# Green Supply Chain Price Discrimination Model Based on Consumer Preference Behavior 

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Keywords: Pricing; Environmental awareness; Price discrimination; Green supply chain


#### Abstract

Based on the price difference between green products and ordinary products, considering the consumer's preference behavior, this paper constructs a price discrimination model of green supply chain under duopoly. Four decision models are established base on the decision of whether manufacturer investigates consumer information, which are II, NN, IN and NI. Then we analyze the optimal pricing strategy and revenue for the members. The results show that the investigation of consumer is beneficial for green manufacturer, and the profits of green manufacturer reaches a maximum when the accuracy of consumer information is one value. At the end, the feasibility of the models is verified through a numerical example.


## 1. Introduction

With the progress of science and technology and the development of economy, the resources on the earth are increasingly scarce. At the same time, the environmental pollution situation caused by human activity is getting more and more serious [1, 2]. Countries are searching for the development pattern of green economy which low resources consumption, less environmental pollution and sustainability under the double pressure of resources and environment. The high production cost of green product and low consumer environmental awareness make the development of green economy is limited [3]. So, if we want to promote the development of green economy and improve the market share of green products, we must solve consumers and enterprises are facing major problems. In recent years, many scholars at home and abroad have researched the green supply chain. This paper is to introduce green supply chain from the view of consumer preference and segmentation.

In green supply chain, many scholars focus on the impact of consumers' environmental awareness on product selection and demand. Conrad studied the impact of consumer environmental awareness on product greenness and pricing when consumers are concerned about environmental issues [4]. Liu et al studied the impact of consumer green awareness on supply chain members in a competitive environment. The result showed that the improvement of consumers' environmental awareness is beneficial to retailers and manufacturers [5]. Zhang et al used the multi product newsboy model to establish a decision-making model in the green supply chain composed of a manufacturer and a retailer [6]. Then they analyzed the impact of consumers' environmental awareness on pricing and channel coordination. Based on the assumption that consumers have higher preference for green products, Jiang and Li established four game models of green supply chain, which are manufacturer led, retailer led, Nash equilibrium and centralized decision-making [7]. According to the different sensitivity of consumers to price and green degree, Liu et al divided consumers into three types and studied the pricing decision-making problem of green products [8].

The related fields of this paper also include product differential pricing, which is mainly focused on the closed-loop supply chain. On the basis of consumers’ different preferences for new products and remanufactured products, Ferrer et al studied the discriminatory pricing decision of new products and remanufactured products [9, 10]. Bayindir et al made discriminatory pricing for new products and remanufactured products, and coordinated the closed-loop supply chain [11]. Under the background of government subsidy policy, Li et al constructed the closed-loop supply chain models of centralized decision-making and decentralized decision-making differential pricing with or without government subsidies [12]. Xu and Tang divided products into new products,
remanufactured products and second-hand products according to whether the product is remanufactured and the degree of old and new. Then they studied the discriminatory pricing problem of closed-loop supply chain based on the different preferences of consumers for these three products [13].

In this paper, consumers are divided into groups based on consumers' preference behavior. Then we adopt a variety of promotion pricing strategies for consumers with different loyalty. And the price discrimination model of green supply chain is built.

## 2. Problem description and model assumptions

Consider one green supply chain system which has two monopolistic manufacturers in the market. The two manufacturers produce two products which green degree are different and can replace each other. The two products are green product and ordinary product, and there is green environmental label on the green product. Green environmental label is awarded by government departments or community groups according to environmental standards, this is to certify the product from develop, produce, transport, sell, use until recycle all conforms with environmental protection standard, and has no damage to ecological environment and human healthy.

The two manufacturers can get consumer preference information for green products and ordinary products (hereafter referred to as a consumer information) based on market survey. For example, we get consumer information from consumer credit card report or a marketing firm. Shaffer and Zhang studied this kind of problem in detail [14]. There are four cases in our model according to whether manufacturers investigate the consumer information, which are: (1) the two manufacturers are not to investigate consumer information, simply $N N$ strategy; (2) the two manufacturers are to investigate consumer information, simply II strategy; (3) green product manufacturer is to investigate consumer information, and ordinary product manufacturer is not, simply ${ }^{I N}$ strategy; (4) green product manufacturer is not to investigate consumer information, and ordinary product manufacturer is, simply ${ }^{N I}$ strategy.

The symbol is used in the paper as follows: ${ }^{p_{1}}$ and ${ }^{q_{1}}$ are retail price and demand of green product, ${ }^{p_{2}}$ and $q_{2}$ are retail price and demand of ordinary product. This paper is established based on the assumption:
(1) Consumers are willing to pay for green products are ${ }^{v}$, assumed to be uniformly distributed between 0 and 1 . Consumers are willing to pay for ordinary products are $\delta v$, and $\delta$ is environmental damage level of consumers. The higher value of $\delta$ indicates the more serious of environmental damage, and $0 \leq \delta \leq 1$.
(2) For convenient calculation, the production costs of green and ordinary product are zero. The hypothesis has its limitation, but may not have much of an impact on calculation, and convenient for formulation derivation and calculation to get more intuitive theoretical results.
(3) The consumer information is uniformly distributed between 0 and 1 , and the interval is divided into ${ }^{N}$, are signed by ${ }^{m}$, and ${ }^{m}=1,2, \ldots \ldots, N$. According to the research of Liu and Serfes [15], order $N=2^{k}$, and $k=0,1,2, \cdots$. $k$ denotes the accuracy of consumer information, the higher value of ${ }^{k}$ indicates the more accurately of consumer information. $k=0$ shows the pricing strategy is non-discrimination, $k=\infty$ shows the pricing strategy is perfect - discrimination. The partition of consumer in a range of $[0,1]$ as show in Fig. 1.
(4) The market size is $U$, and $U=1$. There is no arbitrage between consumers.
(5) Decision order is: 1) the investigation of consumer information, mean manufacturers decide whether investigate consumer information; 2) regular pricing decision; 3) promotional pricing decision, mean manufacturer take various pricing strategies according to consumer information.


Figure 1 Partition of consumer in a range of $[0,1]$

By above assuming that consumer utility from the green product: ${ }^{v-p_{1}}$, consumer utility from the ordinary product: $\delta v-p_{2}$. The condition of consumer buy green product is $v-p_{1}>\delta v-p_{2} \Rightarrow{ }^{v>\frac{p_{1}-p_{2}}{1-\delta}}$ according to the principle of utility maximization. Because ${ }^{v}$ is uniformly distributed between 0 and 1, the demand of green product $q_{1}=\int_{\frac{p_{1}-p_{2}}{1-\delta}}^{1} 1=1-\frac{p_{1}-p_{2}}{1-\delta}$; similarly, the demand of ordinary


### 2.1 Pricing decision

### 2.1.1 $N N$ strategy

This is the standard Cournot duopoly model. The two manufacturers choose their regular prices in stage 2. Known from above analysis that $q_{1}^{N N}=1-\frac{p_{1}-p_{2}}{1-\delta}$ and $q_{2}^{N N}=\frac{p_{1}-p_{2}}{1-\delta}$, so, the profits of the two manufacturers are $\Pi_{G}^{N N}=p_{1}^{N N} q_{1}^{N N}$ and $\Pi_{P}^{N N}=p_{2}^{N N} q_{2}^{N N}$, and $\Pi_{G}^{N N}$ is green product manufacturer's profit, and $\Pi_{P}^{N N}$ is ordinary product manufacturer's profits. We can get the optimal pricing and profit functions of the two manufacturers based on Cournot duopoly theory.

$$
p_{1}^{N N}=\frac{2(1-\delta)}{3} \quad \Pi_{1}^{N N}=\frac{4(1-\delta)}{9} \quad \Pi_{2}^{N N}=\frac{1-\delta}{9}
$$

$1-\delta$ denotes environmental protection level of consumer, the higher value of $1-\delta$ indicates the more of environmental protection level.

1) II strategy

Since both manufacturers have consumer information, they know in which of the segments each consumer is located, and therefore they are able to charge different prices for different segments. The interval $[0,1]$ is divided equally into $2^{k}$ segments, each one having length equal to $\frac{1}{2^{k}}$ Segment m can be expressed as the interval $\left[\frac{m-1}{2^{k}}, \frac{m}{2^{k}}\right]$, where m is an integer between 1and $2^{k}$. In segment $m$, the demands of green and ordinary product are $q_{1}^{I I}=\frac{m}{2^{k}}-\frac{p_{1}-p_{2}}{1-\delta}$ and $q_{2}^{I I}=\frac{p_{1}-p_{2}}{1-\delta}-\frac{m-1}{2^{k}}$, with $q_{1}^{I I} \in\left[0, \frac{1}{2^{k}}\right], q_{2}^{I I} \in\left[0, \frac{1}{2^{k}}\right]$. Their profits are $\Pi_{G}^{I I}=p_{1}^{I I} q_{1}^{I I}$ and $\Pi_{P}^{I I}=p_{2}^{I I} q_{2}^{I I}$. Similarly, the optimal pricing and profit functions of the two manufacturers are as follows.

$$
p_{1}^{I I}=\frac{(m+1)(1-\delta)}{3 \times 2^{k}}, p_{2}^{I I}=\frac{(2-m)(1-\delta)}{3 \times 2^{k}}, q_{1}^{I I}=\frac{m+1}{3 \times 2^{k}}, q_{2}^{I I}=\frac{2-m}{3 \times 2^{k}}
$$

From the above results we can get the following conclusions.
When $m=1$, then $p_{1}^{I I}=\frac{1-\delta}{3 \times 2^{k-1}}, \quad q_{1}^{I I}=\frac{1}{3 \times 2^{k-1}} \quad q_{2}^{I I}=\frac{1}{3 \times 2^{k}} \quad \quad \Pi_{G}^{I I}=\frac{1-\delta}{9 \times 4^{k-1}} \quad \Pi_{P}^{I I}=\frac{1-\delta}{9 \times 4^{k}}$.
When $m \geq 2$, then $p_{1}^{I I}=\frac{(m-1)(1-\delta)}{2^{k}}, p_{2}^{I I}=0, q_{1}^{I I}=\frac{1}{2^{k}}, q_{2}^{I I}=0, \quad \Pi_{G}^{I I}=\frac{(m-1)(1-\delta)}{4^{k}}, \quad \Pi_{P}^{I I}=0$.
So, their profits are

$$
\Pi_{G}^{I I}=\sum_{m=1} \frac{1-\delta}{9 \times 4^{k-1}}+\sum_{m=2}^{2^{k}} \frac{(1-\delta)(m-1)}{4^{k}}=\frac{\left(9 \times 2^{-k}-28 \times 4^{-k}+9\right)(1-\delta)}{18} \Pi_{P}^{I I}=\sum_{m=1} \frac{1-\delta}{9 \times 4^{k}}+\sum_{m=2}^{2^{k}} 0=\frac{4^{-k} \times(1-\delta)}{9}
$$

### 2.1.2 ${ }^{I N}$ strategy

In this strategy, green product manufacturer has information, ordinary manufacturer chooses its regular price in stage 2 , and green product manufacturer chooses its promotional prices in stage 3 . We first solve green product manufacturer's problem. Its demand and profit in each segment are
$q_{1}^{I N}=\frac{m}{2^{k}}-\frac{p_{1}-p_{2}}{1-\delta}$ and $\Pi_{G}^{I N}=p_{1}^{I N} q_{1}^{I N}, \quad \Pi_{G}^{I N}$ taking the derivatives of $p_{1}^{I N}$ has $p_{1, R}^{I N}=\frac{p_{2}^{I N}}{2}+\frac{m(1-\delta)}{2^{k+1}}$.
When ${ }^{m=1}$, then $q_{1, L}^{I N}=\frac{1}{2^{k}}-\frac{p_{1}^{I N}-p_{2}^{I N}}{1-\delta}, \Pi_{G}^{I N} \quad$ taking the derivatives of $p_{1}^{I N}$ has $p_{1, L}^{I N}=\frac{p_{2}^{I N}}{2}+\frac{1-\delta}{2^{k+1}}$.
When $m \geq 2$, then $q_{1, R}^{I N}=\frac{m}{2^{k}}-\frac{p_{1}^{I N}-p_{2}^{I N}}{1-\delta}=\frac{1}{2^{k}}$, So, $p_{1, R}^{I N}=p_{2}^{I N}+\frac{(1-\delta)(m-1)}{2^{k}}$.
Then we can get the profit of green product manufacturer is as follow:

$$
\Pi_{G}^{I N}=\sum_{m=1} p_{1, L}^{I N} q_{1, L}^{I N}+\sum_{m=2}^{2^{k}} p_{1, R}^{I N} \cdot \frac{1}{2^{k}}
$$

Now solve ordinary manufacturer's problem, its demand is $q_{2}^{I N}=\frac{p_{1}^{I N}(p 2, k)-p_{2}^{I N}}{1-\delta}-\frac{m-1}{2^{k}}$, and $p_{1}^{\text {IN }}(p 2, k)=\frac{p_{2}^{I N}}{2}+\frac{1-\delta}{2^{k+1}}$. So ordinary manufacturer's profit is

$$
\Pi_{P}^{I N}=\sum_{m=1} p_{2}^{I N} q_{2}^{I N}+\sum_{m=2}^{2^{k}} 0
$$

A simple derivation we can get

$$
p_{2}^{I N}=\frac{1-\delta}{2^{k+1}}, \Pi_{2}^{I N}=\frac{4^{-k} \times(1-\delta)}{8}
$$

Taking the result above into $\Pi_{G}^{I N}$ we can get the result as follow:

$$
\begin{aligned}
\Pi_{G}^{I N} & =\sum_{m=1} \frac{3(1-\delta)}{2^{k+2}} \cdot \frac{3}{2^{k+2}}+\sum_{m=2}^{2^{k}} \frac{(1-\delta)(2 m-1)}{2^{k+1}} \cdot \frac{1}{2^{k}} \\
& =\frac{\left(2^{-k+3}-15 \times 4^{-k}+8\right)(1-\delta)}{16}
\end{aligned}
$$

### 2.1.3 ${ }^{N I}$ strategy

This strategy is contrary to IN strategy. Ordinary product manufacturer has information, green manufacturer chooses its regular price in stage 2.

There is $m=1, \cdots, m^{*}$, the demand of ordinary product manufacturer

$$
q_{2}^{N I}=\frac{p_{1}-p_{2}}{1-\delta}-\frac{m-1}{2^{k}}=\frac{1}{2^{k}} \quad \Rightarrow \quad p_{2 L}^{N I}=p_{1}-\frac{m(1-\delta)}{2^{k}} \quad \Rightarrow
$$

$\left.\frac{\partial \Pi_{P}^{N I}}{\partial p_{2}}\right|_{p_{2}=p_{1}-\frac{m(1-\delta)}{2^{k}}}=\frac{(1-\delta)(m+1)-2^{k} \times p_{1}^{N I}}{2^{k} \times(1-\delta)} \leq 0$, so has $m_{1}=\frac{2^{k} \times p_{1}^{N I}}{1-\delta}-1$. Assuming $m^{*}$ is the largest integer that less-than $m_{1}$.

There is $m=m^{* *}, \ldots, 2^{k}$, the pricing of ordinary product manufacturer is zero in its interval, mean $p_{2 R}^{N I}=0$. Then the consumer located in the position of $\frac{m-1}{2^{k}}$ is indifferent to buy green or ordinary product, and $v-p_{1}^{N I}=\delta v-0 \Rightarrow m_{2}=\frac{2^{k} \times p_{1}^{N I}}{1-\delta}+1$. Assuming $m^{* *}$ is the largest integer that greater than $m_{2}$.

For any $m^{*}<m<m^{* *}, \frac{\partial \Pi_{P}^{N I}}{\partial p_{2}} \Rightarrow p_{2, M}^{N I}=\frac{p_{1}^{N I}}{2}-\frac{(1-\delta)(m-1)}{2^{k+1}}$. So, the profit of ordinary product manufacturer is

$$
\Pi_{P}^{N I}=\sum_{m=1}^{m^{*}} p_{2 L}^{N L} \cdot \frac{1}{2^{k}}+\sum_{m=m^{+}+1}^{m^{m}-1} p_{2 M}^{N I}\left[\frac{\left(p_{1}^{N I}-p_{2}^{N I}\right)}{1-\delta}-\frac{m-1}{2^{k}}\right]+\sum_{m=m^{*}}^{2^{k}} 0
$$

Taking $p_{2}^{N I}$ obtained in step (3) into green manufacturer's profit we can get

$$
\Pi_{1}^{N I}=\left[\sum_{m=1}^{m^{*}} 0+\sum_{m=m^{*}+1}^{m^{* *}-1}\left(\frac{m}{2^{k}}-\frac{p_{1}^{N I}-p_{2}^{N I}\left(p_{1}, k\right)}{1-\delta}\right)+\sum_{m=m^{*}}^{2^{k}} \frac{1}{2^{k}}\right] p_{1}^{N I}
$$

Through the above analysis, we can get some conclusions as following:
The regular pricing of green product manufacturer $p_{1}^{N I}=(1-\delta)\left(\frac{1}{2}+\frac{1}{2^{k+2}}\right)$.
$m^{*}=2^{k-1}-1, m^{* *}=2^{k-1}+2$.
When $1 \leq m \leq m^{*}, 1 \leq n \leq n^{*}$, the pricing of ordinary product manufacturer $p_{2}^{N I}=(1-\delta)\left(\frac{1}{2}+\frac{1}{2^{k+2}}-\frac{m}{2^{k}}\right)$
When $m^{*}+1 \leq m \leq m^{* *}-1, n^{*}+1 \leq n \leq n^{* * *}-1$, the pricing of ordinary manufacturer is as follow:

$$
p_{2}^{N I}=(1-\delta)\left(\frac{1}{4}+\frac{5}{2^{k+3}}-\frac{m}{2^{k+1}}\right)
$$

When $m^{* *}-1<m \leq 2^{k}$, the pricing of ordinary manufacturer $p_{2}^{N I}=0$
So the function profits of the two manufacturers are as follows:

$$
\begin{gathered}
\Pi_{G}^{N I}=\frac{(1-\delta)\left(3 \times 2^{-k+2}-13 \times 4^{-k}-2^{-k+4}+6\right)}{32} \\
\Pi_{P}^{N I}=\frac{(1-\delta)\left(13 \times 2^{-k+2}-17 \times 4^{-k}+4\right)}{64}
\end{gathered}
$$

### 2.2 Consumer information investigation decision

The game played between the two manufacturers in the first stage can be summarized in Table 1.
Table 1 Manufacturers' profits under the four strategies of $N N, I I, I N, N I$

| Strategy | Green product manufacturer | Ordinary product manufacturer |
| :---: | :---: | :---: |
| NN | $\frac{4(1-\delta)}{9}$ | $\frac{1-\delta}{9}$ |
| II | $\frac{\left(9 \times 2^{-k}-28 \times 4^{-k}+9\right)(1-\delta)}{18}$ | $\frac{4^{-k} \times(1-\delta)}{9}$ |
| IN | $\frac{\left(2^{-k+3}-15 \times 4^{-k}+8\right)(1-\delta)}{16}$ | $\frac{4^{-k} \times(1-\delta)}{8}$ |
| NI | $\frac{\left(3 \times 2^{-k+2}-2^{-k+4}-13 \times 4^{-k}+6\right)(1-\delta)}{32}$ | $\frac{\left(13 \times 2^{-k+2}-4^{-k}+4\right)(1-\delta)}{64}$ |

The table1 shows that when $k=0$, green manufacturer's profit to be maximized under $N N$ strategy, when $1 \leq k<7$, its profit to be maximized under $I N$ strategy, when $k \geq 7$, its profit to be maximized under II or IN strategy. So, green manufacturer can improve its profits by investigating consumer information when $k \geq 1$. For ordinary manufacturer, its profit to be maximized under NI strategy for any $k$, and its profit is zero when $k \geq 6$.

Proof. When $k=0, \quad \Pi_{G}^{N N}=\frac{4(1-\delta)}{9}, \quad \Pi_{G}^{I}=-\frac{5(1-\delta)}{9}, \quad \Pi_{G}^{I N}=\frac{1-\delta}{16}, \quad \Pi_{G}^{N I}=-\frac{11(1-\delta)}{32}, \quad$ so, $\Pi_{G}^{N N}>\Pi_{G}^{I N}>\Pi_{G}^{I}>\Pi_{G}^{N I}$. When $k \geq 1$, as shown in figure 2, figure $a$ is green manufacturer's profit change with $k$, figure $b$ is ordinary manufacturer's profit change with $k$.

When $k=1, \Pi_{G}^{I N}>\Pi_{G}^{N N}>\Pi_{G}^{I I}>\Pi_{G}^{N I} ; \quad$ When $k=2, \quad \Pi_{G}^{I N}>\Pi_{G}^{I I}>\Pi_{G}^{N N}>\Pi_{G}^{N I} ;$ When $k \geq 7$, $\Pi_{G}^{I N}=\Pi_{G}^{I}>\Pi_{G}^{N N}>\Pi_{G}^{N I}$; When $k=\infty, \quad \Pi_{G}^{I N}=\Pi_{G}^{I I} \rightarrow \frac{1-\delta}{2}, \Pi_{G}^{N I} \rightarrow \frac{17(1-\delta)}{2^{8}}$. Similarly to the ordinary manufacturer's decision.


Figure 2 Manufacturers' profits change with $k$ on the strategies of ${ }_{N N}, I I$, IN and ${ }_{N I}$

## 3. Numerical study

In this section, we take numerical experiments to analyze the decisions of the two manufacturers intuitively. ${ }^{k}$ taking 1 as a length of stride 1 change from 1 to 10 . The main researches are as follows. The pricings and profits of the two manufacturers change with ${ }^{k}$ under the strategy of $I I$. The pricings and profits of the two manufacturers change with ${ }^{k}$ under the strategy of ${ }^{N I}$.

### 3.1 II strategy



Figure 3 Manufacturers' profits change with $k$ on II strategy
Figure 3 shows that green manufacturer's profit increase as $k$ when $k \leq 3$, it decrease as $k$ increase and gradually tends to $\frac{1-\delta}{2}$ when $k>4$. Ordinary manufacturer's profit decrease as $k$ increase, and it is zero when $k \geq 6$.

For example, assuming $k=3$, mean $N=8$, between the two manufacturers satisfy Cournot competition in the first interval, green product manufacturer will monopolize the market in interval
of $2,3,4,5,6,7,8$.
The two manufacturers' pricings and profits in the first interval are as follows.

$$
p_{2}^{I I}=\frac{1-\delta}{24} \quad \Pi_{G 1}^{I I}=\frac{1-\delta}{144} \quad \Pi_{P 1}^{I I}=\frac{1-\delta}{576}
$$

Green manufacturer's pricing from the interval of second to eight are as follows.

$$
p_{12}^{I I}=\frac{2(1-\delta)}{8} \quad p_{13}^{I I}=\frac{2(1-\delta)}{8} \quad p_{14}^{I I}=\frac{3(1-\delta)}{8} \quad p_{15}^{I I}=\frac{4(1-\delta)}{8} \quad p_{16}^{N I}=\frac{5(1-\delta)}{8} \quad p_{17}^{I I}=\frac{6(1-\delta)}{8} \quad p_{18}^{I I}=\frac{7(1-\delta)}{8}
$$

Green manufacturer's profit from the interval of second to eight are as follows.

$$
\Pi_{G 2}^{I I}=\frac{1-\delta}{64} \quad \Pi_{G 3}^{I I}=\frac{1-\delta}{32} \quad \Pi_{G 4}^{I I}=\frac{3(1-\delta)}{64} \quad \Pi_{G 5}^{I I}=\frac{1-\delta}{16} \quad \Pi_{G 6}^{I I}=\frac{5(1-\delta)}{64} \quad \Pi_{G 7}^{I I}=\frac{3(1-\delta)}{32} \quad \Pi_{G 8}^{I I}=\frac{7(1-\delta)}{64}
$$

## 3.2 ${ }^{N I}$ strategy



Figure 4 The two manufacturers' profits change with $k$ on the ${ }_{N I}$ strategy
Figure 4 shows that green manufacturer's increase with $k$, and when $k \rightarrow \infty$, the pricing strategy is perfect-discrimination and it tend to $\frac{17(1-\delta)}{2^{8}}$. Profit of ordinary manufacturer decrease with $k$ and tend to $\frac{1-\delta}{2^{4}}$.

For example, assuming $k=3$, mean $N=8$, then we have $m^{*}=3$ and $m^{* * *}=6$. The two manufacturers monopolize the market respectively in the interval of $1,2,3$ and $6,7,8$. Between the two manufacturers satisfy Cournot competition in the interval of 4 and 5 .

Ordinary manufacturer's pricing from the interval of second to eight are as follows.

$$
p_{21}^{N I}=\frac{7(1-\delta)}{16} \quad p_{22}^{N I}=\frac{5(1-\delta)}{16} \quad p_{23}^{N I}=\frac{3(1-\delta)}{16} \quad p_{24}^{N I}=\frac{5(1-\delta)}{64} \quad p_{25}^{N I}=\frac{1-\delta}{64} \quad p_{26}^{N I}=0 \quad p_{27}^{N I}=0 \quad p_{28}^{N I}=0
$$

Green manufacturer's pricing from the interval of first to eight are as follows.

$$
\begin{gathered}
\Pi_{11}^{N I}=0 \quad \Pi_{12}^{N I}=0 \quad \Pi_{13}^{N I}=0 \quad \Pi_{14}^{N I}=\frac{54(1-\delta)}{2^{11}} \Pi_{15}^{N I}=\frac{119(1-\delta)}{2^{11}} \quad \Pi_{16}^{N I}=\frac{17(1-\delta)}{2^{8}} \quad \Pi_{17}^{N I}=\frac{17(1-\delta)}{2^{8}} \\
\Pi_{18}^{N I}=\frac{17(1-\delta)}{2^{8}}
\end{gathered}
$$

Ordinary manufacturer's profit from the interval of second to eight are as follows.

$$
\Pi_{21}^{N I}=\frac{13(1-\delta)}{2^{8}} \quad \Pi_{22}^{N I}=\frac{9(1-\delta)}{2^{8}} \quad \Pi_{23}^{N I}=\frac{1-\delta}{2^{8}} \quad \Pi_{24}^{N I}=\frac{35(1-\delta)}{2^{12}} \quad \Pi_{25}^{N I}=\frac{17(1-\delta)}{2^{11}} \quad \Pi_{26}^{N I}=0 \quad \Pi_{27}^{N I}=0 \quad \Pi_{28}^{N I}=0
$$

## 4. Conclusions

This paper established green supply chain price discrimination model under four strategy of $N N, I I, I N$ and $N I$ based on the difference of the price between green product and ordinary product. Then we can get the optimal pricing strategy and maximizing revenue under the four strategies. By
comparing profits of the two manufacturers under the four strategies we can find: under $N N$ strategy, profit of the two manufacturers only be affected by consumer environmental preferences, and it is positively related to consumer environmental preferences; profit of green manufacturer is positively related to consumer information accuracy when $k \leq 3$, and is negatively related to consumer information accuracy when $k>4$; profit of ordinary manufacturer is negatively related to consumer information accuracy, and it is zero when $k \geq 6$. Under NI strategy, profit of green manufacturer is positively related to consumer information accuracy for any $k$, and it reach $17(1-\delta) / 2^{8}$ when $k \rightarrow \infty$; Profit of ordinary manufacturer is negatively related to consumer information accuracy for any $k$, and it tend to $(1-\delta) / 2^{4}$.

There are some questions we do not solve in this paper. For example, we assume that the production cost is zero. The decision model may be affected when the production cost is not zero. In addition, this paper is not consider the relation of supply and demand impact on the decision of supply chain. All above question will be researched in the next work.

## Acknowledgment

This work was supported by the Person Foundation of Hefei University under Grant No. 20RC59.

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