Analysis of the Effect of Customer Characteristics on Discount Rate on a B2C E-commerce Website in China: JD.Com as an Example

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Abstract. With the development of online shopping in recent years, more and more e-commerce companies realize the importance of carefully formulating competitive discount policies to attract consumers. JD.com, one of China's largest B2C e-commerce websites, is famous for its high-quality products and excellent supply chain. Whether there is room for improvement in its discount policy, that is, whether it can adjust the discount for different consumer groups to improve its discount policy is the main research issue of this paper. This article used the sales data of JD.com in March 2018. This paper firstly interprets the original data and then integrates the original data. At the same time, to facilitate the subsequent analysis, this paper uses the idea of the control variable method to analyze the data and each customer's characteristic studied. Grouping according to characteristics, and then using linear regression to analyze the data of each group to explore the relationship between different types of discounts and customer characteristics, and find out the determinants of discounts and whether there are significant differences in discounts for different consumers groups. Based on the above research methods, this paper obtains the degree of influence of different customer characteristics on different discount types and the total discount rate and finally recommends JD.com, so that it can improve its discount policies to a certain extent, to attract more consumers and gain more revenue.

Keywords: B2C · JD.com · Discount · Customer Characteristics · Linear Regression

1 Introduction

1.1 Background

The development of technology has made online shopping possible for people nowadays. Online shopping has many advantages such as higher convenience, better prices, more

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variety, and no crowds, making many consumers prefer online shopping over shopping in physical stores. There are more than 2 billion people who shop online in 2020, and the E-commerce revenue is more than 4.2 trillion US dollars in the world [1].

The popularity of E-commerce and the promising future of the sector has attracted many companies to enter. Many online sellers aim to meet people's online purchasing needs. Online sellers compete with each other by providing higher quality, lower prices, and higher discounts to attract consumers. A sophisticatedly designed discount policy can give companies a chance to strengthen their long-run competitive position [2]. Therefore, companies, including online sellers, strive to design suitable discount programs.

JD.com, Inc., which was built in 2004 in Beijing, is one of the largest online retailers in China; JD.com is prestigious since consumers recognize products sold by JD.com as products of high quality [3]. In addition, JD.com is famous for its logistics and supply chain management. JD.com is praised for its resilient supply chain, which can even support the exceptional demand for products during the COVID-19 pandemic period with excellent flexibility and collaboration [4]. Considering the success of JD.com, how JD.com determines its discounts for different consumer groups is of interest. Therefore, this research will investigate JD.com's discount model and explore whether there are price discriminations toward different customers.

1.2 Related Research

Many existing studies are exploring the relationship between price or discount and factors that represent consumers' characteristics. Gender is one variable that is usually investigated by researchers. For example, car sellers in the Chinese market charge higher prices to women than men, and additional discounts that are provided to local men are not provided to local women, showing there is car price discrimination in terms of gender [5].

In addition, people's different purchasing power will let them be charged different prices and provided with different levels of discounts. The big data analysis has made price discrimination based on people's different purchasing power possible. For example, Didi charges higher prices for Apple users than Android users based on the belief that Apple users will not stop taking taxis due to relatively high prices [6]. This phenomenon exists since Didi believes Apple users have relatively high purchasing power than Android users.

There are many other determinants of discounts used by companies to design their discount model. For example, age, race, social class, and other demographic features may all affect the discounts that consumers can receive.

Price discrimination normally exists in the e-commerce sector; for example, Taobao uses perfect price discrimination with the application of big data technologies to analyze purchasing history and then provide acceptable prices for uses, increasing the chances of purchasing [6]. Online sellers, especially during special events, rely heavily on price discounts to attract customers and achieve high selling revenue [7].

Currently, there is no existing study investigating how JD.com determines its discounts provided to different customers based on their characteristics, and thus this research will focus on filling this research gap.

1.3 Objectives

This research will focus on JD.com and investigate the relationship between discounts and customer characteristics through running regressions. Quantitative data provided by JD.com will be analyzed. The purpose of this research is to find determinants of discounts provided by JD.com to see whether the discounts are significantly different for different consumer groups.

The objectives of this research are to determine the relationship between discounts and customer characteristics, to define whether there are significant differences between different consumer groups' discounts, and to give recommendations to JD.com about how the company can promote its discount model, and pricing measures, and discount policies.

The structure of the paper is as follows. Firstly, the data description and summary statistics will be shown. Secondly, the strategy used to do the research will be explained. Thirdly, data analysis results will be displayed and interpreted. Finally, conclusions will be drawn, and some practical recommendations will be given to JD.com concerning the research topic.

2 Data Filtering and Processing

2.1 Data Source

The data sets that were used were offered by JD.com for the 2020 MSOM Data-Driven Research Challenge [8]. According to the data providers, Wu and Zhou from JD Corporation (2020), the data sets showed "a detailed view on the activities associated with all the Stock Keeping Units (SKU) within one anonymized consumable category during March in 2018" [9]. During this period, there were "no major holidays or promotions". Therefore, this data set is good to research the relevance between users' characteristics and discounts.

The data sets consist of 7 tables, showing the information of users, orders, delivery, and inventory. Based on the research purpose, table: users and orders will be used in this research.

2.2 Data Description

2.2.1 Users

The table: users offered the customer characteristics that the customers purchased during March 2018 in this product category. And all the key identification information is anonymized (Table 1).

The first row is the user ID. And every column following the ID shows a user's characteristic information, including their user_level, PLUS (membership status), gender and purchase_power. Some of the characteristic information was estimated, and some data was unknown or couldn't be estimated at that time.

The variable of user_level in this data set was numbered as −1, 0, 1, 2, 3, 4. In reality, JD.com's user levels are named Registered Member, Bronze Member, Silver

Table 1. Table: Users

Name of variables	Data type	Range	Sample value
user_ID	string		000089d6a6
user_level	int	[−1,4]	1
plus	int	[0, 1]	0
gender	string	(F, M, U)	F
purchase_power	int	{−1} ∪ [1, 5]	3

Table 2. Table: Orders

Name of variables	Data type	Range	Sample value
order_ID	string		7444318d01
user_ID	string		33a9e56257
sku_ID	string		067b673f2b
quantity	int	[1, +∞)	1
original_unit_price	float	[0, +∞)	99.9
final_unit_price	float	[0, +∞)	53.9
direct_discount_per_unit	float	[0, +∞)	5
quantity_discount_per_unit	float	[0, +∞)	41
bundle_discount_per_unit	float	[0, +∞)	0
coupon_discount_per_unit	float	[0, +∞)	0
gift_item	int	[0, 1]	0

Member, Gold Member, and Diamond Member, as 0–4 in this data [10]. Though named as "member", these are synonyms of user here, rather than a paid premium membership. The user_level is decided by the customer's total purchase value in the past. Level 0 means that an account just registered, and hadn't had any purchase yet.

PLUS membership is JD.com's paid membership. The variable of PLUS membership status can be taken on 0 and 1. 1 means that the user is with PLUS membership at that time. The data on gender is string data. It can be taken on M(male), F(female), and U(unknown). The variable of purchase_power is tiered, ranging from −1 to 5. −1 means unknown or no estimation, and 1 was the highest rank (Table 2).

2.2.2 Orders

The table: orders offed the detailed information of all orders that happened in March 2018 in this specific product category. In the first 3 rows, there are *order_ID, user_ID,* and *SKU_ID*, showing the objective fact of each order. Then, there is a variable of *quantity.*

The 7 variables are very important data and the information on price and discounts. In reality, on JD.com, there are various types of promotional discounts. This data set was treated all the discounts into 4 types in advance:

(1) Direct discount: This type of discount reflects the reduction of price directly on the product detail page.
(2) Quantity discount: It's a conditional discount. Users will have to meet some conditions first, like "buying over RMB 200" or "buy 5 and get 1 free", then they could use this type of discount.
(3) Bundle discount: It's also a conditional discount. Users will have to buy some specific product or can be called a "pre-specified bundle" first, then this discount can be used.
(4) Gift items: The customers can get the free items if they buy a "pre-specified set". On some occasions, some products could be offered as a "free trial", and users who don't need to buy other products can also get a gift item.

Besides these 4 types of discounts, there were also coupons on JD.com. The variable of *gift_item* was a dummy variable, taking the value of 0 and 1. 1 means the product is a free item. The original and final price of a gift item was equal to 0.00 in the data set.

2.3 Merging the Tables and Data Filtering

Firstly, user_ID was used as a key variable to merge table: orders and table: users into 1 file. So that the customer characteristics and discount information can be associated, enabling this research to proceed to the next step. The newly merged table was named table: orders + users.

As the first step of data filtering, we filtered the orders from users whose user_level is 0. Under the definition of level 0 user, if a level 0 user had a first-time purchase, he/she should be classified as level -1. But there are still about 200 orders purchased by level 0 users, so these orders were seen as abnormal values and filtered finally.

Gift item was separated into one of the 4 main types of discounts on JD.com. But the original prices of gift items were shown as 0.00. It's hard to turn a gift item into a discount rate data. Therefore, the columns of gift items are deleted.

Considering during the period, there were no major holidays or promotions, if the linear regression method was used to research the purpose, a method of control variables should be used.

3 Method

The general idea of the research design is to analyze the statistical relationship between different factors and discounts, mainly using the idea of control variables and multiple linear regression, and also consider the interaction between different variables as appropriate. Linear regression has one or more independent variables and a dependent variable while controlling for other variables. The advantage is that it's easy to handle, the statistical relationship between each variable and the discount can be well seen, and

the influence of different independent variables on the discount can also be seen on the weight of the discount.

The linear regression equation is like:

$$Discount_i = \alpha + \beta \times Characteristic_i + \gamma Controls_i + \varepsilon_i \quad (1)$$

The $Discount_i$ means discount rate, which could be calculated by:

$$Discount_i = 100\% \times \left[(original\ unit\ price_i - final\ unit\ price_i)/original\ unit\ price_i\right] \quad (2)$$

Except for the gift item, there are direct discounts, quantity discounts, bundle discounts, and coupons remaining in the data set. Taking different types of discounts into the research is necessary. So that we could know whether a specific user group receives a type of discount or not, or whether these users were like to use a specific type of discount or not.

First, separate the discounts into 3 new types. They were named A discount, B discount, and C discount.

(1) A discount is a direct discount. In this type of discount, the customers would not decide to use it or not by themselves, because it was automatically reflected in the price.
(2) B discount is the "conditional" discount, including the quantity discount and bundle discount. Customers would have to buy some other products or have to buy a required quantity firstly, then they could use this kind of discount. For customers who have high demands for the product, they would be more likely to use a B discount. But those who don't have high demands could also have the right to decide not to use a B discount.
(3) C discount is the coupon. Compared with other types of discounts, coupons had their unique features. For example, the coupons' discount amount is always small. And users were required to get a coupon in advance. Some of them could be gotten on the product detail pages, but also some of them were on the other pages, such as "coupon mall". Therefore, if some new users were not familiar to use JD.com, although some coupons were offered, they might not find it and finish their purchases without using coupons.

Using Eq. (2), the discount rate of these 3 types of discounts in the data set could be calculated. Therefore, for specific customer characteristics, 4 new variables are gotten: total discount rate and the rate of 3 kinds of specific discounts.

4 Results

4.1 User Level

The data of user level in the data set was taken on −1 and 1–4. But after controlling other variables, the columns of level −1 users did not remain. Therefore, 3 dummy variables are set for levels 2–4 and run a multiple linear regression analysis.

Now a hypothesis test is presented:

Table 3. Multiple Regression Results of User Level

total discount	Coefficients	Standard Error	t Stat	*P*-value
Intercept	0.2976	0.0027	109.2645	0.0000
D_lv.2	−0.0006	0.0033	−0.1706	0.8645
D_lv.3	0.0054	0.0034	1.6054	0.1084
D_lv.4	0.0202	0.0038	5.2740	0.0000
A discount				
Intercept	0.1496	0.0021	72.2303	0.0000
D_lv.2	−0.0083	0.0025	−3.3331	0.0009
D_lv.3	−0.0104	0.0026	−4.0610	0.0000
D_lv.4	−0.0090	0.0029	−3.1044	0.0019
B discount				
Intercept	0.1374	0.0030	45.9396	0.0000
D_lv.2	0.0078	0.0036	2.1801	0.0293
D_lv.3	0.0130	0.0037	3.5278	0.0004
D_lv.4	0.0189	0.0042	4.5084	0.0000
C discount				
Intercept	0.0106	0.0008	14.0254	0.0000
D_lv.2	−0.0001	0.0009	−0.1055	0.9160
D_lv.3	0.0028	0.0009	2.9729	0.0030
D_lv.4	0.0103	0.0011	9.6499	0.0000

H_0: The user level has nothing to do with the level of discount the user enjoys.
H_1: The user level is related to the level of discount the user enjoys.

To carry out this hypothesis test, different user levels are used as independent variables, and three discount methods as dependent variables to conduct a multiple regression analysis. The following are the results of the regression analysis in Table 3.

From the above regression analysis table, we can conclude that under the condition that the significance level is less than 0.05, H_0 is rejected, and H_1 is received, that is, user-level will significantly affect the discount enjoyed by users. At the same time, we can also conclude that level 1 users enjoy the highest direct discount. While, level 4 users enjoy the highest B discount, C discount, and total discount.

This could be considered as a higher user level could bring a higher discount. Therefore, a new dummy variable is set to separate the level 1 and 2 users and level 3 and 4 users. Level 1 and 2 users as 0, while level 3 and 4 users as 1. Then we run a linear regression again (Table 4).

The values of coefficients are changed, but the conclusion is the same as above.

Table 4. Regression Results of User Level

total discount	Coefficients	Standard Error	t Stat	*P*-value
Intercept	0.2972	0.0015	199.3352	0.0000
D_lv.34	0.0109	0.0022	5.0263	0.0000
A discount				
Intercept	0.1439	0.0011	126.8684	0.0000
D_lv.34	−0.0041	0.0017	−2.4919	0.0127
B discount				
Intercept	0.1429	0.0016	87.2720	0.0000
D_lv.34	0.0096	0.0024	4.0258	0.0001
C discount				
Intercept	0.0106	0.0004	25.4379	0.0000
D_lv.34	0.0055	0.0006	9.0083	0.0000

4.2 PLUS Membership

Also, we set up a hypothesis test:

H_0: There is no difference between the discounts enjoyed by PLUS members and non-PLUS members.
H_1: There are significant differences in the discounts enjoyed by PLUS members and non-PLUS members.

To perform this hypothesis test, the PLUS membership is used as the independent variable and the three discount types as the dependent variable to perform regression analysis, and obtain the following regression analysis in Table 5.

From the above linear regression data, we can draw: that in the case of significance level p-value $= 0.05$, H0 is rejected and H1 is accepted, that is, PLUS members can enjoy more discounts than non-PLUS members. We conclude that PLUS members can enjoy about 8% more total discount than non-PLUS members. There is no significant difference between the two user groups on direct discounts, but for the B discounts, PLUS members are 1.3% higher than non-PLUS members. For the C discount, PLUS members are 5.9% higher than non-PLUS members, while the average C discount rate is only 1.1% for a non-PLUS member. Therefore, PLUS members can enjoy more coupon discounts and B discounts than non-PLUS members, and coupon discounts are especially significant.

4.3 Gender

A dummy variable is set to show users' gender, female as 1, and male as 0.

Then we propose a hypothesis test:

Table 5. Regression Results of PLUS Membership

total discount	Coefficients	Standard Error	t Stat	*P*-value
Intercept	0.2971	0.0019	159.1835	0.0000
plus	0.0783	0.0050	15.6348	0.0000
A discount				
Intercept	0.1414	0.0014	104.3611	0.0000
plus	−0.0001	0.0036	−0.0212	0.9831
B discount				
Intercept	0.1452	0.0020	74.3824	0.0000
plus	0.0192	0.0052	3.6663	0.0002
C discount				
Intercept	0.0105	0.0008	14.0209	0.0000
plus	0.0592	0.0020	29.3273	0.0000

Table 6. Regression Results of Gender

total discount	Coefficients	Standard Error	t Stat	*P*-value
Intercept	0.2564	0.0038	67.4613	0.0000
D_gender	0.0407	0.0042	9.7115	0.0000
A discount				
Intercept	0.1354	0.0029	47.1045	0.0000
D_gender	0.0060	0.0032	1.8788	0.0603
B discount				
Intercept	0.1088	0.0041	26.3238	0.0000
D_gender	0.0364	0.0046	7.9879	0.0000
C discount				
Intercept	0.0122	0.0009	12.9896	0.0000
D_gender	−0.0016	0.0010	−1.5623	0.1183

H_0: Gender does not affect the discount the user enjoys.
H_1: Gender affects the discounts users receive.

For this hypothesis test, the user's gender is set as the independent variable, the discount enjoyed by the user as the dependent variable, controlled for other variables, and performed linear regression to obtain the following results in Table 6.

From the above linear regression results, you can see, under the premise of the significance level $p\text{-}value = 0.05$, we reject H_0 and accept H_1, that is, gender will

Table 7. Multiple Regression Results of Purchase Power

total discount	Coefficients	Standard Error	t Stat	*P*-value
Intercept	0.2896	0.0117	24.6853	0.0000
D_lv.2	0.0074	0.0119	0.6259	0.5314
D_lv.3	0.0233	0.0120	1.9480	0.0514
D_lv.4	0.0040	0.0147	0.2725	0.7852
D_lv.5	0.0375	0.0905	0.4139	0.6789

significantly affect the discounts enjoyed by users. From the regression results, female users can enjoy a total discount of about 4% more than male users, and at the same time enjoy more B discounts than male users.

4.4 Purchase Power

We propose the following hypothesis tests:

H_0: The level of purchase power has nothing to do with the discount the user enjoys.
H_1: The level of purchase power is related to the discount that users enjoy.

For this hypothesis test, the level of user purchasing power is taken as the independent variable, discount as the dependent variable, and control other variables to perform linear regression, and get the following results in Table 7.

From the results, shown above linear regression, we can draw: that in the case of significance level $p\text{-}value = 0.05$, we reject H_1 to accept H_0, that is, the relationship between the level of purchasing power and the discount enjoyed by users is not significant.

4.5 User Level × PLUS Membership

With the above analysis results, 3 characteristics were found that can affect the discount rate the user received. But the effect of gender may depend on the product category. For example, if there is a product category mainly for women, the female users may receive more discounts, so they will purchase more in this category. Therefore, the gender factor might not be promoted to other product categories, it's not a universal conclusion. While the factors of user-level and PLUS membership are different with the gender, they are more possible to be promoted to other categories.

Thus, we want to explore: when user-level and PLUS are independent variables at the same time, what kind of linear relationship exists between the discount as the dependent variable and the independent variable? Thus, we control for the remaining variables and do the following linear regression in Table 8.

From the above analysis results, we can draw the following conclusions: The effect of PLUS membership is bigger than the high user level. And customers who are with PLUS membership can receive more coupons and higher coupon discounts.

Table 8. Multiple Regression Results of User Level × PLUS Membership

total discount	Coefficients	Standard Error	t Stat	*P*-value
Intercept	0.2999	0.0011	279.2486	0.0000
D_lv.34	0.0135	0.0018	7.4720	0.0000
plus	0.0916	0.0039	23.3180	0.0000
Interaction Term	−0.0393	0.0046	−8.5992	0.0000
A discount				
Intercept	0.1426	0.0008	182.1925	0.0000
D_lv.34	−0.0026	0.0013	−1.9737	0.0484
plus	−0.0021	0.0029	−0.7215	0.4706
Interaction Term	0.0083	0.0033	2.4853	0.0129
B discount				
Intercept	0.1464	0.0011	127.9589	0.0000
D_lv.34	0.0110	0.0019	5.7442	0.0000
plus	0.0280	0.0042	6.7038	0.0000
Interaction Term	−0.0107	0.0049	−2.1940	0.0282
C discount				
Intercept	0.0110	0.0004	25.0316	0.0000
D_lv.34	0.0051	0.0007	6.8700	0.0000
plus	0.0657	0.0016	40.9889	0.0000
Interaction Term	−0.0369	0.0019	−19.8039	0.0000

5 Discussion

5.1 Gender

In China, people celebrate International Women's Day on March 8th. Although JD.com claimed that throughout the whole period, there were no major holidays or promotions, they also didn't deny all possibilities, for example, some brands could hold "super brand day" promotions during the period.

In the data set, the number of orders purchased by female customers is 3 times more than male customers. Therefore, in some way, it can be said that the data belonged to a product category for ladies. Also, it was a reasonable thing that some brands held promotions to celebrate International Women's Day. And because of this, female users received more discounts. So gender became a factor to affect the discount rate finally.

With many other conditions affected, females got a higher discount on average in this product category. It might be an inevitable outcome. But the situation may be very different in other categories, so the gender factor couldn't be promoted to other categories.

5.2 User Level

We think that the data at the user level could be an evaluation metric of users' stickiness. Because the level would be re-rated in a yearly cycle. Therefore, if a customer wants to maintain his/her existing level, a level 2 user, needs to get 1000 "growth value" on JD.com during the year, and a level 3 user is required 4000, a level 4 user for 10,000. Users could get the "growth value" not only from their purchases, but also from their log-in activities, leaving reviews, and sharing their orders with others [11]. Therefore, as a high-level user in JD.com, he/she is required to open apps and have interaction with JD.com's community frequently.

Ren et al. pointed out that the online marketing consumers could be divided into 4 types: "low discount sensitive user, high discount sensitive user: discount preference and high discount sensitive user: fixed preference (fixed is limited-time price reduction)". And the segment of low discount sensitive users has the highest average frequency of purchases [12].

Based on this, we think that the high-level user on JD.com, may not need a higher discount. Because their stickiness is high and consumption habits are formed. Without higher discounts, considering their high user level, they may still log in to JD.com's app every morning.

On the other hand, for low-level users, JD.com offered a higher direct discount for them. This is a good way to attract new users. Low-level users may have higher psychological resistance to using B discounts. Some of them may not know the way of getting a coupon, so giving them low coupon discounts are also a reasonable discount strategy.

5.3 PLUS Membership

The PLUS membership is paid on an annual cycle, paying for this means the user has a high stickiness to JD.com. If a user decides on paying for a PLUS membership, he/she may be more inclined to spend money at JD.com in the next year.

Furthermore, on the PLUS members' homepage, PLUS members will also have more opportunities for free shipping and more "JingDou" (reward points) in return [13]. Points are also a discount in some way. However, the data of it wasn't offered at this time.

5.4 User Level × PLUS Membership

After the discussion above, the JD.com's users' stickiness ranking maybe seem like this:

PLUS members > high-level users > low-level users

And turning low stickiness users into high stickiness ones should be a good way for JD.com to make more revenue. As discussed in Sect. 5.2, JD.com should give a lower total discount rate to high-level users and a higher total discount rate to low-level users.

Also, turning the high-level users into PLUS members are considered a useful way. But under the analysis, the interaction items in total discount, B discount, and C discount are negative values. Meaning that if a high-level user pays for a PLUS membership, he/she would get a lower discount than if he/she wasn't a PLUS member. If they notice

this, it would be harmful to their loyalty. While, the negative value also means that if a low-level user pays for PLUS membership, he/she will get a great improvement on the discount rates they received. But the low-level users had low stickiness, so expecting them to pay for PLUS membership seems not a good idea. Therefore, our opinion is to turn the interaction term into a positive value.

6 Conclusion

This paper uses the linear regression method to investigate the effect of customer characteristics on discount rates on the JD.com platform. In conclusion, gender, user-level, and PLUS membership factors had effects. Female customers, high-level customers, and PLUS members could receive a higher discount rate on JD.com. But gender may not be used in other product categories. However, the discount strategy based on user level and PLUS membership also had some points that could be improved. JD.com could give a lower total discount rate to high-level users and a higher total discount rate to low-level users. Also, turning the interaction term of user-level × PLUS membership to a positive value could make the strategy more reasonable.

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