**Appendix**

**A.1**

Case (1)：

Suppose O deviates to , then consumers in choose O channel and those in  choose BOPS channel and the remaining consumers  choose T channel . The O’s demand is and its profits are . When , O’s optimal deviating pricing is , make profits .

Let 



The numerator 





Such a deviation is not profitable for O since ,therefore, O will not unilaterally deviate from the equilibrium price. Similarly, T’s optimal deviating price at or below , yielding profits . However, T will not deviate to from a price since .

**A.2**

Case (2)：

In this case, the equilibrium price are:





where .

Suppose T deviates the equilibrium price  , we have . Those consumers in  will choose T channel. So T’s profits are  with . The T’s optimal deviating price at . When , . The proof process is similar to case (1) and is omitted here. If O deviates the equilibrium price , those consumers in will choose O channel. E-commerce department O’s is with . The O’s optimal deviating price at , then . When , . Therefore, neither department will unilaterally deviate from the equilibrium price.

**A.3**

Case (3)：

When , the unique equilibrium price isand . when , neither department will deviate from any higher . Suppose O deviates to, the O’s demand is zreo. Suppose T deviates to, the consumers in  will choose T channel. T’s profits are  with . Departments make profits are  and . When , the T’s optimal deviating price at ，and make profits . Let , we obtain . This means that T deviating from the equilibrium price will lead to lower profits, and therefore will not unilaterally deviate from the equilibrium price.

**A.4**

Case (4): 

When , the equilibrium price are: 

Suppose O deviates to, where . Consumers in  choose O channel, and return the unsatisfactory product, and remaining consumers choose T channel. Then O’profits are . However, when , , , .

Suppose T deviates to , where . Those in  consumers choose T channel, and remaining consumers choose O channel. Then, the T’ profits are. Clearly,  with the previous restrictions.

**A.5**

Case (5): 

When , the unique price equilibrium is  and , and departments make profits and.

Similaritily , neither department will unilaterally deviate form the equilibrium price. Suppose T deviates to , consumers in  choose T channel and its profit function is , where . The T’s optimal deviating price at.

However, when . On the other hand, suppose O deviates to , those consumers in  choose O channel, and consumers in choose BOPS channel. The O’s profit functiong is  where . The O’s optimal deviating price at. However,  under restricted conditions.

**A.6**

When the distance cost is medium (case (2), case (4)), we use  to represent the profits of O under the BORO strategy, and make. To facilitate analysis, we assume that O receives full revenue from the BOPS channel. Making, we have :

Equation (11)







Equation (5)







When , where. Using Matlab 2022, we obtain . Due to the complexity of the expression, it is not presented here.

When the distance cost is medium, we use represnets the revenue of T under the BORO strategy. We still assume that O gets all the revenue of BOPS channel, i.e., . Then equation (6)-(12):









Simplifying , when, i.e., , . However, in case (2), we have , thus .