Chapter 8
Pricing for Green Product

Mengdan Wang, Nengmin Wang, Qi Jiang, and Bin Jiang

Abstract The rise in consumers' green preferences promotes manufacturers to produce and provide green products and services, which is conducive to achieving sustainable enterprise development and meeting consumers' growing green consumption demand. In the competition between green and common products, price is still one of the key factors affecting consumers' purchase decisions. There is information asymmetry in the green product market, which will lead to "bad money drives out good". Consumers have incomplete knowledge and information about green products, and cannot accurately know about the green state of products. Consumers can only make indirect judgments through product prices. If the price is too high, some consumers give up their purchases. Whereas if it is too low, it will not only fail to cover the production cost but will also make consumers question the quality of green products. Based on the above analysis, this chapter focuses on the impact of green product pricing in enterprises' green growth model of and analyzes the differences in pricing between green products and common products. In addition, it discusses the factors that enterprises need to consider when making green product pricing decisions. Then, based on the theoretical analysis, pricing models of green products between manufacturers and consumers, retailers, and the government are established, and the influence of information asymmetry on the pricing of green products under different conditions is analyzed. Finally, the conditions for distinguishing qualified and unqualified green products in the market are discussed to promote standardized operation of the green product market and improve the confidence of consumers in the green market.

M. Wang · N. Wang (✉) · Q. Jiang
School of Management, Xi'an Jiaotong University, Xi'an, Shaanxi 710049, China
e-mail: wangnm@mail.xjtu.edu.cn

M. Wang
e-mail: wangmengdan2017@163.com

B. Jiang
Department of Management, Driehaus College of Business, DePaul University, Chicago, IL 60604, USA
e-mail: bjiang@depaul.edu

8.1 Pricing for Green Product and Enterprises' Green Growth Model

8.1.1 The Impact of Pricing for Green Product in Enterprises' Green Growth Model

(1)   Affecting Market Demand and Corporate Profits

Dissimilar to common products, green products have green value in addition to the functional value of common products. With the continuous development of a green economy and consistent improvement of consumers' awareness of environmental protection, consumers will pay more attention to the impact of products' on the environment, and green products are favored as they integrate innovative technologies and environmental-friendly design. In 2019, JD Big Data Research Institute released the "2019 Green Consumption Trend Development Report", showing that the types of "green consumption" commodities exceeded 100 million, the growth rate of sales volume exceeded 18% of JD.com, and the types of "green consumption" are constantly penetrating the low-line market.[1] However, the development and production of green products usually require enterprises to use green technologies and implement cleaner production, etc. In addition, it has to pay a lot of costs, which objectively increases the price of green products. For example, for the same series of air conditioners manufactured by Haier, the price of air conditioners with energy efficiency level 1 is higher than that of air conditioners with energy efficiency level 3; further, the price of BYD electric vehicles is higher than that of oil-burning vehicles of the same series. Yang et al. analyzed 991 valid questionnaires and found that public willingness to pay for green products is generally low, accounting for only 30.1% [1]. Zhong and Chen found that the average green premium that Chinese consumers are willing to pay for low-carbon agricultural products is low [2]. The above research shows that the steep pricing of green products has become the main obstacle for consumers to shift from their green consumption willingness to actual purchase behavior. In contrast, Berger argued that green products can generate signal benefits, which can incentivize consumers to pay a premium for environmental-friendly products. This, in turn, can compensate for price disadvantages, which implies that marketers should price green products more expensive than non-green products so that they can be clearly identified as green products [3]. The underlying reasons behind the two contradictory impacts of green product prices on consumer demand are as follows. As an important market signal, green product prices convey the high-quality image of green value to consumers, which is in line with consumers' psychology of "high quality with high price". However, a large amount of green costs in green prices will be passed on to consumers. Nevertheless, consumers still hope that product prices are relatively cheap, so higher green prices will cause companies

---

[1] https://www.sohu.com/a/363240287_694904.

to lose some consumers. The price premium of green products needs to be controlled at a reasonable level. Salladarre et al. studied the willingness of French consumers to pay for ecologically labeled fresh seafood products, and found that on average, the highest premium paid by consumers was about 10% of the product price [4]. Green price is an important means of green product marketing. Setting green prices reasonably is important in corporate marketing decisions, which directly affects the market demand for green products and corporate profits. Therefore, enterprises need to reasonably set green prices, find the best premium space, choose the most favorable green pricing strategy to seize vitality, and obtain long-term development in the fierce market competition.

(2)   Promoting the Value Chain Cycle and Green Growth of Enterprises

Green products are the final market-oriented result of the green development of enterprises. The ultimate goal of producing green products is to turn ecological environmental protection into a new driving force for economic development. Similar to traditional industries, the virtuous cycle of green industry development needs to smoothly transform the productivity invested in the production process into capital for enterprises to continue green production. Therefore, obtaining green consumption is key for enterprises to realize the transformation from cost input to economic benefits. The price of green products, as the only means to balance high investment and output in green development, is the economic pillar of enterprises and the key to unlocking their dependence on traditional development paths. However, green premium affects consumers' willingness to pay. Li et al. found that nearly half of the consumers were willing to pay a premium of no more than 5% for green products, which is lower than the premium for green products relative to non-green products [5]. However, the actual premium for green products generally exceeds this level, reducing the dominant position of green products in the market. Based on a comparative analysis of consumer survey data and online sales data of green products in representative cities, Wang et al. used a fuzzy cognitive map to quantitatively study the influence of their interaction mode on the gap between green intention and actual behavior. It was found that the difference between the actual premium of green products and consumers' willingness to pay an additional price is currently the biggest factor hindering green behavior [6]. To control the green price within a reasonable premium level, open the channels between production and sales, implement enterprises' green growth model, and achieve green transformation, enterprises need to carry out local and overall optimization from the perspective of the whole value chain to reduce production costs and improve green payment willingness from the demand end.

With the support of the next-generation information and communication technology and other technologies, core enterprises can quickly build a production system involving designers, suppliers, logistics providers, and other partners aiming at resource conservation and low-carbon recycling. Through complementary advantages and resource sharing, low-cost and innovative green product production can be realized to effectively control premium space, reduce product prices, promote green consumption, open up the entire value network from green production to consumption, realize the value chain cycle, and promote the spiral green growth

of enterprises. For example, Haixiangtao, a sub-platform of Haier's COSMOPlat in the ceramics industry, has comprehensively empowered Tongyi Ceramics through a series of empowerment fields such as open resources, sales empowerment, procurement empowerment, intelligent manufacturing, R&D empowerment, and financial services. It helps enterprises and ecological partners realize the value and benefits of data sharing, cost reduction, digital transformation, energy conservation, environmental protection and inventory reduction, efficiency improvement, quality improvement and innovation, and strive to build a new ecosystem.[2]

(3)   Reasonably Allocating Resources and Improving Resource Use Efficiency

The scarcity of resources makes it an obstacle to economic development. To overcome this obstacle, it is necessary to use limited resources more efficiently. Through the green product price mechanism, along with the use-value and exchange value of the product, the resource value is also considered. Factors such as the loss of natural resources, environmental pollution, treatment and restoration, enterprise resource utilization, and the resulting social and environmental costs are included as environmental costs in the green product pricing mechanism, which can truly reflect the value of resources and enable enterprises and consumers to form the concept of "resources are paid for use". The formation of the price mechanism for green development requires the joint efforts of the market and government. Taking the energy field as an example, the price mechanism can play a significant role in improving the industrial and energy structures and reducing the pollution degree of fossil energy. Sha et al. found that negative fossil energy price distortion further hinders green economic efficiency by inhibiting technological innovation and hindering optimization of the energy consumption structure. To realize China's green economy, it is necessary to improve the market-oriented energy pricing mechanism and formulate differentiated regional energy pricing policies [7]. Knappl et al. investigated consumers' energy attitudes and willingness to pay for renewable energy and found that green power programs, such as utilities' green tariffs, provide consumers with a market-based mechanism to fulfill their desire to buy renewable energy [8]. Green price reform based on the ecological environment will help leverage more private capital into ecological and environmental protection; promote resource conservation, environmental protection, pollution prevention, and control; and foster the formation of green development spatial patterns, industrial structures, modes of production, and ways of life. For example, the government's subsidies for new energy vehicles enable enterprises to have more flexible pricing space, help them reduce pricing pressure, and encourages them to enter the field of energy vehicles.

---

[2] https://www.cosmoplat.com/news/detail?newsid=2513&sourcePage=search.

8.1.2 Difference Analysis of Pricing Between Green Products and Common Products

(1) Product Cost

In contrast to common products, enterprises producing green products need to bear the cost of natural resources consumed by green products and environmental costs owing to environmental problems, in addition to traditional product costs. Therefore, resource and ecological environment costs are important factors in distinguishing the pricing differences between green products and common products. The green product premium is a market way in which enterprises transfer input resources and environmental costs to consumers to compensate for green expenditures. Therefore, enterprises can effectively control premium levels by reducing costs. From the perspective of enterprises, cost-efficiency can be improved through the green process and product innovation [9]. From the perspective of the entire value network, different entities should coordinate green production and sales goals and establish cost-sharing, resource-sharing, and revenue-sharing mechanisms. Zhang et al. studied a two-level supply chain composed of a manufacturer and a retailer and designed a Stackelberg game model with cost-sharing contracts and wholesale price contracts, which considered the consumer reference price effect. They found that the consumer reference price effect would reduce the proportion of cost-sharing contracts when the manufacturer was dominant. However, the problem of double marginalization can be alleviated by lowering wholesale and retail prices for both contracts, thereby increasing consumer surplus [10].

(2) Market Demand

Compared with common products, the impact of pricing for green product on product market demand is mainly reflected in two aspects.

First, the effects of green pricing vary by types of purchasing choices. As green consumption is affected to a certain extent by the level of economic development, the current green consumption market has not yet been fully developed. The results of global public opinion surveys show that, although most citizens have a positive attitude toward environmental protection issues, purchase preferences demonstrate that their attitude is not implemented in practice. In fact, consumers' shift from their green consumption attitude into actual green purchasing behavior still largely depends on green product prices. Green consumers can be divided into three categories according to their behavior status: light green, green, and dark green consumers. Light green consumers have the lowest attitude toward environmental standards, whereas dark green consumers have the highest attitude toward environmental standards [11]. Du et al. investigated the role of cost, consumers' green segmentation, and competition in enterprises' green production decisions and found that in the competition, traditional enterprises may lower the price of traditional products to defend their market share, resulting in a balance in which green products are only sold to green market segments [12].

Second, the information transmitted by green prices affects market demand for green products. A green market is a typical decision-making environment with limited and ambiguous information. In reality, the publicity of many green products is ambiguous, and may even deceive and mislead consumers. Owing to professional and technical limitations, consumers usually lack effective knowledge and methods to identify green products before purchasing them, and it is difficult to evaluate the authenticity of green information even after purchase. In this case, consumers usually judge the green value of products based on their price [3]. Therefore, if the price is low, it will not only can not compensate for the green cost already paid by enterprises, but also make consumers misperceive that the green degree of products is not high or not up to standard. However, if the price is too high, it will inhibit some consumers' purchase desires. Therefore, when determining green product prices, enterprises also need to consider the asymmetric factors of green market information and avoid pricing products too high or too low based on the psychological perception of consumers.

(3)   Competition

In contrast to common product pricing, green product pricing, in terms of competition, is reflected in the effect of the product price on the direction of the consumer market. This is reflected in the market competition of green products caused by pricing. From the positive flow direction of green product output to sales, there is information asymmetry between the producer and receiver, where the seller has more information about the greenness of the product than the buyer. The cost of green products was positively correlated with greenness and price. If two enterprises produce similar products with different greenness, but the enterprise with lower greenness still promotes its products with high greenness, it will bring unfair competition in the "lemon market" [13]. Therefore, in green market competition, it is important to understand how an enterprise producing high green products enables consumers to identify products with different greenness through reasonable pricing in an environment of information asymmetry. The green product pricing strategy enables consumers to distinguish between genuine and fake product information, which is conducive to ensuring the fairness of the green product market. This kind of "lemon market" dilemma caused by incomplete disclosure of information transparency is less threatening in the common product market.

(4)   Policies and Regulations

Judging from existing practices, promoting the green upgrade of products is inseparable from the role of relevant policies and regulations. Specifically, the differences in the pricing of green products and common products in terms of policies and regulations are mainly reflected in the following two aspects.

First, policies and regulations promote green consumption, which has a positive pulling effect, prompting more consumers to accept the premium of green products. Since the green market starts late, the green market order is chaotic, green products are mixed, and consumers are disadvantaged by information. Given the lack of effective

government supervision and the support and constraints of relevant policies and regulations, the phenomenon of "bad money driving out good" is highly likely to occur, thus hindering the development of the green market [14]. By contrast, if the government actively supervises, formulates effective policies and regulations for the problems of the green market, develops a complete evaluation standard and certification system for green products, and improves consumers' trust in the green market, consumers can have a higher green premium, which ultimately promotes the formation of a reasonable and sound green product pricing mechanism.

Second, a policy inclination toward green industries can appropriately reduce green product prices. Supportive policies, such as tax incentives and financial subsidies, can compensate for the green cost of enterprises' implementation of green development, R&D, and production of green products. Otherwise, to compensate for the green cost of additional investment, enterprises set a higher green price to transfer part of the cost to consumers and reduce consumers' willingness to buy, which hinders the smooth circulation of green production and sales. Government's provision of support and subsidies for the environmental and resource costs consumed by enterprises in terms of taxes and subsidies can reduce the cost of enterprises, thereby indirectly reducing green product prices and increasing the market demand for green products. For example, in the field of new energy passenger vehicles in China, the subsidy standards for energy vehicles in 2022 are as follows. Pure electric passenger cars of more than 400 km (including 400 km) are subsidized by 12,600 yuan per vehicle, whereas pure electric passenger cars ranging from 300 to 400 km (including 300 km) are subsidized by 9100 yuan per vehicle. There is no subsidy for purely electric passenger cars with a range of less than 300 km. Thus, the government's subsidy policy has promoted the development of electric vehicles.[3] The comparison between green products and ordinary products is shown in Table 8.1.

8.1.3   Factors to Consider in Pricing for Green Product

(1)   The Trend of Green Consumption

The trend of green consumption promotes the development of the green industry and improves consumer acceptance of green product premium space. At present, consumers are not only willing to buy high-quality green products but also pay attention to the impact of production methods on the ecological environment. According to the Survey and Research Report on the Current Situation of Public Green Consumption in China (2019 Edition), the concept of green consumption is becoming increasingly popular in the public's daily consumption, and 83.34% of the respondents expressed their willingness to support green consumption behavior.[4] The release of green consumption potential will provide an important driving force for the green

---

[3] http://www.gov.cn/zhengce/zhengceku/2021-12/31/content_5665857.htm.

[4] http://sdg-china.net/portal/article/index/id/727/cid/5.html.

Table 8.1 Comparison between green products and common products

	Green product	Common product
Product cost	Production, inventory and logistics costs, including green costs such as resource recycling and environmental friendliness	Production, inventory, logistics and other economic costs
Market demand	Product pricing has different impacts on the demand of light green consumers, green consumers, and dark green consumers, and green price can convey green information	The effect of product pricing on market demand has nothing to do with consumers' green preference
Competition	Information competition and market competition are obvious	Information competition and market competition are not obvious
Policies and regulations	Policies and regulations favor green industries	There are no supportive policies

and low-carbon transformation of traditional industries and the industrialization of ecological and environmental protection technologies and lay an important foundation for achieving carbon peaking and carbon neutrality goals. Green consumption leads enterprises to improve the green value of products from the demand side, which also creates new opportunities for enterprises to price green products. Consumers' attention to the green value of products shows that the scope of the premium they bear is expanding. In the future, with further development of green consumption, several light green or green consumers may become dark green consumers. The inhibitory effect of the green product price on consumers' purchase behavior is relatively reduced, which is conducive for enterprises to maintain their reasonable interests through price strategies and realize compensation for green input in the early stage of the sales link.

(2) Policy Tilt

Two main types of policies affect the pricing of green products. The first type of policy starts from the production of green products and provides tax incentives, subsidies, and technical support for enterprises implementing green development. The second type starts from the sales side of green products and aims to promote green consumption. For the first type of policy, for example, to promote the green development of enterprises, in 2016, the Notice on the Construction of Green Manufacturing System issued by the Ministry of Industry and Information Technology of the People's Republic of China mentioned that the Ministry of Industry and Information Technology will use relevant policies such as industrial transformation and

upgrading funds, special construction funds and green credit to support the construction of green manufacturing system.[5] For the second type of policy, to promote the development of the green consumption industry chain, in March 2020, China's National Development and Reform Commission and the Ministry of Justice jointly issued a notice on "Opinions on Accelerating the Establishment of a Green Production and Consumption Regulatory System", further promoting "green consumption" into the lives of the masses.[6] In the subsequent executive meeting of the State Council, it was decided that: first, the new energy vehicle purchase subsidy and purchase tax exemption policies would be extended for two years; second, the central government would adopt incentives instead of subsidies to support key regions such as Beijing, Tianjin, and Hebei to eliminate diesel trucks with emission standards of National III and below.[7]

(3)   Information Asymmetry and Bad Money Drives out Good

Information asymmetry theory is a core component of microeconomic research and is used to explain the influence of the asymmetric distribution of relevant information on market transaction behavior and market operation efficiency in an incomplete information market [15]. Information asymmetry in economic activities is generally manifested in two aspects. First, after the transaction is completed, the information-dominant party conceals relevant information from the information inferior party, resulting in information asymmetry. Second, there is an asymmetry in the ability and information state of people participating in economic activities to obtain information before trading, which is also an important reason for "adverse selection" [16]. Information asymmetry in the green product market is reflected in the latter. The latter "adverse selection" mainly refers to the wrong choice made by the information inferior party, which objectively leads to the unreasonable distribution of the market. This further results in the economic phenomenon of "lemon market" and "bad money drives out good money". Before trading, manufacturers, and sellers in the production system of green products have a lot of information about the price and greenness of products, whereas consumers' information about products comes only from the promotion of products by manufacturers or sellers. Under such asymmetric information, consumers often judge the greenness of products by price, which also allows enterprises to use false quality. To reduce the risk of buying high-priced but low-quality products, consumers are only willing to pay the price according to the average green degree of the product. Then, sellers with higher quality withdraw from the transaction, leaving only low-quality sellers to enter the market. In extreme cases, the phenomenon of "bad money drives out good" may occur, resulting in the shrinkage of the entire green market.

---

[5] https://www.miit.gov.cn/jgsj/jns/wjfb/art/2020/art_40aa852f1c654540bc53b7f9594809e1.html.

[6] http://www.gov.cn/zhengce/zhengceku/2020-03/19/5493065/files/8c46733fd72b47779e8ae64b4fec2977.pdf.

[7] http://www.gov.cn/zhengce/2020-04/01/content_5497820.htm.

8.2 Game Analysis of Pricing for Green Product

8.2.1 Background

Green products refer to products that cause no or extremely low harm to humans or the environment during production, use, and consumption; these include environmentally labeled products and organic food. In recent years, driven by both government environmental regulations and green consumption, green products have gradually replaced traditional products. In addition, building a green growth model for enterprises has become a new growth point for their high-quality development. The price of green products is a key factor in determining whether consumers engage in green consumption behavior. Therefore, to realize the smooth flow of green products from production to consumption and to open up the entire value chain of the enterprise's green growth, it is necessary to formulate a reasonable pricing strategy. From the perspective of the entire value network of green production, the factors that affect the pricing of green products include external consumers' green consumption intentions, relevant government policies, competitors for producing substitutes, and the influence of information asymmetry between buyers and sellers. In addition to production costs, enterprises should consider resource and environmental costs. Information asymmetry leads to the replacement of real products with fake products. In a market with asymmetric information, there is a large operating space to obtain profits using false quality information pricing, and enterprises tend to use false quality information pricing. For green products, due to their high cost, the price of green products is generally higher than that of common products, and the price of products is one of the few pieces of information related to the green quality of products available to consumers, which also provides an internal driving force for enterprises to obtain high profits by using false quality information.

To promote the healthy development of the green product market, break through the links of green production and consumption, and reduce the adverse effects of information asymmetry on the green product market, we discuss the game models between manufacturers and consumers, manufacturers and retailers, and manufacturers and governments under information asymmetry from the perspective of stakeholders in the production, sales, use, and supervision. Moreover, we try to distinguish between qualified and unqualified green products in the market through model analysis and pricing mechanisms to reveal the operational law of the green product market, safeguard consumer interest, and promote sustainable development.

8.2.2 Literature Review

Liu et al. constructed a two-stage supply chain to examine the pricing strategy of green product supply chains based on behavioral pricing. They found that when consumers are less sensitive to green products, as green product market share increases, green product retailers will increase their loyalty prices, and consumers' emphasis on green products will lead to higher profits for green product manufacturers and retailers [17]. Heydari et al. analyzed the coordination of green channels in secondary supply chains, where demand is a function of the sales price and product green quality. They found that green cost-sharing contracts and revenue-sharing contracts can achieve channel coordination, improve product green quality, reduce prices, and stimulate market demand [18]. However, the literature above does not consider information asymmetry between green product sellers and buyers. Information asymmetry in the market affects consumers' purchasing decisions, green product supply chain production, and sales decisions. Shao and Unal studied the sustainable information attributes that consumers pay attention to in green purchasing, and how these attributes promote consumers' willingness to pay a premium [19]. Hong et al. studied the pricing of green products by considering consumers' environmental awareness and non-green product references. The results show that the pricing strategy for green products is significantly affected by information asymmetry. Compared with information symmetry, enterprises should apply differentiated pricing strategies by considering their green production costs [20].

The above studies only considered the pricing of green products from the market perspective. Since green production has a strong positive externality, the government often needs to promote green production in the initial development stage of the green market. Meng et al. constructed a two-stage green supply chain price decision model composed of a manufacturer and a retailer and studied four types of price decisions: no government subsidies, government subsidies to the manufacturer, government subsidies to the retailer, and government subsidies to green product consumers. Compared with no government subsidies, government subsidies to the manufacturer will reduce the wholesale and sales prices of green products, whereas subsidies to the retailer will lead to higher wholesale and sales prices of green products. Regardless of which object is subsidized by the government, the wholesale price of common products remains unchanged, and the sales price decreases. Government subsidies promote the sales of green products, thereby expanding the market share of green products [21].

Based on the above literature, our research considers green product prices as a way of information transmission from sales to consumers. Through the information game, we analyze the game model between consumers and manufacturers, retailers, and the government under information asymmetry from the perspective of the supply chain. In addition, we explore how the producers and sellers of green products can help consumers correctly distinguish between green and non-green products in the market through a price strategy.

8.2.3 Pricing for Green Product Model of Game Between the Manufacturer and Consumers Under Information Asymmetry

(1) Problem Description and Assumptions

Suppose that the main players of the game are the green product manufacturer and consumers, the manufacturer is a signal sender and consumers are signal receivers, and the manufacturer has absolute advantages in information. According to the trading characteristics of the green product market, a signal game is applied, and the following assumptions are made.

It is assumed that both parties of green product transactions are strictly rational and committed to pursuing the maximization of their own interests. There are two types of manufacturers θ: manufacturer h produces qualified green products and manufacturer l produces unqualified green products. The utilities of consumers purchasing qualified and unqualified green products are u_h and u_l, respectively, and $u_h > u_l$ [22]. At the same time, whether the green products produced by the manufacturer are qualified is private information, and consumers only know the price of the product and can only judge the type of product based on its price. If the manufacturer produces qualified green products, they need to pay high cost c_h; otherwise, they pay a low-cost c_l [20]. Qualified or non-qualified manufacturers can choose to sell green products at a high price of p_h or low price of p_l [23]. Suppose that the consumer either accepts the manufacturer's pricing or does not purchase it. To simplify the analysis, we assume $u_h - p_h > u_l - p_l > 0 > u_l - p_h$, that is, buying qualified green products at a high price is more cost-effective than buying non-qualified green products at a low price, and buying non-qualified green products at a low price will not result in negative returns.

According to the representation method of the signal game, the game can be expressed as: (a) "Nature" first chooses the type of the manufacturer, and the prior probabilities are $\mu(\theta = h) = q$ and $\mu(\theta = l) = 1 - q$, respectively; (b) after the enterprise understands its type, it selects the price level p_θ as the signal to be sent; (c) after the consumer observes the price level p_θ, they use the Bayesian rule to obtain the posterior probability $\mu(\theta|p_\theta)$, and then choose to buy; (d) the manufacturer realizes their own benefit and consumers realize their own utility.

According to the above assumptions, the expected income of consumers choosing to buy is $E_{M1} = (u_h - p_h)\mu(h|p_h) + (u_l - p_h)\mu(l|p_h) + (u_l - p_l)\mu(l|p_l) + (u_h - p_l)\mu(h|p_l)$; the expected benefit of consumers not buying is $E_{M2} = 0$.

If $E_{M1} > E_{M2}$, consumers buy green products; otherwise, they give up buying. The signal game model of green product manufacturers and consumers is shown in Fig. 8.1.

(2) Equilibrium Analysis

Since $p_h - c_l > p_l - c_l$, unqualified green product manufacturers always wanted to sell products at a high price. There is no separating equilibrium in this game; but
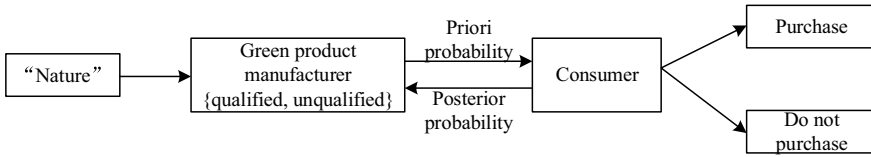
Fig. 8.1 The signal game model of green product manufacturers and consumers

when $q > \frac{(p_h - u_l)(1-q)}{(u_h - p_h)}$, there is a pooling equilibrium. Pooling equilibrium implies that manufacturers of qualified green products, regardless of being qualified or not, offer the same price (high price). Therefore, the consumers' posterior judgment of the manufacturer is $\mu(h|p_h) = q$, $\mu(l|p_h) = 1 - q$, $\mu(l|p_l) = 0$, and $\mu(h|p_l) = 0$. At this point, the expected benefit of the consumer's purchase is $E_{M1} = (u_h - p_h)q + (u_l - p_h)(1 - q) > 0$ and the consumer chooses to buy the product.

(3) Conclusion

The analysis results show that when only the manufacturers and consumers play the game, the unqualified green products sell at a high price. This is because the unqualified green product manufacturers are not constrained by the outside world and are in information advantage; thus, they do not need to pay any cost for counterfeiting behavior. Qualified green product manufacturers can only sell their qualified green products at a high price; therefore, there is no separating equilibrium in the game. Market forces cannot effectively distinguish between qualified and unqualified green products, and consumers can only buy in a market where unqualified and qualified green products are sold together, which reduces consumers' trust in the green market.

8.2.4 *Pricing for Green Product Model from the Perspective of Supply Chain Under Information Asymmetry*

(1) Problem Description and Assumptions

Assuming that the game subject is the manufacturer and retailer of green products, the green products produced by the manufacturer are sold to consumers through the retailer. However, the retailer does not know whether the green products are qualified, and will decide whether to test the green products according to the wholesale price of the manufacturer. The assumptions of the model are as follows.

The manufacturer and retailer of green products are strictly rational and committed to maximizing their own interests. There are two types of manufacturers θ: manufacturer h produces qualified green products; manufacturer l produces unqualified green products. If the manufacturer produces qualified green products, they need to pay high cost c_h, and if the manufacturer produces unqualified green products, they need to pay low cost c_l [20]. Both qualified and non-qualified manufacturers can choose to wholesale green products to retailers at the high wholesale price of

w_h or the low wholesale price of w_l. The market price of green products set by the retailer is p, and the final sales volume of qualified and non-qualified green products is Q_h and Q_l respectively [24]. Suppose the retailer either tests the green products from the manufacturer to assess whether they are qualified or not. If the retailer chooses to test, it will definitely detect non-qualified products, but it will cost c_r. The unit compensation of the unqualified manufacturer is L_θ. And the manufacturer who makes high wholesale price will bear high compensation, who makes low wholesale price will bear low compensation If the non-qualified green products flow into the market without testing, the loss to the retailer is D.

According to the representation method of the signal game, the game can be expressed as: (a) "Nature" first chooses the type of the manufacturer, and the prior probabilities are $\mu(\theta = h) = q$ and $\mu(\theta = l) = 1 - q$, respectively; (b) after the manufacturer understands its type, they select the wholesale price w_θ as the signal to be sent; (c) after the retailer observes the price level w_θ, they uses the Bayesian rule to obtain the posterior probability $\mu(\theta|w_\theta)$, and then choose whether to test; (d) the manufacturer and retailer realize their own benefits.

According to the above assumptions, the expected revenue of the retailer's choice of test is:

$$E_J = (p - w_h - c_r)Q_h\mu(h|w_h) + (p - w_h - c_r + L_h)Q_l\mu(l|w_h)$$
$$+ (p - w_l - c_r + L_l)Q_l\mu(l|w_l) + (p - w_l - c_r)Q_h\mu(h|w_l);$$

The expected benefit of choosing not to test is:

$$E_B = (p - w_h)Q_h\mu(h|w_h) + (p - w_h - D)Q_l\mu(l|w_h)$$
$$+ (p - w_l - D)Q_l\mu(l|w_l) + (p - w_l)Q_h\mu(h|w_l).$$

If $E_J > E_B$, the retailer chooses to test, otherwise, does not test. The signal game model of green product manufacturer and retailer is shown in Fig. 8.2.

(2) Equilibrium Analysis

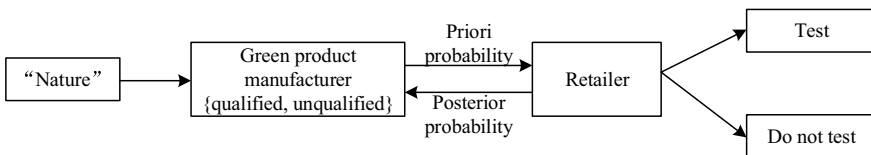When

$$(w_h - c_l - L_h)Q_h < (w_l - c_l - L_l)Q_l$$

and

Fig. 8.2 The signal game model of green product manufacturer and retailer

$(p - w_h - c_r)Q_h + (p - w_l - c_r + L_l)Q_l > (p - w_h)Q_h + (p - w_l - D)Q_l$, a separating equilibrium is reached. The strategy combination under the separating equilibrium is high wholesale price agreed upon by qualified green product manufacturers, low wholesale price agreed upon by unqualified manufacturers, and retailer selection testing. Therefore, the posterior probability judgments of the retailer to the manufacturer are $\mu(h|w_h) = 1$, $\mu(l|w_h) = 0$, $\mu(l|w_l) = 1$, and $\mu(h|w_l) = 0$. Thus, the expected revenue of the retailer choosing the test is $E_J = (p - w_h - c_r)Q_h + (p - w_l - c_r + L_l)Q_l$, and the expected benefit of choosing not to test is $E_B = (p - w_h)Q_h + (p - w_l - D)Q_l$ and $E_J > E_B$.

When

$$(w_h - c_l - L_h)Q_h > (w_l - c_l - L_l)Q_l$$

and

$(p - w_h - c_r)Q_h q + (p - w_h - c_r + L_h)Q_l(1 - q) > (p - w_h)Q_h q + (p - w_h - D)Q_l(1 - q)$, the result is pooling equilibrium. The strategy combination of the pooling equilibrium is that both qualified and non-qualified green product manufacturers set high wholesale prices, and retailers choose testing. Therefore, the posterior judgment of the retailer on the manufacturer is $\mu(h|w_h) = q$, $\mu(l|w_h) = 1 - q$, $\mu(l|w_l) = 0$, and $\mu(h|w_l) = 0$. The expected revenue of the retailer choosing to test is $E_J = (p - w_h - c_r)Q_h q + (p - w_h - c_r + L_h)Q_l(1 - q)$; the expected revenue of choosing not to test is $E_B = (p - w_h)Q_h q + (p - w_h - D)Q_l(1 - q)$, and because $E_J > E_B$, the retailer chooses to test.

(3) Conclusion

The manufacturer's production behavior is supervised by the internal members of the supply chain when the retailer chooses whether to test the manufacturer's products according to the wholesale price. In this case, there is a separating and pooling equilibrium in the game. Since the manufacturers of both qualified and non-qualified green products set high wholesale prices under the pooling equilibrium, it is impossible to distinguish qualified green products from non-qualified green products by relying on the wholesale price. Retailers should reasonably adjust the retail price and the compensation charged to manufacturers to achieve the conditions $(w_h - c_l - L_h)Q_h < (w_l - c_l - L_l)Q_l$ and $(p - w_h - c_r)Q_h + (p - w_l - c_r + L_l)Q_l > (p - w_h)Q_h + (p - w_l - D)Q_l$ of separating equilibrium. Hence, the wholesale price can accurately reflect whether the manufacturer's green products are qualified, that is, qualified green product manufacturers can set a high wholesale price, whereas unqualified green product manufacturers can set a low wholesale price to ensure the interests of qualified green product manufacturers.

8.2.5 Pricing for Green Product Model with Information Asymmetry Under Government Supervision

(1) Problem Description and Assumptions

Assume that the main players in the game are the green product manufacturer and the government, the green product manufacturer is the signal sender, while the government is the signal receiver. The model assumptions are as follows.

The manufacturer and government are both rational and committed to maximizing their own benefits. There are two types of manufacturers θ: manufacturer h produces qualified green products; manufacturer l produces unqualified green products. The social benefits of the production of qualified green products are V_h, and the social benefits of the production of unqualified green products are V_l, and $V_h > V_l$ [25]. If the manufacturer produces qualified green products, they need to pay a high cost c_h; otherwise, they pay a low-cost c_l [20]. Both the qualified and non-qualified manufacturers can choose to sell green products at a high price p_h or a low price p_l. The government either regulates or does not regulate. Under the supervision of the government, a subsidy αp_θ will be given to the qualified green product manufacturer based on pricing, and a penalty $\beta_\theta p_\theta$ ($\beta_h > \beta_l$) will be imposed on the unqualified green product manufacturer.

The game can be expressed as: (a) "Nature" first chooses the type of the manufacturer, and the priori probability are $\mu(\theta = h) = q$, $\mu(\theta = l) = 1 - q$; (b) after the manufacturer understands its type, it selects the price level p_θ as the signal to be sent; (c) after the government observes the price level p_θ, it uses the Bayesian rule to get the posterior probability $\mu(\theta|p_\theta)$, and then chooses whether to monitor the manufacturer; (d) the manufacturer and the government realize their own benefits.

According to the above assumptions, the expected benefit of the government's choice of regulation is $E_G = (V_h - \alpha p_h)\mu(h|p_h) + (V_l + \beta_h p_h)\mu(l|p_h) + (V_l + \beta_l p_l)\mu(l|p_l) + (V_h - \alpha p_l)\mu(h|p_l)$, while the expected benefit of the government's non-regulation is $E_N = V_h\mu(h|p_h) + V_l\mu(l|p_h) + V_l\mu(l|p_l) + V_h\mu(h|p_l)$. When $E_G > E_N$ occurs, the government chooses to regulate, and if vice versa, it does not regulate. The signal game model of green product manufacturer and the government is shown in Fig. 8.3.

(2) Equilibrium Analysis

If $p_h - c_l - \beta_h p_h < p_l - c_l - \beta_l p_l$ and $(V_h - \alpha p_h) + (V_l + \beta_l p_l) > V_h + V_l$, we obtain a separating equilibrium. The strategic combination under separating equilibrium is that qualified green product manufacturers set high prices, unqualified manufacturers set low prices, and the government chooses supervision. Therefore, the manufacturer's posterior probability judgment is $\mu(h|p_h) = 1$, $\mu(l|p_h) = 0$, $\mu(l|p_l) = 1$, and $\mu(h|p_l) = 0$. Thus, the expected benefit of the government choosing to regulate is $E_G = (V_h - \alpha p_h) + (V_l + \beta p_l)$; the expected benefit of the government not regulating is $E_N = V_h + V_l$ ($E_G > E_N$), and the government chooses to regulate.
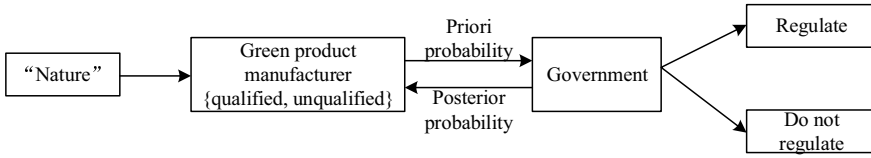
Fig. 8.3 The signal game model of green product manufacturer and the government

For $p_h - c_l - \beta_h p_h > p_l - c_l - \beta_l p_l$ and $(V_h - \alpha p_h)q + (V_l + \beta_h p_h)(1 - q) > V_h q + V_l(1 - q)$, the result of the game is a pooling equilibrium. The strategic combination under the pooling equilibrium is as follows: both qualified and unqualified green product manufacturers set a high price and the government chooses to regulate. Therefore, the government's a posteriori judgment of the manufacturer includes $\mu(h|p_h) = q$, $\mu(l|p_h) = 1 - q$, $\mu(l|p_l) = 0$, and $\mu(h|p_l) = 0$. The expected benefit of the government's choice of regulation is $E_G = (V_h - \alpha p_h)q + (V_l + \beta_h p_h)(1 - q)$; the expected benefit of the government's non-regulation is $E_N = V_h q + V_l(1 - q)$ $(E_G > E_N)$, and the government chooses to regulate.

(3) Conclusion

When the external government regulates the manufacturer's production and sales behavior, the game results also have separating and pooling equilibriums. In turn, the equilibrium result is ultimately determined by the conditions satisfied by the relevant parameters. Since manufacturers of both qualified and unqualified green products set high prices in the pooling equilibrium market, consumers cannot distinguish green products accurately based on the product price. To ensure that the result of the game reaches separating equilibrium, the government needs to mandate reasonable punishment for unqualified green product manufacturers and appropriate subsidies for qualified green product manufacturers. It doesn't mean that the more punishment the government mandate, the better. When $p_h - c_l - \beta_h p_h < p_l - c_l - \beta_l p_l$ and $(V_h - \alpha p_h) + (V_l + \beta_l p_l) > V_h + V_l$ are satisfied, the government can separate qualified manufacturer from unqualified manufacturer according to market price. By doing so, consumers can correctly distinguish qualified green products from non-qualified green products based on their price, thus enhancing their trust in the green market.

8.3 Summary

Green product prices affect market demand and enterprise profits. Reasonable green prices can encourage more consumers to convert their green consumption intentions into actual purchasing behaviors, and provide a guarantee for enterprises to implement green growth models. Compared with common products, green products require enterprises to invest significant green costs, and their prices are usually higher

than common products. This makes enterprises lose part of their price-sensitive consumers. However, the green market also possesses opportunities that are not available to common products, such as the growing trend in green consumption and government policies. Consumption and policy environments provide favorable conditions for enterprises to produce green products. However, the interior of a green market is a typical decision-making environment with limited and vague information. If there is no guidance and constraint of system and mechanism, bad money drives out good, which is not conducive to enterprises' implementation of the green growth model. Therefore, government or upstream and downstream supervision of the supply chain is particularly important for creating a healthy and green production and consumption environment. The game analysis between manufacturers, retailers, and the government from the perspective of the supply chain and government supervision also shows that if the pricing of green products meets certain conditions, consumers can separate qualified and unqualified green products to ensure healthy operation of the green market.

References

1. Yang, M., Chen, H., Long, R., Wang, Y., Hou, C., & Liu, B. (2021). Will the public pay for green products? Based on analysis of the influencing factors for Chinese's public willingness to pay a price premium for green products. *Environmental Science and Pollution Research, 28*(43), 61408–61422.
2. Zhong, S., & Chen, J. (2019). How environmental beliefs affect consumer willingness to pay for the greenness premium of low-carbon agricultural products in China: Theoretical model and survey-based evidence. *Sustainability, 11*(3), 592.
3. Berger, J. (2019). Signaling can increase consumers' willingness to pay for green products. Theoretical model and experimental evidence. *Journal of Consumer Behaviour, 18*(3), 233–246.
4. Salladarre, F., Brecard, D., Lucas, S., & Ollivier, P. (2016). Are French consumers ready to pay a premium for eco-labeled seafood products? A contingent valuation estimation with heterogeneous anchoring. *Agricultural Economics, 47*(2), 247–258.
5. Li, Y., Lu, Y., Zhang, X., Liu, L., Wang, M., & Jiang, X. (2016). Propensity of green consumption behaviors in representative cities in China. *Journal of Cleaner Production, 133*, 1328–1336.
6. Wang, Y., Li, Y., Zhang, J., & Su, X. (2019). How impacting factors affect Chinese green purchasing behavior based on Fuzzy Cognitive Maps. *Journal of Cleaner Production, 2019*(240), 118199.
7. Sha, R., Li, J., & Ge, T. (2021). How do price distortions of fossil energy sources affect China's green economic efficiency? *Energy, 232*, 121017.
8. Knapp, L., O'shaughnessy, E., Heeter, J., Mills, J., & Decicco, J. (2020). Will consumers really pay for green electricity? Comparing stated and revealed preferences for residential programs in the United States. *Energy Research & Social Science, 65*, 101457.
9. Costantini, V., Crespi, F., Marin, G., & Paglialunga, E. (2017). Eco-innovation, sustainable supply chains and environmental performance in European industries. *Journal of Cleaner Production, 155*, 141–154.
10. Zhang, R., Liu, J., & Qian, Y. (2022). Wholesale-price vs cost-sharing contracts in a green supply chain with reference price effect under different power structures. *Kybernetes*. https://doi.org/10.1108/k-11-2021-1096

11. Susanty, A., Akshinta, P., Ulkhaq, M., & Puspitasari, N. (2022). Analysis of the tendency of transition between segments of green consumer behavior with a Markov chain approach. *Journal of Modelling in Management*. https://doi.org/10.1108/jm2-09-2020-0252

12. Du, S., Tang, W., Zhao, J., & Nie, T. (2018). Sell to whom? Firm's green production in competition facing market segmentation. *Annals of Operations Research, 270*(1–2), 125–154.

13. Chang, T., Chen, Y., Yeh, L., & Li, H. (2021). Sustainable consumption models for customers: Investigating the significant antecedents of green purchase behavior from the perspective of information asymmetry. *Journal of Environmental Planning and Management, 64*(9), 1668–1688.

14. Nuttavuthisit, K., & Thogersen, J. (2017). The importance of consumer trust for the emergence of a market for green products: The case of organic food. *Journal of Business Ethics, 140*(2), 323–337.

15. Donald, D., Ketchen, D. J., Orlandi, I., Heugens, P., & Boyd, B. K. (2019). Information asymmetry in management research: Past accomplishments and future opportunities. *Journal of Management, 45*(1), 122–158.

16. Zhang, W. Y. (2012). Game theory and information economics. Truth & Wisdom Press.

17. Liu, K., Li, W., Cao, E., & Lan, Y. (2021). A behaviour-based pricing model of the green product supply chain. *Environmental Science and Pollution Research, 28*(46), 65923–65934.

18. Heydari, J., Govindan, K., & Basiri, Z. (2020). Balancing price and green quality in presence of consumer environmental awareness: A green supply chain coordination approach. *International Journal of Production Research, 59*(7), 1957–1975.

19. Shao, J., & Unal, E. (2019). What do consumers value more in green purchasing? Assessing the sustainability practices from demand side of business. *Journal of Cleaner Production, 209*, 1473–1483.

20. Hong, Z., Wang, H., & Yu, Y. (2018). Green product pricing with non-green product reference. *Transportation Research Part E: Logistics and Transportation Review, 115*, 1–15.

21. Meng, Q., Li, M., Li, Z., & Zhu, J. (2020). How different government subsidy objects impact on green supply chain decision considering consumer group complexity. *Mathematical Problems in Engineering*, 5387867.

22. Zhang, J., Li, S., & Zhang, S. (2019). Manufacturer encroachment with quality decision under asymmetric demand information. *European Journal of Operational Research, 273*, 217–236.

23. Yenipazarli, A., & Vakharia, A. (2015). Pricing, market coverage and capacity: Can green and brown products co-exist? *European Journal of Operational Research, 242*, 304–315.

24. Zhu, W., & He, Y. (2017). Green product design in supply chains under competition. *European Journal of Operational Research, 258*, 165–180.

25. Yang, R., Tang, W., & Zhang, J. (2021). Technology improvement strategy for green products under competition: The role of government subsidy. *European Journal of Operational Research, 289*, 553–568.