

# **Research on decision-making of distribution channels for manufacturers in the presence of disruption risks under internet environment**

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**Abstract:** Disruption risks have taken place frequently and had a great effect on the traditional distribution channels of manufacturers. This paper focus on the relationship between the probability of disruption risks and the decision-making of distribution channels for manufacturers through formulating the expected profit functions. Two critical values of the probability are first obtained and then the conclusions are examined by numerical examples. At last, some guidelines are suggested for the distribution channel managers to make the decision about channel selection.

**Keywords:** Disruption risk, Distribution channel, Internet, Dual-channel

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## **1. Introduction**

Disruption risks have taken place frequently and had a great effect on the traditional distribution channels of manufacturers in recent years, such as the failure or breakdown of the distribution tasks, the great losses of manufacturers and so on. For example, the SARS crisis in 2003, the global financial crisis in 2008, and the spread of the H1N1 flu virus in 2009 are all disruption risks and all of them have a great impact on the traditional distribution channels.

In order to deal with those disruption risks, many manufacturers have built another distribution channel in addition to the traditional one named the e-channel with the development of Internet in China, which can help the manufacturers to distribute their products when the disruption risks of the traditional distribution channel occurred. Take the software makers of Rising for example, the e-channel helped her to survive from the SARS crisis and had a

rapidly development in 2003.

Therefore, the manufacturers have to make their decision about the selection of distribution channels in consideration of disruption risks. In another word, the manufacturers should make a choice among the sole traditional distribution channel which is with higher profit level but less controllable, the sole e-channel which is with lower profit level but effectively controllable and the dual-channel which is a compromised way.

## **2. Literature Review**

Considering the relevance to the focus of this paper, we review two aspects of recent literature here: one is focused on the channel selection under Internet and the other is the disruption risks management.

### **2.1. Channel Selection under Internet**

Chiang etc. (2003) analyzed the problems of channel selection for manufacturers by a Stackelberg game theoretical model, specifically; it is the problem of choosing among the sole traditional distribution channel, the sole e-channel and the dual-channel. Chen etc. (2008) pointed out that the e-channel can play an important role in the task of distribution through an empirical study on the book market. Zhang & Wu (2008) pointed out that the manufacturers had better integrate the traditional distribution channel with the e-channel through theory and case study method. Zhu (2010) analyzed the similarities and differences between the traditional channel and the e-channel, and then gave some suggestions for the manufacturers to make the decision about channel selection under the Internet environment. Liang etc. (2006) analyzed the structure of market and the behaviour of customers by reviewing the currently academic achievements of channel selection and management in the academic community.

### **2.2. The Disruption Risks Management**

Lei & Xu (2004) analyzed the impact of disruption risks on the supply chain through defining and classifying the disruption risks and then gave a framework of disruption risks management. Tang (2006) pointed out that most of the strategies of regular risks management had adopted by the manufacturers but the disruption risks management were still lack of studying through reviewing lots of quantitative models for managing supply chain risks. Liu (2009) analyzed the reason why the ability of enterprises dealing with disruption risks were

becoming worse and worse and then pointed out that the involvement of supplier can help to reduce the vulnerability of the supply chain. Yu etc. (2009) analyzed a two-stage supply chain including one buyer and two suppliers and then gave some guidelines for the buyer to decide the sourcing method with the purpose of gaining maximum profit.

In summary, the existing literature of distribution channel selection under Internet environment were still not taking the disruption risks of traditional distribution channel into account but the disruption risks have had a huge impact on the distribution of enterprises. Therefore, this paper will focus on the distribution channel selection under Internet environment with the consideration of disruption risks in order to achieve the maximum profit of manufacturers.

### **3. Models and Analyses**

In this paper, we assume that there are two different distribution channels: one is the traditional channel, which enjoys the higher wholesale price and provides the higher profit level for manufacturers but may be broke down by some disruption risks; the other is the e-channel, which is built by the manufacturers of their own and enjoys the lower wholesale price than the one provided for the traditional channel because the price is the internal transfer price but may be easily controlled by the manufacturers. So there are three different scenarios for the manufacturers to choose from: the first one is the sole traditional distribution channel; the second is the sole e-channel; the third is the dual-channel and the manufacturers provide the proportion of order quantity for each channel.

#### **3.1. Model Assumptions**

The assumptions of this paper are as follows:

(1) The profit of manufacturers only comes from the difference between the wholesale price and production costs, no matter that the e-channel or the traditional one (According to Deng (2007), the assumption that the e-channel is regarded as an independent accounting retailer is consistent with the actual conditions because many enterprises have adopted the independent financial accounting system by department);

(2) The traditional distribution channel is completely broke down and cannot accomplish the distribution task when it is struck by disruption risks;

(3) The market scale of product is stationary and the disruption risks can't affect it;

(4) The order quantity of distribution channel is related to the market scale;

(5) The order quantity of distribution channel is sensitive to the wholesale price.

### 3.2. The State of Relevant Variables

We list the relevant variables in Table 1.

Table 1: The relevant variables

Scenarios States	Single channel	Dual-channel	
Normal state (1 - p)	$w_t^s$	$w_t^h$	$w_e^h$
Disrupted state (p)	$w_0$	$w_{ed}$	$w_e^h$

In Table 1,  $p$  is the probability of disruption risks by the traditional channel in a distribution stage;  $w_t^s$  is the unit wholesale price of traditional channel when the scenario is the sole traditional channel in a normal state;  $w_t^h$  is the unit wholesale price of traditional channel when the scenario is the dual-channel in a normal state;  $w_e^h$  is the unit wholesale price of e-channel when the scenario is the dual-channel in no matter the state is normal or disrupted;  $w_0$  is the unit loss of manufacturer because of the traditional distribution channel is broke down by disruption risks when the scenario is the sole traditional distribution channel in a disrupted state;  $w_{ed}$  is the unit wholesale price of the order quantity which transfers from the traditional distribution channel to the e-channel when the scenario is the dual-channel in a disrupted state.

According to the actual situation,  $w_t^s$  is the highest price among all the wholesale price;  $w_t^h$  has to be lower than  $w_t^s$  because manufacturers have to reassure the traditional channel after introducing the e-channel but it still has to be higher than  $w_e^h$ ;  $w_{ed}$  has to be lower than  $w_e^h$  because the order quantity is transferred from the traditional channel to the e-channel and the manufacturers have to share the profit with the e-channel for the urgent distribution task. Thus, this paper can be reasonable to assume that  $w_{ed} < w_e^h < w_t^h < w_t^s$ . Meanwhile, this paper assumes that the production cost of manufacturer is  $c$ . In addition, the order quantity of dual-channel is calculated with the average of wholesale price of each channel when the scenario is dual-channel.

### 3.3. The Expected Profit Functions

In this paper, we use an exponential function as follows to describe the order quantity of distribution channel in a distribution stage:

$$D = M \exp(-kw) \quad (3.1)$$

n(3.1), the base element  $M$  is the maximum market scale of product, according to the assumption (3) above,  $M$  is stationary,  $w$  is the unit wholesale price of each channel,  $k(k > 0)$  is the coefficient of price sensitivity, and  $D$  is the order quantity of distribution channel when the wholesale price, the market scale and the coefficient of price sensitivity are given.

The order quantity is calculated as  $D = M \exp(-kw_t^s)$  when the scenario is the sole traditional channel and then the order quantity becomes  $D = M \exp[-k(w_t^h + w_e^h)/2]$  when the scenario is the dual-channel.

Thus, in a normal state, the profit function of the manufacturer when the scenario is the sole traditional channel,  $\pi_t^s$  is given by

$$\pi_t^s = (w_t^s - c)M \exp(-kw_t^s) \quad (3.2)$$

And the profit function of the manufacturer when the scenario is the dual-channel in a normal state,  $\pi_n^h$  is given by

$$\pi_n^h = [(w_t^h - c) - x(w_t^h - w_e^h)] \times M \exp[-k(w_t^h + w_e^h)/2] \quad (3.3)$$

In (3.3)  $x$  is the proportion of the order quantity by the e-channel in a distribution stage.

Similarly, we can get the profit functions of the manufacturer when the traditional distribution channel is broke down by the disruption risks.

Because of the complete loss, the profit function of the manufacturer when the scenario is the sole traditional distribution channel in a disrupted sate,  $\pi_d^s$  is given by

$$\pi_d^s = (-w_0)M \exp(-kw_t^s) \quad (3.4)$$

In a disrupted sate, the e-channel gets a proportion  $x$  of the order quantity which is charged by the wholesale price  $w_e^h$ , but the wholesale price of the rest proportion  $(1-x)$  of order is decreased to  $w_{ed}$  because this proportion of the

order quantity is transferred from the traditional distribution channel to the e-channel. Therefore, the profit function of the manufacturer when the scenario is dual-channel in a disrupted state,  $\pi_d^h$  is given by

$$\pi_d^h = [(w_{ed} - c) + x(w_e^h - w_{ed})] \times M \exp[-k(w_t^h + w_e^h)/2] \quad (3.5)$$

Thus the expected profit function of the manufacturer when the scenario is the sole traditional distribution channel according to the probability of disruption risks  $P$ ,  $\Pi_t^s$  is given by

$$\Pi_t^s = (1 - p)\pi_t^s + p\pi_d^s \quad (3.6)$$

And the expected profit function (EPF) of the manufacturer when the scenario is the dual-channel,  $\Pi^h$  is given by

$$\Pi^h = (1 - p)\pi_n^h + p\pi_d^h \quad (3.7)$$

When the proportion of the order quantity by the e-channel is given by  $x=1$ , that is the scenario is the sole e-channel, the expected profit function of the manufacturer  $\Pi_e^s$  is given by

$$\Pi_e^s = \pi_n^h = \pi_d^h = (w_e^h - c)M \exp[-k(w_t^h + w_e^h)/2] \quad (3.8)$$

### 3.4. The Analyses of the EPFs

We have obtained the EPFs of the manufacturer for three different scenarios, which is the sole traditional channel, the dual-channel and the sole e-channel. Thus the manufacturer has to decide which scenario outperforms the others and we do some analyses here to give the managers some guidelines.

We have assumed the relationship among the wholesale price above, that is  $w_{ed} < w_e^h < w_t^h < w_t^s$ , and we use the price  $w_{ed}$  as the base price to write the other entire price in the following format:

$$w_e^h = (1 + \alpha_1)w_{ed} \quad (3.9)$$

$$w_t^h = (1 + \alpha_2)w_{ed} \quad (3.10)$$

$$w_t^s = (1 + \alpha_3)w_{ed} \quad (3.11)$$

Where  $\alpha_1, \alpha_2, \alpha_3 \in R$  and  $0 < \alpha_1 < \alpha_2 < \alpha_3$ .

$$c = (1 + \beta_1)w_{ed} \quad (3.12)$$

$$w_0 = (1 + \beta_2)w_{ed} \quad (3.13)$$

Where  $\beta_1, \beta_2 \in R$  and  $\beta_1 < 0 < \alpha_1 < \alpha_2 < \alpha_3$ .

Moreover, we define the following expression terms in order to simplify the final analysis results:

$$e_0 = w_{ed}M \exp(-kw_{ed}) \quad (3.14)$$

$$e_{12} = M \exp[-k(\alpha_1 + \alpha_2)w_{ed}/2] \quad (3.15)$$

$$e_3 = M \exp(-\alpha_3kw_{ed}) \quad (3.16)$$

Therefore, (3.6), (3.7) and (3.8) can be simplified as

$$\begin{aligned} \Pi^h = e_0e_{12}\{ & (1-p)(\alpha_2 - \beta_1) - x(\alpha_2 - \alpha_1) \\ & + p(\alpha_1x - \beta_1)\} \end{aligned} \quad (3.17)$$

$$\Pi_t^s = e_0e_3[(1-p)(\alpha_3 - \beta_1) - p(1 + \beta_2)] \quad (3.18)$$

$$\Pi_e^s = e_0e_{12}(\alpha_1 - \beta_1) \quad (3.19)$$

In the following, we will calculate the critical values of the probability of disruption risks that is the relationship  $P$  should satisfy.

Firstly, if we would like to achieve the goal that the level of profit from the dual-channel is higher than that from the sole traditional channel that is  $\Pi^h > \Pi_t^s$   $P$  should satisfy the expression as follows:

$$p > 1 - \frac{e_{12}(\alpha_1x - \beta_1) + e_3(1 + \beta_2)}{e_3(\alpha_3 - \beta_1) - e_{12}\alpha_2(1-x) + e_3(1 + \beta_2)} \quad (3.20)$$

We denote the right-hand-side of (3.20) as  $p_1$ , that is when  $P$  satisfies the relationship  $p > p_1$ ,  $\Pi^h > \Pi_t^s$ , that is the dual-channel outperforms the sole traditional channel.

Secondly, if we would like to achieve the goal that the level of profit from the sole e-channel is higher than that from the dual-channel that is  $\Pi_e^s > \Pi^h$ , the  $P$  should satisfy the expression as follows:

$$p > 1 - \alpha_1/\alpha_2 \quad (3.21)$$

We denote the right-hand-side of (3.21) as  $P_2$ , that is when  $P$  satisfies the relationship  $P > P_2$ ,  $\Pi_e^s > \Pi^h$ , that is the sole e-channel outperforms the dual-channel.

According to the actual situation, it is obvious that  $P_2 > P_1$ . So we use these two critical values  $P_1$  and  $P_2$ , we can summarize the guidelines for decisions in the following:

- (1) If  $P < P_1$ , then the manufacturer choose the traditional distribution channel as the single distribution channel;
- (2) If  $P > P_1$ , then the dual-channel is superior to the sole traditional channel in reducing the loss of manufacturer caused by disruption risks;
- (3) If  $P_1 < P < P_2$ , then the manufacturer choose the dual-channel;
- (4) If  $P > P_2$ , then the manufacturer choose the e-channel as the single distribution channel;
- (5) From the relationship  $P_2 = 1 - \alpha_1 / \alpha_2$ , we can see that  $P_2$  only has the relationship with the values of  $\alpha_1$  and  $\alpha_2$ , that is the values of  $w_e^h$  and  $w_t^h$ . So if we would like to achieve the goal that the sole e-channel outperforms the dual-channel, the value of  $P$  should change with the difference of wholesale price between the traditional channel and the e-channel.

According to our study above, we can provide some guidelines for the channel managers of manufacturers as follows: channel managers can use some indicators and methods to measure the probability of disruption risks,  $P$ , if the value of  $P$  is little, the manufacturer choose the traditional channel as the single distribution channel; if the value of  $P$  can maintain in a certain range, the manufacturer choose the dual-channel; if the value of  $P$  is large and has been beyond a certain range, the manufacturer choose the e-channel as the single distribution channel.

### 3.5. The Numerical Analysis of EPFs

It is seen from (3.6) and (3.7), the EPFs of the manufacturer are linearly correlated with. The values of the relevant variables are listed in Table 2.

Table 2: The values of the relevant variables

$M$	$k$	$x$	$w_{ed}$
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10000	0.002	0.3	330	
$w_e^h$	$w_t^h$	$w_t^s$	$w_0$	$c$
340	360	400	150	200

And then the expected profits of different scenarios are displayed in Figure 1.

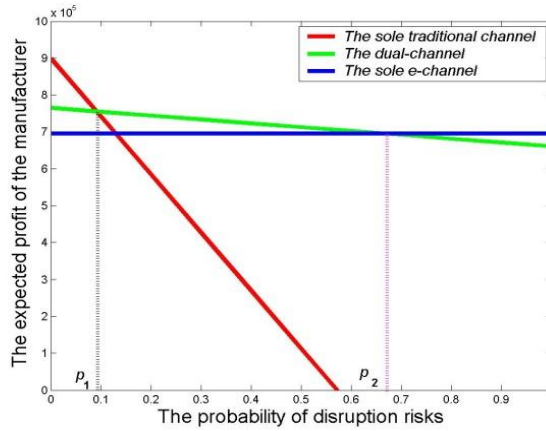


Figure 1: The expected profit of the manufacturer in different scenarios about channel selection.

Figure 1 shows that the results are the same with the analysis results in above and two critical values are  $p_1 = 0.09$  and  $p_2 = 0.67$ , that is if  $p$  satisfies the relationship  $p < p_1 = 0.09$ , the manufacturer choose the traditional channel as the single distribution channel; if  $p$  satisfies the relationship  $p_1 = 0.09 \leq p \leq p_2 = 0.67$ , the manufacturer choose the dual-channel; if  $p$  satisfies the relationship  $p \geq p_2 = 0.67$ , the manufacturer choose the e-channel.

#### 4. Conclusions

This paper focus on the relationship between the probability of disruption risks and the channel selection of manufacturers through formulating the expected profit functions. Two critical values of the probability are first obtained and then the conclusions are examined by numerical examples. At last, some guidelines are suggested for the distribution channel managers to make the decision about channel selection under Internet environment.

This paper only examines the problem of channel selection for manufacturers in the presence of disruption risks, but the strategies of the traditional channel in

the disrupted state and the probability of disruption risks by e-channel are not taken into consideration. These represent our future research directions.

## Acknowledgements

This research is supported by Humanities and Social Sciences Research projects of Ministry of Education (08JC630051).

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