only defined from 0 to 1. When, β^* decreases so that β^* becomes 0 or smaller than 0, then if discount coupon is adopted the discount coupon will be 100% or more. This means that firms give their products for free, which is rather illogical. Therefore, introduction of discount coupon is useless. However, oppositely, when T is short, β^* exists so that discount coupon is a useful method to increase firm's profit. From this proposition, managers can imply that discount coupon is ideal as short term strategy. This insight is advocated from past literature by Neslin (1990).

4.3. Numerical analysis

In this section, numerical analysis will be carried out in order to look for the trend and to get a grasp on the optimal level of discount coupon. Demand function $d(t)$ and order cancellation intensity function $\lambda(l(d(t), M))$ will be set to follow specific function. With these settings, optimal level of β^* in different T will be found. Lead time function, $l(d(t), M)$ will be naturally formulated with demand function as mentioned in Chapter 3. Therefore, only two functions $d(t)$ and $\lambda(l(d(t), M))$ will be set.

4.3.1 Settings

Demand function in this numerical analysis will follow quadratic function. Quadratic function setting is done by considering demand function of popularity developed by Korchevska et al. (2013). Thus, using quadratic function as demand function is reasonable. Furthermore, order cancellation intensity function $\lambda(l(d(t), M))$ will be assumed to follow linear function. Xu et al. (2021) found that consumers' longer waiting time, more likely to cancel the order, thus also practical. The settings can be organized as following table:

No	Notation	Setting	Reason
1	$d(t)$	Quadratic Function=at^2	Korchevska et al. (2013)
2	$l(d(t), M)$	$\frac{\int_0^T [at^2 - M]dt}{M}$	
3	$\lambda(l(d(t), M))$	Linear Function= $bl(d(t), M)$	Xu et al. (2021)
4	$p(\beta, l(d(t), M))$	Inverse Function= $k \cdot \frac{1-\beta}{l(d(t),M)}$	Literature Review

Table 5. Summary of the settings for the functions in model

By inserting such functions into the optimal discount coupon level of $\beta^* = 1 + \frac{p-c}{2p} - \frac{\int_0^T [d(t) - M + \lambda(l(d(t),M))]dt}{2k\int_0^T \frac{\lambda(l(d(t),M))}{l(d(t),M)} dt}$, following trend can be drawn:

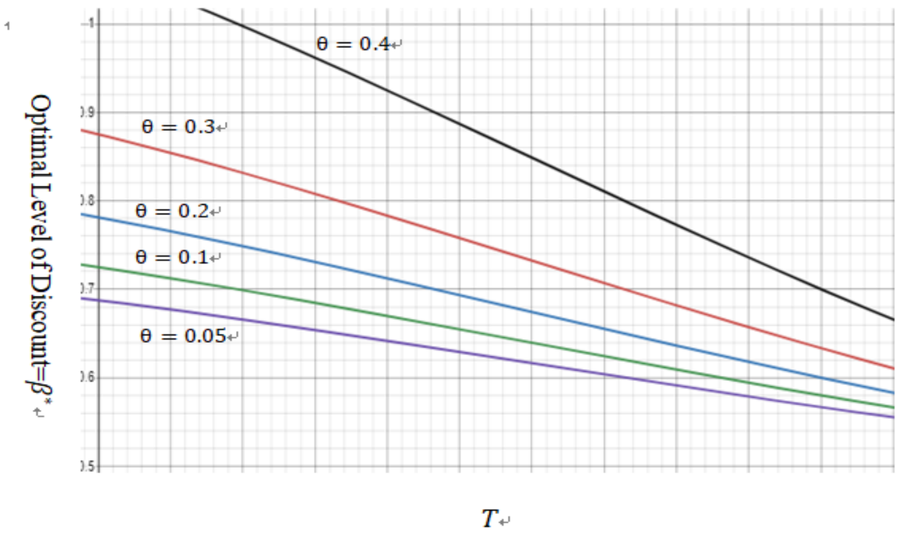

Figure 4. Optimization Level of β^* with different Coefficient Levels

In order to draft a trend, the coefficients, constants, had to be arbitrary fixed. For convenience, all of the constants will be drawn forward and multiplied together to form new constant, θ, where it is multiple of:

$$\theta = Coefficient\ of\ demand \times\ lead\ time \times order\ cancellation \times probability \times Maximum\ number\ of\ production\ per\ time = a \times a \times b \times k \times M$$

4.3.2 Result

By using graphing calculator, optimal level of discount coupon level, $\beta^* = 1 + \frac{p-c}{2p} - \frac{\int_0^T [d(t)-M+\lambda(l(d(t),M))]dt}{2k\int_0^T \frac{\lambda(l(d(t),M))}{l(d(t),M)}dt}$, has been sketched at five different levels of $\theta = 0.05, 0.1, 0.2,\ 0.3$ and 0.4. The trend of graph is presented as figure 4 above.

From numerical analysis, given that the demand function and intensity function follow quadratic and linear function respectively, for level $\theta = 0.05, 0.1, 0.2$ and 0.3, the optimal discount coupon level always lies below 1. Therefore, if condition from Chapter 4.2 is satisfied, then introduction of discount coupon is always economically beneficial. However, for, $\theta = 0.4$, at certain T, the optimal discount coupon level goes over 1, thus optimal point does not exist.

From numerical analysis, role of coefficient can be found. From figure 4, as the coefficients increases, then the optimal rate increase also. Therefore, whether the discount coupon should be adopted or not can be determined. For example, for $\theta = 0.4$, it can be seen from the figure that at certain T, optimal level of discount coupon gets larger than 1. Thus, clearly, discount coupon should not be adopted at such point.

Chapter 5. Conclusion

In conclusion, discount coupon is intended to provide economic benefits to the firms by providing an increase in their profits. This paper has determined in which situation offering discount coupon brings positive results to the profit and exactly at what rate of discount coupon the firm should provide to the customers to maximize firm's profit.

In order to find the findings, profit functions have been modeled step by step. Starting from basic profit equation, order cancellations due to lead time has been added and last, profit function with discount coupon introduction has been modeled in Chapter 3. Then, by using the models developed, in Chapter 4, analysis on what situation discount coupon is useful, the optimal level of discount coupon and trend on optimal level of discount coupon on different T is been carried out.

From Lemma 1, whether using discount coupon has consistent effect so that maximum point of profit level exists from 0 to T. Then from Proposition 1, at what discount coupon rate should be set in certain given condition helps firm economically is explained. Lastly, from Proposition 2, in which situation the introduction of discount coupon loses its advantage is been looked. To get a clear picture on the trend of the optimal discount coupon level of coupon on different T, numerical analysis providing a figure was done by inserting specific function.

As a conclusion, discount coupon was useful strategy only when $\beta > 1 - \frac{p-c}{p} \cdot \frac{\int_0^T [\lambda(l(d(t),M)) \cdot (prob(\beta, l(d(t),M))] dt}{\int_0^T [d(t) - M - \lambda(l(d(t),M)) \cdot (1 - prob(\beta, l(d(t),M))] dt}$. In this certain situation, a new profit function when discount coupon was introduced always had a maximum point with benefit, where optimal discount coupon level expressed as $\beta^* = 1 + \frac{p-c}{2p} - \frac{\int_0^T [d(t)-M+\lambda(l(d(t),M))]dt}{2k\int_0^T \frac{\lambda(l(d(t),M))}{l(d(t),M)}dt}$. However, there is a situation when discount coupon is not always economically beneficial. When $d(t)$ is strictly increasing function and T gets longer, discount coupon is less effective. It may not only do not have optimal level of discount coupon but also not adopting discount coupon would become the best option. It is because $1 - \frac{p-c}{p} \cdot \frac{\int_0^T [\lambda(l(d(t),M)) \cdot (prob(\beta, l(d(t),M))]dt}{\int_0^T [d(t)-M-\lambda(l(d(t),M)) \cdot (1-prob(\beta, l(d(t),M))]dt}$, the turning point where $\pi_3 > \pi_2$ gets closer or smaller than 0.

Chapter 6. Discussion

From this research, the optimal point of level of discount coupon has been determined in a special situation when order cancellations occur due to the postponed lead time. This paper contributes both to academic and managerial view. However, despite these contributions there exist some limitations.

Firstly, from academic point of view, this paper extended the study in the field of profit maximization. It considered firm’s profit in a specific problem where order cancellations occur due to a long lead time and determined at what level of incentive the profit is maximized. In addition, it is meaningful study in a sense that it studied by combining two areas. Discount coupon is popular area of study in Marketing and an order cancellation by lead time is topic where Operations Management deals carefully. Thus, it is meaning since it tried to collapse a barrier for these areas by jointly considering together. Though many people might think that marketing and operations management are different areas thus deal with different topics, as a whole it is closely connected together.

However, limitations exist in this paper. Firstly, assumptions were set by past literatures such as longer the lead time, the more order cancellations will occur. There are studies bolstering these assumptions but studies at what rate order cancellations increase are yet limited. Therefore, further studies not only analytically but also empirically should be carried out to find the rate and prediction of number of order cancellations. Furthermore, demand function was set. Therefore, automatically lead time function was determined. Developing this setting stochastically will bring more clear view on this topic. Thus future research considering this setting should be carried out.

From managerial point of view, this paper handled how to improve firm's profit by offering guidance to consider introduction of discount coupon. The main goal of a firm is to make as much profit as one can. Thus this paper is meaningful. In addition, order cancellations do not only mean losing chance to sell product. Order cancellations mean more. Customers, who cancelled their order initially, are people who decided to buy a certain product of a certain firm rather than products of other companies. It can be inferred that they are loyal customers. However, if a company loses loyal customers due to long lead time, then it is not only that certain moment that a company loses its profit but also in long term with products in the future.

However, like academic point of view, managerial view carries limitations. Limitations are, as a broad concept, real life factors. In real life, there are factors which affect profit. However, these factors were not individually dealt in this paper. One of the main factors is discount coupon initiating price. Adopting discount coupon requires some amount of price to initiate and to operate. Liu et al. (2020) found that coupon helps profit to increase but not monotonically when imitating price is considered. There are not only negative factors to consider but also positive factors. For example, coupon trading helps profit to increase (Su et al., 2014). However, this paper did not consider both types of factors. Managers who are serving in real industry companies should mandatorily consider these factors related with profit carefully before adopting discount coupon.

In the future, studies which compensate the limitations should be investigated. Academically more empirical and analytical papers dealing discount coupon and order cancellations should be studied. More papers considering factors, which affect profit, should be written so that there is more contributions not only academically but also managerial level.

References

Amazon Prime. (2021). FREE 2-hour delivery. Retrieved from https://www.amazon.com/gp/prime

Bass, F. M. (1969). A New Product Growth for Model Consumer Durables. *Management Science, 15*(5), 215-227.

Bawa, K., Srinivasan, S. S., & Srivastava, R. K. (1997). Coupon Attractiveness and Coupon Proneness: A Framework for Modeling Coupon Redemption. *Journal of Marketing Research, 34*(4), 517-525.

Clark, R. A., Zboja, J. J., & Goldsmith, R. E. (2013). Antecedents of Coupon Proneness: A Key Mediator of Coupon Redemption. *Journal of Promotion Management, 19*(2), 188-210.

Cowling, K., & Waterson, M. (1976). Price-Cost Margins and Market Structure. *Economica, 43*(171), 277-287.

Dai, J., Kleywegt, A. J., & Xiao, Y. (2018). Network Revenue Management with Cancellations and No- Shows. *Production and Operations Management, 28*(2), 292-318.

Davis, S., Inman, J. J., & Mcaslister, L. (1992). Promotion Has a Negative Effect on Brand Evaluations: Or Does It? Additional Disconfirming Evidence. *Journal of Marketing Research, 29*(1), 143-148.

Emerson, R. M. (1976). Social Exchange Theory. *Annual Review of Sociology, 2*(1), 335-362.

Jiang, Y., & Liu, Y. (2012). Optimization Of Online Promotion: A Profit-Maximizing Model Integrating Price Discount And Product Recommendation. International *Journal of Information Technology & Decision Making*, *11*(05), 961-982.

Jiao, Y., Du, J., Jiao, R. J., & Butler, D. L. (2008). Operational implications of early supplier involvement in semiconductor manufacturing firms. *Journal of Manufacturing Technology Management*, *19*(8), 913-932.

Korchevska, L., Zhosan, G., & Kavun, S. (2013). Social Responsibility as a Contextual Component of the Enterprise Economic Security. *Journal of Finance and Economics, 1*(4), 95-104.

Lambrecht, A., & Tucker, C. (2012). Paying with Money or Effort: Pricing When Customers Anticipate Hassle. *Journal of Marketing Research, 49*(1), 66-82.

Lee, C., & Huh, S. (2017). Technology Forecasting Using a Diffusion Model Incorporating Replacement Purchases. *Sustainability*, *9*(6), 1038.

Leone, R. (1996). Coupon face value: Its impact on coupon redemptions, brand sales, and brand profitability,. *Journal of Retailing*, *72*(3), 273-289.

Levitt, T. (1965). *Exploit the product life cycle*. Boston, MA: Graduate School of Business Administration, Harvard University.

Li, Y., Sun, Y., Zhang, Y., & Hu, X. (2018). Online Grocery Retailing for Fresh Products with Order Cancellation and Refund Options. *Journal of Supply Chain and Operations Management*, *16*(1).

Li, Y., Tang, S. Y., Johnson, J., & Lubarsky, D. A. (2019). Individualized No-Show Predictions: Effect on Clinic Overbooking and Appointment Reminders. *Production and Operations Management*, *28*(8), 2068-2086.

Li, Z., Yang, W., Jin, H. S., & Wang, D. (2021). Omnichannel retailing operations with coupon promotions. *Journal of Retailing and Consumer Services*, *58*, 102324.

Liao, C., & Shyu, C. (1991). An Analytical Determination of Lead Time with Normal Demand. International *Journal of Operations & Production Management*, *11*(9), 72-78.

Lichtenstein, D. R., Netemeyer, R. G., & Burton, S. (1990). Distinguishing Coupon Proneness from Value Consciousness: An Acquisition-Transaction Utility Theory Perspective. *Journal of Marketing*, *54*(3), 54-67.

Lim, S., Hur, S., Kim, Y., & Kim, S. (2012). Control of Lead Time for Retailer-Supplier Contract with Stochastic Demand and Order Cancellation. *Information*, *15*(12C), 5919-5930.

Lin, J., Zhang, J., & Cheng, T. (2020). Optimal pricing and return policy and the value of freight insurance for a retailer facing heterogeneous consumers with uncertain product values. *International Journal of Production Economics*, *229*, 107767.

Liu, B., Li, X., Wang, H., Fang, Q., Dong, J., & Wu, W. (2020). Profit Maximization Problem with Coupons in Social Networks. *Theoretical Computer Science*, *803*, 22-35.

Michaelidou, N., & Micevski, M. (2019). Consumers ethical perceptions of social media analytics practices: Risks, benefits and potential outcomes. *Journal of Business Research*, *104*, 576-586.

Milkman, K. L., Rogers, T., & Bazerman, M. H. (2009). I'll have the ice cream soon and the vegetables later: A study of online grocery purchases and order lead time. *Marketing Letters*, *21*(1), 17-35.

Nayal, P., & Pandey, N. (2020). Framework for measuring usage intention of digital coupons: A SPADM approach. *Journal of Strategic Marketing*, 1-21.

Neslin, S. A., & Shoemaker, R. W. (1983). A Model for Evaluating the Profitability of Coupon Promotions. *Marketing Science*, *2*(4), 361-388.

Neslin, S. A., & Shoemaker, R. W. (1989). An Alternative Explanation for Lower Repeat Rates after Promotion Purchases. *Journal of Marketing Research*, *26*(2), 205-213.

Neslin, S. A. (1990). A Market Response Model for Coupon Promotions. *Marketing Science*, *9*(2), 125-145.

Raghubir, P. (2004). Coupons in context: Discounting prices or decreasing profits? *Journal of Retailing*, *80*(1), 1-12.

Reibstein, D. J., & Traver, P. A. (1982). Factors Affecting Coupon Redemption Rates. *Journal of Marketing*, *46*(4), 102-113.

Rogers, E. M. (1983). *Diffusion of innovations*. New York, NY: Free Press.

Ross, S. M. (2009). *Introduction to probability models* (10th ed.). Amsterdam: Academic Press.

Shaffer, G., & Zhang, Z. J. (1995). Competitive Coupon Targeting. *Marketing Science*, *14*(4), 395-416.

So, K. C., & Zheng, X. (2003). Impact of suppliers lead time and forecast demand updating on retailers order quantity variability in a two-level supply chain. International *Journal of Production Economics*, *86*(2), 169-179.

Son, J., Kang, J., & Jang, S. (2019). The effects of out-of-stock, return, and cancellation amounts on the order amounts of an online retailer. *Journal of Retailing and Consumer Services*, *51*, 421-427.

Su, M., Zheng, X., & Sun, L. (2014). Coupon Trading and its Impacts on Consumer Purchase and Firm Profits. *Journal of Retailing*, *90*(1), 40-61.

Swaminathan, S., & Bawa, K. (2005). Category-specific coupon proneness: The impact of individual characteristics and category-specific variables. *Journal of Retailing*, *81*(3), 205-214.

Treville, S. D., Schürhoff, N., Trigeorgis, L., & Avanzi, B. (2014). Optimal Sourcing and Lead-Time Reduction under Evolutionary Demand Risk. *Production and Operations Management*, *23*(12), 2103-2117.

Wagner, S. M., Ullrich, K. K., & Transchel, S. (2014). The game plan for aligning the organization. *Business Horizons*, *57*(2), 189-201.

Wang, X., & Truong, V. (2018). Multi-Priority Online Scheduling with Cancellations. *Operations Research*, *66*(1), 104-122.

Wang, X., Liu, W., Yang, H., Wang, D., & Ye, J. (2020). Customer behavioural modelling of order cancellation in coupled ride-sourcing and taxi markets. *Transportation Research Part B: Methodological*, *132*, 358-378.

Xu, X., & Jackson, J. E. (2019). Investigating the influential factors of return channel loyalty in omni-channel retailing. *International Journal of Production Economics*, *216*, 118-132.

Xu, X., Yan, N., & Tong, T. (2021). Longer waiting, more cancellation? Empirical evidence from an on-demand service platform. *Journal of Business Research*, *126*, 162-169.

Yin, W., & Dubinsky, A. J. (2004). Framing Effects of Coupon Face Value on Coupon Redemption: A Literature Review with Propositions. *Journal of Marketing Management*, *20*(7-8), 877-896.

Zhang, J., Xu, Q., & He, Y. (2018). Omnichannel retail operations with consumer returns and order cancellation. *Transportation Research Part E: Logistics and Transportation Review*, *118*, 308-324.

Abstract in Korean

생산 운영 관리에서 배송은 성공의 핵심적인 요인으로 작용한다. 하지만, 완벽한 운영 체계를 가지고 있지 않은 회사들은 제품의 인기로 인한 갑작스러운 주문 폭주를 감당할 수 없어 고객에게 제때 배송을 할 수 없는 경우가 발생한다. 이로 인해 고객은 기다리다 지쳐 주문을 취소할 수 있으면 이는 회사의 이익 손실과 직결된다. 따라서 본 논문에서는 인센티브의 일종인 쿠폰 (판촉)을 제공하여 기업의 손실을 최소화하고자 한다. 본 연구의 목적은 다음과 같다. 1) 쿠폰 도입이 주문 취소가 발생하는 상황에서 기업 이익에 얼마나 도움이 되는지 2) 최적의 쿠폰 할인 수준을 어떻게 결정해야하는지 3) 기업이 쿠폰을 도입해야 하는 시기가 어떻게 되는지 알아볼 것이다. 본 연구를 진행하기 위해서 비동질적인 포아송 과정(nonhomogeneous Poisson process)을 통하여 예측된 주문 취소 양과 쿠폰을 받아들일지에 대한 확률 함수를 이용하여 이익 함수를 구조화한다. 다음 최적의 쿠폰 레벨 변화 추이를 살펴볼 것이다. 결론적으로 고객에게 쿠폰을 제공하는 것은 기업의 이익 손실을 최소화하는데 도움이 된다. 그러나 제품의 인기 기간이 늘어나고 제품의 인기가 증가 함수를 따르면, 어느 특정한 시점부터는 쿠폰의 효율을 감소되고 심지어 무용지물이 된다. 본 연구는 길어진 리드 타임으로 인한 주문 취소가 발생하는 상황에서 기업 관리자들이 기업의 이익을 극대화하기 위해 쿠폰 도입을 고려하여 어떻게 대처해야 하는지에 대한 통찰력을 제공하고 학문적인 부분에서는 쿠폰과 리드 타임으로 인한 주문 취소를 같이 고려하여 이익을 극대화하는 연구 분야를 확장하는데 의미를 지니고 있다.

주요어 : 프로모션, 쿠폰, 주문 취소, 리드 타임

학번: 2019-21062