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Coordination with Price Subsidy When Channels Compete in Real Estate Supply Chain

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Abstract

With the expansion of real estate business, many real estate developers begin to sell some of their houses to some real estate agents and consumers buy those houses through real estate agent in China, which forms market competition with the direct sales channels that real estate developers establish. In order to obtain more profits, some real estate developers provide some real estate agents with price subsidy in the competitive sales channels. Therefore, pricing strategy and price subsidy level become key parameters of the developers' decision. By solving the real estate developer's profit function, some key indexes in the centralized supply chain and those in the supply chain with the wholesale price contract are obtained. They include the retail price, the sales quantity in each sales channel, the price subsidy level and the total developer's profit. The revenue-sharing contract is used to coordinate developer-dominant supply chain in decentralized decision. The results shows that the total profit of the real estate supply chain with the price subsidy is larger than that without the price subsidy and the revenue-sharing contract can coordinate the decentralized real estate supply chain. The optimal price subsidy decreases in the market scale that the real estate agent faces and the price subsidy will be canceled by the real estate developer when the market share the agent faces is fifty percent.

Keywords*: real estate supply chain, price subsidy, supply chain contract*

1. Introduction

The development of China's economy has become key concern throughout the world in recent years and the development of real estate industry in China is always one of the industries which has been paid much attention to. The recent development of the real estate market in China is as follows. Firstly, the investment of the real estate industry compared with previous years decreases. The total investment of the real estate industry in China amounts to 9.5 trillion Yuan in 2014. The increase rate is 10.5%, which is the lowest level compared with the past decade. The construction area of commercial houses which ought to be built is 1.8 billion square meters, which decreases by 10.7%. The decrease rate is the lowest level compared with that during the past decade. Secondly, the sales area of commercial houses decreases dramatically. The total sales area of commercial houses in China is 1.2 billion square meters in 2014, which decreases by 7.6%. The total sales area of commercial houses in China increases stably every year since 2002 while it decreases in 2008 and 2014. Thirdly, the development policy of the real estate industry is adjusted in recent years. The development of the real estate industry in China decreases in the first half year of 2014. The regulation policy of the real estate market begins to adjust in the second half year of 2014. The policy, "doing everything possible to decrease the inventory of commercial houses", is put forward by the Chinese Department of Housing in July, 2014. The restriction policy of buying commercial houses is implemented in some two-class and three-class cities. The restriction policy of

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buying commercial houses is canceled or relaxed in almost all cities nationwide except Beijing, Guangzhou, Shenzhen and Sanya at the end of 2014. Furthermore, a series of macro-economic policies is put forward by the central government. For example, the Central Bank of China and the Chinese Banking Regulatory Commission require that all local Chinese banks should provide consumers with relax monetary policy which is used to buy the first house and the improved-type house. The executive meeting is held by the Chinese State Council in the second half year of 2014, which aims at promoting housing consumption, upgrading the real estate market and, at the same time, stabilizing housing consumption. The Central Bank of China lowers the interest rate for deposit and loan again in the second half year of 2014 after the policy is implemented two and a half years ago. The implementation of those policies makes the total real estate market nationwide recover at the end of 2014.

With the implementation of "The National New-type Urbanization Plan (2014-2020)", the increase of housing demand will bring new opportunity for the development of the real estate market. There will be "three type of 100 million people" who will be settled in cities and towns around China in the next few years, which will lead to continuous growth in the demand of urban houses and bring a huge impetus to the development of the real estate market in China during the 13th national "Five-year Development Plan". For the first-class cities and some second-class central cities, the future trend of the urban housing demand in China is as follows.

At first, a large number of college students will graduate each year, which will bring a lot of new housing demand. According to the data released by the Chinese Ministry of Education, the number of college graduates is 7.27 million in 2014 and the number of new talent in cities and towns each year is about 10 million if that number adds the number of graduates from secondary vocational schools. According to recent statistics, the graduates will be settled in the first-class cities and the capital cities in Chinese provinces where they begin their living. It is estimated that the number of graduates in major cities each year will increase by 100-200 thousand and that number in Beijing, Shanghai, Guangzhou and Shenzhen will be more than 100-200 thousand. The graduates not only increase the employment number but also bring the new demand for local housing.

At second, the number of agricultural people who will be settled in cities and towns in the next few years will be one hundred million, which will contribute to the growth in the demand for renting urban houses. In order to reach the goal in 2020, the number of city & town immigrant each year will be 17 million, equivalently, 6-10 million families. Because of the lower consumption in buying houses among those people, the their expense in housing is mainly in renting existing houses. Taking Shenzhen as an example, the demand of renting houses each year will increase by 100 thousand in the next few years.

At last, there are many urban shanty towns and urban villages which will be upgraded and this will lead to the continuous growth in the improved housing demand. According to the "three-type-of-100-million-people" goal, there will be about one million people living in urban shanty towns and urban villages who want to improve their housing conditions by 2020. According to the analysis from the Chinese Ministry of Housing, the improved housing demand in cities and towns nationwide each year will be 315 million square meters, which is a huge housing demand. Taking Shenzhen as an example, the homeownership rate in Shenzhen is 30% while the rate both in Beijing and Shanghai is 70%, and the rate in Guangzhou is 90%. The rate in those cities is higher than that in Shenzhen. With the development of the future new-type urbanization, there will be twenty-three years when the homeownership rate in Shenzhen reach the current homeownership rate in Beijing and Shanghai. The analysis is based on the assumption that there are 4.5 million families which do not have their houses and there are 110 thousand houses which are built each year. We only calculate the improved housing

demand and do not take the housing demand of the new-added people into consideration. Thus, the improved housing demand is very strong.

From the analysis mentioned above, we can obtain that there are still plenty rooms for the development of the future real estate market and there are innovation rooms for the development of business model and marketing policies for real estate enterprises.

2. Literature Review

There are many studies related to the real estate industry. One branch of researches is related to how house price affects the flow of workforce. The flow of workforce is usually related to many factors such as wage, unempolyment and city attribute *etc.*, (Pissarides and McMaster, 1990; Jackman and Savouri, 1992). Helpman (1998) introduces real estate market into new economical geography standard model established by Krugman (1991) , which shows that higher house price can influence workforce's relative utility and, furthermore, inhibit gathering of workforce in the region where house price is high. That is ignored in standard Krugman-model and other new economical geography model (Tabuchi *et. al.,* 2001). Hanson *et. al.,* (1999, 2005) certify Helpman's conclusion by using empirical method.

The discussion about the relationship between housing investment and economy development is a hot issue in academic world while there are not some empirical studies in this field until 1980s. Boléat and Coles (1987) compares the relationship between the rate that housing investment occupies GDP and the annual increase rate of average GDP in different countries such as United Kingdom, U.S.A., Western Germany, France, Italy, Canada and Japan from 1960 to 1983. They conclude that there is correlated relationship between the two rates in those developed countries. Greenwood and Hercowitz (1991) states that housing investment leads many macro-economic variables such as commercial investment and family durable commoditie in America after they analyze the data of those three variables from 1954 to 1989. There are many studies about the relationship between housing investment and GDP in America from 1990 to 2000, which takes different control variables into consideration. Green (1997) and Coulson ＆ Kim (2000) discover that housing investment is the Granger factor of GDP and it leads the business cycle. Gauger and Snyder (2003) testify the conclusion drawn by Green (1997) and Coulson ＆ Kim (2000) through using the quarterly data from 1959 to 1999 in America.

There are many studies related to how the government subsidies influence the operation of enterprises. Girma *et. al.,* (2007) discuss the effectiveness of the Ireland government subsidies and find that the government subsidies is effective when they are used in technical innovation. Beason and Weinstein (1996) find that the Japanese government subsidy makes its enterprises develop slowly and makes scale return decrease slowly. Van Tongeren (1998) and Tzelepis & Skuras (2004) find that direct financial subsidy can increase enterprises' solvency and this leads to manager's corruption and laziness. Bergström (2000) analyzes the impact of subsidy utility on Sweden enterprises by using the data from 1987 to 1993 and finds that the subsidies produce positive utility to those enterprises which obtain the government subsidy in the first year and negative utility in the second year.

The literature closely related to this paper comes from studies in dual-channel supply chain. Dumrongsiri (2008) finds that the total profit of dual-channel supply chain will increase when the retailer improves service level . Hua *et. al.,* (2010) examine the impact of lead time commitment in the electronic channel on the manufacturer's and the retailer's pricing strategy. Cai (2010) examines the impact of dual-channel supply chain structure on the decision-making of the manufacturer, the retailer and the total supply chain. There are a lot of researches related to dual-channel supply chain coordination. Chen (2008) studies how manufacturer builds and manages dual-channel supply chain when there exists service competition between the two channels. Cai (2009) studies how

to implement price-discount contract after the supplier establishes dual-channel supply chain structure. An improved revenue-sharing contact is put forward by Xu (2014) and it is used to coordinate a dual-channel supply chain in which there is different substitution for the same product. Yan (2009) studies the impact of retail service in the dual-channel supply chain on channel competition, channel conflict and supply chain performance. Dan *et. al.*, (2012) study the impact of customer loyalty for the traditional channel and retail service on supply chain members' pricing decisions.

There appear a lot of new business models because of the immaturity in the operation of dual-channel supply chain, in which the channel retail price is the same. In January 2014, two major taxi companies in China, Didi Taxi and Fast Taxi, begin to implement price subsidy policy. They return cash to taxi passengers and taxi drivers who use their APP. Many Internet companies in China, such as www.dianping.com and dd.taobao.com, also begin to offer price subsidy to their customers. They also want to attract more customers. How to attract customers by offering price subsidy has become the core for many enterprises. The tipping point originates from the taxi subsidy competition. Other industries are also influenced by the competition. One of them is the real estate industry. Some real estate developers' price subsidy strategy does come from the competition. Some real estate developers offer price subsidy to consumers who buy houses through some real estate agents after the developers sells some of their houses to those real estate agents. Although price subsidy is not a long-lasting marketing policy, the strategy does take some effects on the operation of some real estate companies in short term. There are some literatures related to supply chain with price subsidy. Dual-channel closed-loop supply chain under the government subsidy is established by Ma *et. al.*, (2013), which shows that recycling subsidy is beneficial for consumers, the manufacturer and the retailer. Kurata *et. al.*, (2007) begin to do their studies from the perspective of interchain subsidy. They discuss how to make pricing decision for self-owned products and common-owned products from the perspective of channel competition and brand competition, and an wholesale-price subsidy contract is used to coordinate the supply chain.

As mentioned above, there are many researches related to real estate industry and dual-channel supply chain coordination while there are few researches related to real estate supply chain. With the spread of price subsidy policy, many enterprises begin to implement the policy before it turns out to be practical in theory. This is the first study which tries to quantify real estate supply chain with price subsidy. This paper studies the operation decision of a real estate supply chain which taking price subsidy into account. The supply chain consists of a real estate developer and a real estate agent. The real estate developer provides those consumers who buy their houses through the real estate agent with price subsidy. The optimal price subsidy policy is obtained by modeling the supply chain and the revenue-sharing contract is designed to coordinate the real estate supply chain in which the real estate developer is the price leader and the real estate agent is the price follower.

3. Basic Model

Suppose that there is a real estate supply chain, in which there exit one real estate developer (she) and one real estate agent (he). The developer directly sells houses to consumers and he also sells houses to consumers through real estate agent. There are a lot of real estate agents in China such as Xinya Real Estate Company, a company in Yunnan Province, Century 21 and Fang.com, an online company, *etc.*, Therefore, two competitive sales channels are established in the real estate market. The market scale the developer faces is $a(a>0)$ and the proportion which consumers buy houses through the real estate agent is $\mu(0<\mu<1)$. The unit cost of building one house is $c_b(c_b>0)$. The price substitution coefficient between the two sales channels is $\theta(0<\theta<1)$.

The retail price in the two sales channels, p, is the same and it is one of the critical decision variables in this paper. The demand function in the direct sales channel is q_d. The demand function the real estate agent faces is q_a. The corresponding demand functions are established as follows:

$$\begin{cases} q_d = (1-\mu)a - p \\ q_a = \mu a - p \end{cases} \tag{1}$$

The supply chain profit function is

$$\Pi = (p - c_b)[a - 2(1-\theta)p]. \tag{2}$$

According to the first-order optimality condition $\partial\Pi / \partial p = 0$, the optimal retail price in the supply chain is obtained. It is shown as follows:

$$\overline{p} = \frac{a}{4(1-\theta)} + \frac{c_b}{2}.$$

The sales quantities in the two channels are

$$\begin{cases} \overline{q}_d = \frac{1}{4}[a(4\mu - 1) - 2(1-\theta)c_b], \\ \overline{q}_a = \frac{1}{4}[a(3 - 4\mu) - 2(1-\theta)c_b] \end{cases}$$

and the total sales quantity in the real estate market is

$$\overline{Q} = \frac{a}{2} - (1-\theta)c_b.$$

The total supply chain profit is

$$\overline{\Pi} = \frac{[a - 2(1-\theta)c_b]^2}{8(1-\theta)}.$$

4. Price Subsidy Policy in the Real Estate Supply Chain when Making Centralized Decision

With the expansion of real estate business, real estate developers begin to sell houses through real estate agents by offering them subsidies. In order to expand market scale and attract consumers, offering subsidies to real estate agents has become a new business model. Suppose that unit price subsidy the developer offers to consumers through real estate agent is p_s. Then, the demand functions in the supply chain are as follows.

$$\begin{cases} q_d = (1-\mu)a - (1-\theta)p - \theta p_s \\ q_a = \mu a - (1-\theta)p + p_s \end{cases} \tag{3}$$

Therefore, the supply chain profit function is obtained as follows.

$$\begin{aligned} &\Pi = (p - c_b)[(1-\mu)a - (1-\theta)p - \theta p_s] + (p - p_s - c_b)\left[\mu a - (1-\theta)p + p_s\right] \\ &s.t. p, p_s \geq 0 \end{aligned} \tag{4}$$

Π is a strictly concave function with respect to p and p_s, where p and p_s are decision variables.

When $0 < \mu \leq 0.5$, we obtain the optimal retail price in the supply chain and the corresponding subsidy price.

$$\begin{cases} p^* = \frac{(1-\mu)a + \theta\mu a}{2(1-\theta^2)} + \frac{c_b}{2}, \\ p_s^* = \frac{a(1-2\mu)}{2(1+\theta)} \end{cases}$$

The optimal sales quantities in the supply chain channels are

$$\begin{cases} q_d^* = \dfrac{(1-\mu)a-(1-\theta)c_b}{2}. \\ q_a^* = \dfrac{\mu a-(1-\theta)c_b}{2} \end{cases}$$

The optimal total sales quantity in the supply chain is

$$Q^* = \frac{a}{2}-(1-\theta)c_b = \overline{Q}.$$

The optimal total supply chain profit is

$$\Pi^* = \frac{a^2[1-2\mu(1-\theta)(1-\mu)]}{4(1-\theta^2)} - \frac{[a-(1-\theta)c_b]c_b}{2}.$$

The difference between the supply chain profit with price subsidy and that without price subsidy is as follows: $\Delta\Pi = \Pi^* - \overline{\Pi} = \dfrac{a^2(1-2\mu)^2}{8(1+\theta)} > 0.$

When $0.5 < \mu < 1$, the optimal retail price in the supply chain and the corresponding subsidy price are as follows.

$$\begin{cases} p^* = \dfrac{a}{4(1-\theta)} + \dfrac{c_b}{2}. \\ p_s^* = 0 \end{cases}$$

The corresponding optimal supply chain profit with price subsidy is equal to the supply chain profit without subsidy, *i.e.*, $\Pi^* = \overline{\Pi}$.

Theorem 1 is obtained, which illustrates the optimal price subsidy policy.

Theorem 1. When the proportion which consumers buy houses through the real estate agent is relatively small, the optimal price subsidy policy the real estate developer offers is as follows:

$$\begin{cases} p^* = \dfrac{(1-\mu)a+\theta\mu a}{2(1-\theta^2)} + \dfrac{c_b}{2}, \\ p_s^* = \dfrac{a(1-2\mu)}{2(1+\theta)} \end{cases}$$

where p^* is the optimal retail price in the supply chain and p_s is the optimal unit price subsidy.

5. Price Subsidy Policy in the Real Estate Supply Chain when Making Decentralized Decision

What decide retail price in real estate market is real estate developer who is usually the leader in the game among supply chain members. Thus, we suppose that there exist real-estate-developer-led Stackelberg game in the supply chain. When the developer offers subsidy to those consumers who buy houses through real estate agent, the price subsidy the develper offers is cash which is directly returned to the consumers through the real estate agent. In practice, there may exist other types of price subsidy. This occurs because the real estate developer is the price leader.

5.1. Supply Chain Decision with the Wholesale Price Contract

The wholesale price contract is the contract which is usually used in our daily life. The developer sells houses to the agent at the wholesale price according to his building cost. The developer provides the consumers who buy houses through the agent with the price subsidy, p_s.

There are two periods in the game. In the first period, the agent decides the retail price

of the houses the developer provides according to the marker demand. Then, the real estate developer's profit function is

$$\Pi_b^N = (p - c_b)[(1-\mu)a - (1-\theta)p - \theta p_s] + (w - p_s - c_b)\left[\mu a - (1-\theta)p + p_s\right]. \quad (5)$$

The real estate agent's profit function is

$$\Pi_a^N = (p - w)[\mu a - (1-\theta)p + p_s]. \quad (6)$$

The real estate agent's response function with respect to the developer's wholesale price and retail price is

$$p(w, p_s) = \frac{\mu a + p_s}{2(1-\theta)} + \frac{w}{2} \textbf{Error! Reference source not found.}. \quad (7)$$

The following procedure is implemented in the second period. Substituting Eq. (7) into Eq. (5), the wholesale price and the retail price can be obtained by solving the first-order optimality condition, $\frac{\partial \Pi_b^N}{\partial p} = \frac{\partial \Pi_b^N}{\partial w} = 0$. The results are as follows.

$$\begin{cases} w^N = \dfrac{a(2-3\mu) + c_b(3-5\theta)}{2(2-3\theta)} \\ p_s^N = \dfrac{a(2-\mu(5-3\theta)) + c_b(1-4\theta+3\theta^2)}{2(2-3\theta)} \end{cases} \quad (8)$$

Substituting Eq. (8) into Eq. (7), the retail price in the supply chain is obtained.

$$p^N = \frac{a(2-\theta-2\mu) + 2c_b(1-3\theta+2\theta^2)}{4-10\theta+6\theta^2}$$

The corresponding sales quantities in the market are

$$\begin{cases} q_d^N = \dfrac{a(2-7\theta-\mu(2-\theta(11-3\theta))) - c_b(2-5\theta+3\theta^3)}{4-6\theta} \\ q_a^N = \mu a + \dfrac{a(\theta-3\mu(1-\theta)) - c_b(1-\theta)^2}{4-6\theta} \end{cases}.$$

The total sales quantities of the supply chain are

$$Q^N = \mu a + \frac{a(2-5\mu-\theta(6-\mu(14-3\theta))) - c_b(3-\theta(7-\theta-3\theta^2))}{4-6\theta}.$$

The real estate agent's profit is

$$\Pi_a^N = \frac{(c_b(1-\theta)^2 + 3\theta\mu a - a(\theta+\mu))(c_b(1-\theta)^2 - a(\theta-3\mu(1-\theta)) - \mu a(4-6\theta))}{4(1-\theta)(2-3\theta)^2}.$$

The real estate developer's profit is

$$\Pi_b^N = \frac{(2c_b(1-\theta)^2 - a(2-\theta-2\mu))(c_b(2-5\theta+3\theta^3) - a(2-7\theta-\mu(2-\theta(11-3\theta))))}{(4-6\theta)(4-10\theta+6\theta^2)} + \frac{(\mu a - c_b(1-\theta))((4-6\theta)\mu a + a(\theta-3\mu(1-\theta)) - c_b(1-\theta)^2)}{2(4-6\theta)}.$$

The total supply chain profit, Π^N, satisfies the following equation.

$$\Pi^N = \Pi_b^N + \Pi_a^N \neq \Pi^*$$

In decentralized decision, the total supply chain profit with the wholesale price contract is not equal to the total supply chain profit in the centralized decision, which means that the decentralized supply chain with the wholesale price contract cannot be coordinated. Hence, Theorem 2 is obtained.

Theorem 2. When the real estate developer offers price subsidy, the decentralized supply chain with the wholesale price contract cannot be coordinated.

5.2. Supply Chain Decision with the Revenue-Sharing Contract

In centralized decision, the supply chain profit can be maximized by offering price subsidy. However, the decentralized real estate supply chain cannot be optimized because of the double marginalization effect. The real estate supply chain can be optimized by designing effective supply chain contract. The revenue-sharing contract is used to

coordinate the decentralized supply chain in this paper. The contract operates in this way. The real estate developer provides the real estate agent with the houses at certain wholesale price, w^{RS}. The agent reserves certain part, $\phi(0<\phi<1)$, of his total channel revenue and returns the remainder part of his total channel revenue to the developer.

The agent sells the houses at the same retail price in the two sales channels and provides the consumers who buy houses through him with unit price subsidy. The subsidy, p_s^{RS}, satisfies the following equation, which means that the price subsidy in the decentralized decision equals to that in the centralized decision.

$$p_s^{RS} = p_s^* = \frac{a(1-2\mu)}{2(1+\theta)} \tag{9}$$

In decentralized decision, the real estate developer's profit function is

$$\Pi_b^{RS} = (p-c_b)q_d + (w-p_s-c_b)q_a + (1-\phi)pq_a . \tag{10}$$

The real estate agent's profit function in the decision is

$$\Pi_a^{RS} = \phi pq_a - wq_a . \tag{11}$$

There are also two periods in the decision. In the first period, the agent's response function with respect to the developer's wholesale price and price subsidy is obtained, which is shown below.

$$p(w, p_s^{RS}) = \frac{\mu a + p_s}{2(1-\theta)} + \frac{w}{2\phi} \tag{12}$$

The following procedure is implemented in the second period. Substituting Eq. (9) and Eq. (12) into Eq. (10), the wholesale price the developer offers can be obtained by solving the first-order optimality condition, $\frac{\partial \Pi_b^{RS}}{\partial w} = 0$, where

$$w^{RS} = \frac{(\phi-2\mu)a}{(1-\theta)(2+\phi)} + \frac{\phi(1+2\mu\theta)a}{2(1-\theta)^2(2+\phi)} + \frac{2\phi c_b}{2+\phi} . \tag{13}$$

Substituting Eq. (9) and Eq. (13) into (12), the retail price in this scenario is

$$p^{RS} = \frac{(2+\theta-2\mu+\phi+2\phi\theta\mu)a}{2(1-\theta^2)(2+\phi)} + \frac{c_b}{(2+\phi)} . \tag{14}$$

By solving $p^{RS} = p^*$, the total supply chain profit is maximized if the wholesale price of the house w^{RS} and the revenue sharing proportion ϕ satisfy the condition shown below.

$$\begin{cases} w^{RS} = \frac{(\phi-2\mu)a}{(1-\theta)(2+\phi)} + \frac{\phi(1+2\mu\theta)a}{2(1-\theta)^2(2+\phi)} + \frac{2\phi c_b}{2+\phi} . \\ \phi = \frac{(1-2\mu)\theta a}{(1+\theta)((1-\theta)c_b - \mu a)} \end{cases} \tag{15}$$

Theorem 3. The real estate supply chain with the price subsidy is coordinated by using the revenue-sharing contract (w^{RS}, ϕ), where

$$\begin{cases} w^{RS} = \frac{(\phi-2\mu)a}{(1-\theta)(2+\phi)} + \frac{\phi(1+2\mu\theta)a}{2(1-\theta)^2(2+\phi)} + \frac{2\phi c_b}{2+\phi} \\ \phi = \frac{(1-2\mu)\theta a}{(1+\theta)((1-\theta)c_b - \mu a)} \end{cases} .$$

According to Theorem 3, the real estate developer's profit function, Π_b^{RS}, satisfies

$\Pi_b^{RS} = \Pi_b^*$ and the real estate agent's profit function, Π_a^{RS}, satisfies $\Pi_a^{RS} = \Pi_a^*$, where

$$\Pi_b^{RS} = \Pi_b^* = \frac{a^3(-\theta+\theta(7+\theta)\mu+(2-\theta(11+\theta))\mu^2-2(1-3\theta)\mu^3)}{4(1-\theta)(1+\theta)^2(\mu a-(1-\theta)c_b)} + \frac{a^2c_b(1-\theta^2)(6(-1+\mu)\mu-\theta(3-2(2-\mu)\mu))}{4(1-\theta)(1+\theta)^2(\mu a-(1-\theta)c_b)}$$
$$+\frac{ac_b^2(1-\theta)(4+5\theta-2\mu-4\theta\mu)}{4(1+\theta)(\mu a-(1-\theta)c_b)} - \frac{2c_b^3(1-\theta)^2}{4(\mu a-(1-\theta)c_b)},$$

and $\Pi_a^{RS} = \Pi_a^* = \frac{\theta a(1-2\mu)((1-\theta)c_b-\mu a)}{4(1-\theta^2)}$. This means that the supply chain members' profits in the decentralized decision equal to those in the centralized decision.

6. Numerical Examples

We will analyze the impact of the channel preference, μ, on some key indexes of the supply chain such as the total supply chain profit, each supply chain member's profit, the retail price, the price subsidy, the sales quantity, the wholesale price and the revenue allocation proportion by using numerical examples in this section.

Suppose that $a = 210$, $\theta = 0.4$ and $c_b = 20$. The total supply chain performance is shown in Figure 1, which includes the optimal total real estate supply chain profit with and without price subsidy, $\bar{\Pi}$ and Π^*, the optimal total supply chain profit with the wholesale price contract, Π^N, and the optimal total supply chain profit with the revenue-sharing contract, Π^{RS}. The impact of the channel preference on the supply chain members' profits is analyzed in Figure 2.

As is shown in Figure 1, the total supply chain profit with the price subsidy is larger than that without the price subsidy. The total supply chain profit with the wholesale price contract is lowest compared with the other two profits and the real estate supply chain in this scenario cannot be coordinated. The revenue-sharing contract can coordinate the supply chain, which means that the total supply chain profit with the contract is equal to that in the centralized decision. Both the total supply chain profit in the centralized decision and that with the revenue-sharing contract decrease in the channel preference, μ, and they tend to be the same with the increase of the channel preference. However, the total supply chain profit with the wholesale price contract increases in the channel preference, μ, and it also tends to equal to that without the price subsidy when μ is large enough. As is shown in Figure 2, the real estate agent's profit with the price subsidy is smaller than that without the subsidy. The real estate agent's profit function is a convex one with respect to the channel preference, μ. When μ is relatively small, the agent's profit adecreases in μ. When μ is large enough, larger than 0.28, the agent's profit increases in μ. The real estate agent's profit without the price subsidy decreases in μ. The real estate developer's profit with the price subsidy is larger than that without the subsidy when is μ large enough, and it increases in μ. However, the real estate developer's profit function with respect to μ is not a continuous function which has a discontinuity point, *i.e.*, $\mu = 2/35$. The real estate developer's profit without the price subsidy increases in μ. When μ is large enough, the corresponding developer's profit is greater than the agent's profit with the subsidy, which illustrates the impact of the channel preference.

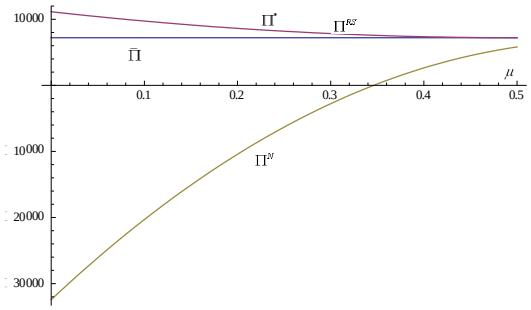

Figure 1. The Impact of the Channel Preference on the Total Supply Chain Performance

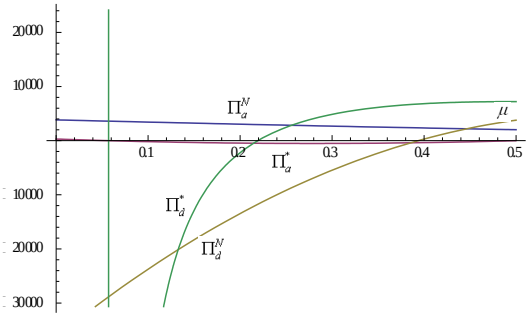

Figure 2. The Impact of the Channel Preference on the Supply Chain Members' Profit

Comparison between the retail price and the price subsidy with different supply chain contracts is illustrated in Figure 3. As can be seen from Figure 3, both the channel retail price and the price subsidy with the two supply chain contracts decrease in the channel preference, μ. Both the optimal channel retail price and the optimal price subsidy are lower than those with the wholesale price contract. This shows the effectiveness of the revenue-sharing contract. When $\mu = 0.5$, the price subsidy the developer offers is equal to zero, which shows how to implement the price subsidy policy.

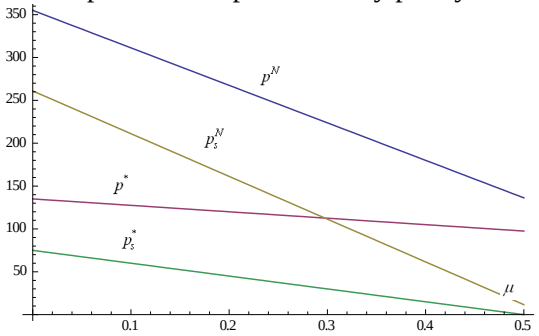

Figure 3. The Impact of the Channel Preference on the Retail Price and the Price Subsidy

The impact of the channel preference on different sales quantities with different supply chain contracts is analyzed in Figure 4. As can be seen from Figure 4, the optimal sales quantity in the developer's direct sales channel decreases in the channel preference, μ, while the optimal sales quantity in the agent's sales channel increases in the channel preference, μ. The optimal sales quantity in the developer's direct sales channel is always higher than that with the wholesale price contract. The optimal sales quantity in the agent's sales channel is lower than that with the wholesale price contract when μ is

relatively small. This also illustrates the impact of the revenue-sharing contract on the sales quantities in the real estate supply chain.

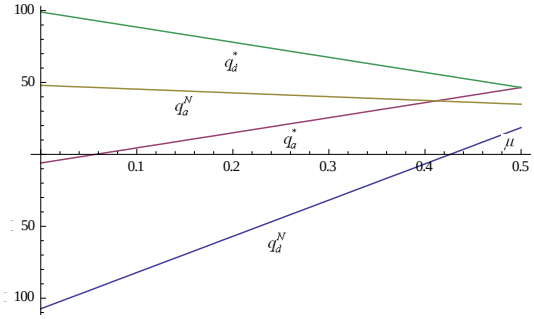

Figure 4. The Impact of the Channel Preference on Sales Quantity

7. Conclusions

With the expansion of real estate business, real estate developers always want to take measures to expand their sales channels, which can increase their profits. Price subsidy becomes a useful tool for real estate developers to increase sales quantities, which can increase supply chain profit through pricing strategy. According to the operation of supply chain, an operation model of a real estate supply chain with price subsidy is established in this paper. The decision-making of the supply chain is studied and some key indexes of the supply chain model are obtained such as the retail price, the price subsidy level, the sales quantity in each sales channel and the profit of the real estate supply chain, *etc.*, The results are as follows. The real estate supply chain with the price subsidy can be optimized. When the market scale that the real estate agent faces is relatively small, price subsidy is attractive for consumers to buy houses through the agent and the price subsidy can increase supply chain profit. With the increase of the market share the agent faces, the price subsidy for those consumers will be gradually reduced. When it reaches certain value, the price subsidy for the consumers will be canceled by the real estate developer. The real estate supply chain with the wholesale price contract in the decentralized decision cannot be coordinated while the supply chain with the revenue-sharing contract can be coordinated.

There are abundant research opportunities in the future. For example, it is interesting to study other policies to increase the supply chain profit and how to coordinate the supply chain with other supply chain contracts. Other supply chain structure is also worth studying. The problem which other investor such as the government offers subsidy can also be taken into consideration.

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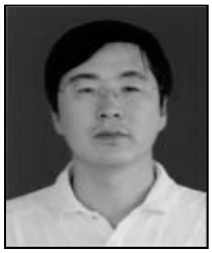

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