Chapter 13
Resource Recycling

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Abstract Resource recycling is an important part of enterprises' green growth model, and is necessary for the upgrade and reconstruction of enterprise value chains. Based on the new forms of industry, new business models, and next generation information and communication technologies, we examine the new problem of resource recycling of manufacturing enterprises on the Internet platform. This chapter studies the efficiency and benefits for manufacturers and third-party platforms in recycling used products. Different platform recycling models are modeled and analyzed. We find that recycling prices, agency fees, and consumers' willingness to use different recycling models affected consumers' recycling choices. Consumer willingness results in different third-party recycling platforms occupying different market shares. Our research demonstrates the impact of consumers' willingness to recycle on recycling efficiency. We provide management implications for recycling enterprises when reconstructing the value chain.

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13.1 Resource Recycling and Enterprises' Green Growth Model

13.1.1 Resource Recycling: An Element of Enterprises' Green Growth Model

Currently, the operating environment of enterprises has undergone revolutionary changes. Given the changes in the international competitive environment and the deepening of the concept of green consumption, resource and environmental constraints have tightened. The increase in the disposable income of consumers has changed their demand from emphasizing cost-effective mass consumption to the pursuit of green, personalized services, product performance, and so on [1]. Enterprises that carry out green development and transformation have become an inevitable trend.

Resource recycling is an important part of the transformation of enterprises into a green growth model. It is also important to value chain reconstruction. A resource circular economy is an economic development model characterized by resource conservation and recycling. It is harmonious with the environment, and is characterized by low mining, high utilization, and low emissions [2]. At the micro level of the enterprise, resource recycling requires the enterprise to organize internal economic activities into a feedback process of "resource-product-renewable resource". All materials and energy can be rationally and sustainably used in this ongoing economic cycle to reduce the impact of economic activities on the natural environment as much as possible. The reverse value chain of resource recycling connects the end consumer with the manufacturing enterprise in a positive value chain [3]. It is also a key activity for enterprises to achieve green growth.

Cainiao Logistics is a representative enterprise of logistics value chain reconstruction in China. In 2016, Cainiao Logistics and several major Chinese express-delivery companies, such as ZTO Express, YTO Express, and STO Express, jointly launched Cainiao Green Action to promote the upgrade of the logistics industry to a green industry. In China, the Cainiao Green Action is the largest environmental protection action in the logistics joint industry. Since the "Double 11" in 2017, Cainiao Logistics has set up approximately 5,000 recycling stations in 200 cities across the country. Consumers can find the nearest recycling station, using the AutoNavi map, to donate cartons. Cainiao Logistics provides recycled cartons offline directly to consumers of Cainiao Station for free, pioneering the local recycling of express cartons. According to Cainiao Logistics's "Double 11 Green Logistics Carbon Reduction Report" in 2021, Double 11, Cainiao Logistics joined with T-mall Supermarket to promote original, used, and recycled box deliveries. More than 70% of their parcel shipments no longer use new cartons. The proportion of single-warehouse recycled cartons was 30%–40%. A total of 75,000 packages were issued using recycled cartons. The T-mall warehouse in Shanghai Jiading reduced the number of carton and plastic packaging materials by nearly 300,000 daily. A total of 4.8 million people participated in and shared Cainiao Logistics's express packaging recycling activities online and offline. By 2021, Cainiao Green Logistics had more than 1.8 billion green behaviors. Cainiao Logistics' merchants and consumers jointly reduced carbon emissions by 53,000 tons for the entire society.[1]

13.1.2 Resource Recycling: An Element of Value Chain Reconstruction

In the traditional growth model, products abandoned by consumers due to damage, waste, and other factors are not returned to the value chain through recycling. They are eventually landfilled as garbage, which has a significant impact on the environment. However, the backlog of the large number of used products that remain idle with consumers due to product upgrade or other reasons is also a huge waste of resources. For enterprises, used and waste products are recycled into the production line through some channels. The recycled waste products are decomposed, reused, and remanufactured. After dismantling modules or product refurbishment, they enter new sales channels to reduce the resource investment in new product manufacturing and realize resource recycling [4]. The realization of resource recycling requires enterprises to reconstruct some activities and modules in the value chain, reduce the cost of recycling, and improve the efficiency of resource recycling through technological upgrade and industrial transformation. Consumer electronics is a prime example.

Taking Huawei as an example, in the traditional consumer electronics industry, Huawei as the upstream product manufacturer, sells products through regional distributors. The recycling business of used mobile phones is often concentrated in the hands of small recycling vendors and secondary dealers in local regions. The distance between manufacturers and consumers is quite large, making a high cost of recycling old electronics from customers. And it is also very expensive to disassemble recyclable electronic components for remanufacturing before mobile phones achieve uniform production standards and modularization. With the upgrade of mobile phone manufacturing and recycling technology, and the popularization of Internet platforms and big data technologies, Huawei began to recycle used mobile phones to improve the efficiency of resource recycling. Consumers can find the nearest recycling outlet on Huawei's official website and visit the outlet to recycle their mobile phones. In 2015, Huawei launched the "Green Action 2.0" for mobile phone recycling. Consumers can value and recover idle mobile phones on the Huawei Mall trade-in platform, receiving mobile phone vouchers to purchase Huawei's new devices. Huawei assesses the recycled used mobile phones and divides them into two types: "mobile phones that can continue to use", and "mobile phones that cannot continue

[1] https://www.cainiao.com/green.html.

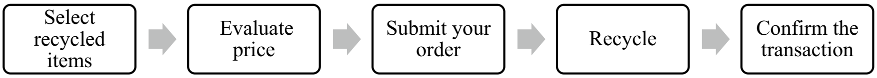

Fig. 13.1 Huawei's official trade-in process for consumers

to use" [2]. Mobile phones that can continue to be used will be handed over to third-party recyclers who have undergone rigorous qualification review. After the third-party recycler cleans the data on the mobile phone and performs related processing measures, it is sold through regularly used mobile phone retail channels. If mobile phones can no longer be used, the recycler will disassemble the modular accessories that can continue to be used through 23 processes, including disfiguring and scanning codes, returning them to the mobile phone manufacturers for the manufacture of new products, and carrying out thorough environmental protection and pollution-free treatment of accessory materials that cannot be used.[2] Huawei's trade-in process for consumers on its official website is as shown in Fig. 13.1.

13.2 Drivers of Resource Recycling

13.2.1 To Conform to Consumers' Environmental Protection Concepts

As the concept of environmental protection gradually becomes popular, consumer demand for green products increases daily, and the importance of green products is emphasized more [5]. Consumers' preference for environmentally friendly products is considered an important driving force for enterprises to implement green environmental protection and resource recycling. It is also a key factor for consumers to assume social responsibility [6]. Simultaneously, resource recycling by enterprises changes consumers' consumption concepts and market demand. If more enterprises in a certain industry begin to carry out recycling activities and promote a resource circular economy to society, consumer prejudice against recycled products will gradually be eliminated. Through the continuous implementation of these appropriate incentives, consumers will pay more attention to the overall image of the enterprise when choosing goods and will be more willing to choose products produced by enterprises that consider environmental protection. Therefore, through recycling, trading in, and other methods, enterprises can better meet consumers' preferences for green consumption, thereby enhancing their competitiveness.

Alibaba's Freshhema is an example. As a new retail format, Freshhema has been exploring models to innovate and optimize its services. In 2019, Freshhema announced the launch of the "Green Box Plan", which involved optimizing the supply chain and processes from the source to the table, to reduce the use of plastic products.

[2] https://www.vmall.com/help/faq-7923.html.

The annual target is to reduce plastic use by 3.8 million kilograms. To encourage consumers to spend in environmentally conscious ways in stores, Freshhema and Alibaba's Alipay Ant Forest declared that consumers who did not buy plastic bags when checking out with the Freshhema APP would obtain 21g of green energy in the ant forest once a day. Simultaneously, Freshhema and Octopus Recycling placed smart machines that sort and recycle plastics in stores in Hangzhou, Beijing, and Shanghai. Consumers would only need to open their mobile phones to scan items to be recycled. They can participate in plastic recycling delivery and exchange them for environmentally friendly gifts. This novel, full self-service recycling method has attracted the participation of many Freshhema users. In less than two months, the first two stores participating in the pilot recycled more than 1700 plastic bottles and more than 1400 kg of plastic.[3]

13.2.2 To Respond to Government Environmental Regulations

Governments' environmental protection laws and regulations are important influencing factors and driving forces for enterprises to implement resource recycling. To promote resource recycling and strengthen environmental protection and industrial green development, local governments issue requirements for environmental protection capabilities and relevant environmental protection laws and regulations for local enterprises. They also provide corresponding incentives or constraints on the production behavior of domestic enterprises [7]. Governments' environmental rules causes companies to consider transitioning to the green growth model to avoid larger policy fines or even business closure penalties. Governments have put forward corresponding protection laws and regulations for environmental protection and the green development of enterprises and have formulated a series of environmental management systems. Furthermore, a series of international regulations have been introduced to strengthen resource recycling. For example, in 2002, the European Union issued the WEEE, ROHS, and EUP Directives. Through these, the government promotes the recovery of recyclable products by setting the appropriate target recovery rates.

In this context, society began to pay attention to green development, and the irrational factors of enterprises began to reflect the awareness of corporate social responsibility. Although companies' responses to environmental regulatory policies may be passive, they reduce environmental risks and enhance the company's corporate social responsibility image. However, mandatory environmental laws and regulations have a significantly positive impact on enterprises' green innovation practices [8]. For example, China began implementing the "Circular Economy Promotion Law of the People's Republic of China" in 2009. Since then, China introduced a policy for the "trading-in of used appliances for new ones" to promote urban consumption. This

[3] https://www.163.com/dy/article/E820OCF30512DU6N.html.

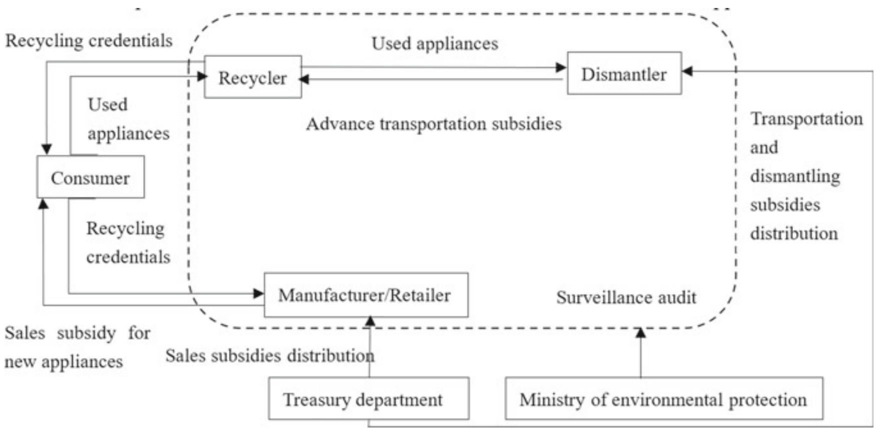

Fig. 13.2 Implementation process for "trading-in used appliances for new ones" [9]

was first piloted in nine provinces and cities, including Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Shandong, Guangdong, Fuzhou, and Changsha. Since June 1, 2010, the scope of implementation has gradually expanded to the entire country. The Ministry of Commerce, Ministry of Finance, and Ministry of Environmental Protection issued the Work Plan for the Replacement of Household Appliances. The implementation process is showed in Fig. 13.2, [9]. Initially, the policy was led by the state and was subject to financial subsidies. Since then, more home appliance manufacturers, recycling platforms, and other entities have participated, and the "old-for-new" appliances have gradually evolved into market-oriented measures, such as "Suning Tesco" and "JD". Other large e-commerce platforms have launched "old-for-new" subsidies for household appliances as well.

In 2021, the number of trade-in orders on JD's appliance platform increased by more than 300% year-on-year. The air conditioner alone saved nearly 300 million yuan for users.[4] The Suning Tesco platform has achieved exchanges between home appliance categories as well. For example, computers are exchanged for mobile phones. Refrigerators are exchanged for air conditioners. The platform has 350 stores ordering and renewing services. Suning Tesco's appliance recycling process is showed in Fig. 13.3. In 2021, Suning Tesco launched an appliance replacement and upgrade scheme to increase the subsidy for replacement. The newly upgraded trade-in service is simpler, more convenient, and more comprehensive, realizing one-click valuation and price-difference payments. In addition, it is a one-stop service for new machines and old tractors, which greatly saves consumers' waiting time.[5] The relevant person in charge of JD appliances pointed out that the "old-for-new" appliances can guide users to update them promptly. It is also one way to activate a huge stock market. Simultaneously,

[4] http://news.cheaa.com/2022/0124/602208.shtml.

[5] https://new.qq.com/omn/20210416/20210416A0B0I900.html.

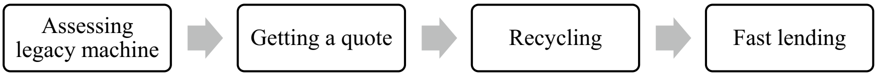

Fig. 13.3 Suning Tesco's appliance recycling process[6]

for enterprises, a strong after-sales system is the guarantee for upgrading the "old-for-new" policy. Enterprises need to sort and professionally crush recovered electronic products to ensure the rational use of idle resources and protect the privacy rights and interests of consumers. Therefore, in addition to stimulating consumer demand, the "old-for-new" policy has also positively driven the sustainable development of the waste electronic product recycling industry.[7]

13.2.3 To Promote the Reconstruction and Upgrade of Value Chains

The traditional high-input, high-consumption growth model has long led to different degrees of environmental pollution and large resource consumption problems worldwide, especially in developing countries. The enterprises' traditional growth model focuses mainly on resource and labor consumption and pollution-end control. Regarding low-cost resource and labor and loose environmental constraints, the growth of the traditional model may have obvious performance. The implementation of a green performing resource cycle is not obvious, or may even be negative. The cost of resource recycling has gradually decreased, which can better meet consumers' demand for green environmental protection and reduce potential policy risks. The main reasons for cost reduction are the requirements of policies, innovation of environmental protection technologies and means, and continuous development of consumer concepts. Changes in the resource environment restrict enterprises from choosing a green growth model. Recycling resources can reduce the resource consumption of enterprises. Following this, a closed loop of the value network can be built. The realization of resource circulation must be supported by new technologies and enterprise models. Enterprises need to use more advanced technology and replace material inputs with knowledge input, as much as possible, to achieve the recycling of the resource life cycle.

The resource life cycle of enterprises needs to comply with the "3R1D" principle of "reducing, reusing, recycling and degradable" [10]. "Reducing" belongs to the input side. It is required to input less raw materials and energy to achieve the intended production or consumption purposes, and then pay attention to saving resources and reducing pollution from the source of economic activity. "Reusing" belongs to the

[6] https://hx.suning.com/.

[7] https://huishou.jd.com/home.html.

process aimed at prolonging the length of use of products and services. “Recycling” belongs to the output side; it aims to reduce the amount of disposal. “Degradable” means the product should be easy to degrade at the end of its life cycle. Resource recycling requires enterprises to evolve to a stage with a more advanced form, complex division of labor, and reasonable structure. Enterprises should implement the green growth model during the entire life cycle of the product and reengineering and reconstruction of the value chain. In the resource development stage, enterprises should consider rational development and the multilevel reuse of resources. In the product and production design stage, enterprises should consider the basic functional attributes of the product, while considering its negative impact on the environment, from the non-polluting and non-toxic selection of raw materials and processes to manufacturing. In other words, the design of all aspects, from use to recycling after disposal, must implement the concept of green design, consider the multilevel utilization of resources, and integrate a standardized design of the production process. In the production, product transportation, and sales stages, enterprises should consider process integration and waste reuse. In the circulation and consumption stage, enterprises should consider extending the service life of products and realizing multiple uses of resources. At the end of the lifecycle, enterprises should consider the reuse of resources and waste recycling.

Taking the new energy vehicle battery industry as an example, recycling is the last link in the value chain and has drawn a completely closed loop for the power battery industry.[8] Upstream of the power battery industry are positive and negative electrode materials, electrolytes, diaphragms, and other materials. The intermediate link is the preparation of these materials. The downstream industry is the new energy automobile industry. By recycling the power battery, most materials other than the separator and negative electrode can be retained. Thus, resource recycling can be achieved. The front and back end of the value chain are the link that forms an important closed loop for power battery recycling. The new battery passes through the battery enterprises, vehicle enterprises, car dealers, and finally, the consumers. Consumers will replace the scrapped battery through after-sales service outlets, and battery rental enterprises will replace the new battery. After-sales outlets and battery rental enterprises collect waste batteries and transfer them to recycling service outlets and waste battery comprehensive utilization enterprises, to generate reusable products. The batteries return to the comprehensive utilization enterprises for the renewable resource to be utilized after scrapping. These renewable resources flow into battery production enterprises to create new batteries. Then, they flow to vehicle enterprises, forming a closed loop.

As one of the leading enterprises in the field of new energy vehicles in China, “XPENG” recycles the waste power batteries contained in the models it sells. Waste power batteries include those that cannot be repaired after scrapping or damage, and XPENG has the right to dispose of them. XPENG will recycle them through the after-sales service center and the recycling network established in cooperation with battery recycling enterprises to avoid environmental pollution and waste of resources.

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[8] https://www.zhidx.com/p/135289.html.

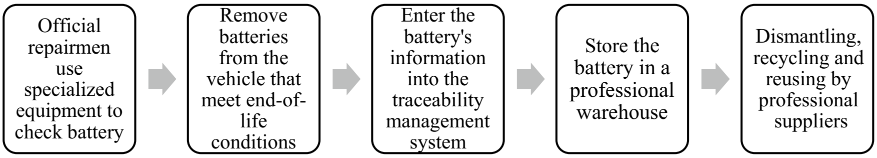

Fig. 13.4 XPENG's waste power battery recycling management process

XPENG's waste power battery recycling management process is as Fig. 13.4 shown. In terms of wastewater, waste gas, and waste recycling, XPENG uses a deep treatment system to produce reclaimed water from the sewage treatment station, treating qualified wastewater for factory greening, toilet flushing, car washing, and cooling towers in its Zhaoqing production base. This saves 110,000 tons of freshwater per year. Additionally, the welding workshop adopts an efficient filter dust collector to adsorb soot. The dust removal efficiency is 99%. The painting workshop uses environmentally friendly water-soluble coatings as well, to reduce the amount and emission of organic pollutants from the source. To improve the efficiency of solid waste recycling, XPENG further built a waste warehouse in June 2021 to improve the storage conditions and transfer methods of recyclable materials. As of May 2021, XPENG has achieved a 100% recyclable solid waste utilization rate.

XPENG strives to complete the green ecological layout of its entire industry chain from manufacturing and use, to recycling. Under the Chinese government's "double carbon" goal, the transformation of "zero emissions" in the entire life cycle of pure electric vehicles will be realized. In the production and manufacturing process, XPENG promotes clean energy research, development, and application projects, and adopts a large number of intelligent equipment and concepts. It realizes lean production methods that consider quality, environmental protection, flexibility, and efficiency. In terms of production technology, the Zhaoqing production and application base achieves emission reduction with a high automation rate and advanced technology. For example, their painting workshop adopts advanced treatment film technology, which reduces the slag production from waste paint by 94% and reduces energy consumption by more than 25%. It further adopts circulating air in the painting room, which saves energy and reduces exhaust emissions by 30%. On October 14, 2021, XPENG released its first Environmental, Social, and Governance (ESG) report, which was also the first ESG report released by China's new car-making enterprise with reference to national standards. For two consecutive years, XPENG received an ESG rating of AA, which is the highest rating for global car companies. This indicates that the leading ESG achievements of XPENG have been recognized by the industry.[9]

[9] https://3g.163.com/dy/article/GS7AL40O0527CR28.html.

13.3 Design of Transaction Model of the Online Used Product Recycling Platforms

13.3.1 Resource Recycling with the Next Generation Information and Communication Technology

The integration of next generation information and communication technology and environmental protection technology provides an important means for enterprises to implement the green growth model [11]. The next generation information and communication technology is profoundly changing the strategic decision-making, organizational form, business model, and operation model of enterprises. New models and formats of recycling and resource recycling have spawned from the establishment of various used goods trading platforms and product recycling platforms based on Internet technology. The most typical examples include the following:

(1) The emergence of the Internet platform has formed a recycling and trading system that combines online and offline channels. For example, the "easy to sell" business of the Idle Fish APP integrates the online recycling, warehouse management, and distribution transaction service sharing platform of various brands of mobile phones. The Idle Fish receives consumers' requests online, detects and recycles the used goods offline, and evaluates price by big data valuation.[10] This integration improves the recovery rate of renewable resources and completely changes the traditional offline recycling method. Similarly used product trading recycling platforms are "Aihuishou," which recycles waste electronic products; Baidu recycling stations; and other young recycling platforms.[11] The core of this innovation lies in the fact that the next generation internet technology instantly and accurately matches the supply and demand of recycling. Moreover, a collection and transaction system that combines online and offline channels have been established.

(2) The internet, combined with the real economy, develops into an ecosystem with integrated processes. For example, China Baowu has built a micro platform for collecting hazardous waste, specifically for enterprises with small industrial waste production. The Baowu platform helps enterprises choose appropriate channels for disposal, either by the enterprise itself, or entrusted to qualified hazardous waste disposal units.[12] China Lanzhou Renewable Resources Company chose the chain operation business model of self-operation and franchise, to build a recycling station base, professional sorting center, and processing enterprises as the core of a "Trinity" recycling system.[13] The core

[10] https://goofish.com/.

[11] https://www.aihuishou.com/.

[12] https://www.thepaper.cn/newsDetail_forward_15115265.

[13] http://lz.wenming.cn/wmcj1/wmcj/202010/t20201022_6773364.shtml

of the above-mentioned enterprise model innovation is the use of the next generation internet technology, while achieving an instant and accurate matching of recycling supply and demand. This further extends the recycling behavior to remanufacturing, resale, and recycling. These behaviors do not include all the activities undertaken by the enterprise itself, but follows the labor advantages of core competitiveness in the platform and ecosystem to find the most suitable partner. The core of this model is to solve the information-matching problem of scattered supply and demand and build an ecosystem of value added and shared profits.

The rapid development of Information and communication technology provides important technical support for promoting green consumption. With the development of e-commerce, more merchants conduct business on Internet trading platforms. In the secondary market, recyclers can use the convenience and timeliness of Internet platform transactions to cover more consumers, expand the scope of recycling, and improve recycling efficiency. However, one challenge is the competition between various used product recycling platforms online.

13.3.2 Transaction Model of Used Product Recycling Platforms

At present, most mainstream product recycling platforms in the market are large-scale, third-party, recycler-led product trading platforms that provide manufacturers and consumers with a market for used product recycling transactions. There are three main trading models on platforms: the conventional third-party recycling platform model, the agency third-party recycling platform model, and the emerging guaranteed selling duration (GSD) recycling model.

Conventional third-party recycling platform models, including online recycling platforms for used electronic products such as Aihuishou and Idle Fish, acquire used products from consumers and resell them to manufacturers for recycling. Third-party platforms conduct quality checks on the used products, assess product conditions, set wholesale prices, and purchase used products from consumers. The platforms determine the resale prices to manufacturers based on various factors. The agency third-party recycling platform model is one in which the manufacturer relies on a bilateral market to directly conduct recycling business for consumers on the used product recycling trading platform. The platform acts as an agent for buyers and sellers, providing manufacturers and consumers with trading channels. The platform provides a channel for consumers to sell used products that are evaluated, priced, and recycled by manufacturers. The manufacturer or consumer must only pay an agency fee to the platform. The platform itself is not involved in the buying process.

A key difference between the conventional and agency recycling models is the ownership of used products. In the agency recycling model, the manufacturer is the direct recycler of the used product, which means that the platform does not bear the risk of transaction failure. In the conventional recycling model, the platform owns the product; therefore, it must bear the risk of transaction failure and product backlog. However, while the agency recycling model eliminates the risk of trade failure for manufacturers, they lose a portion of their recycling pricing rights for used products when faced with third-party platforms with independent recycling capabilities. Only two models have managed to strike a balance between profit and risk in an increasingly complex platform economy. Therefore, the platform needs to expand its trading model to be more responsive to the market.

Combined with the market environment and real cases, we propose a hybrid retail model that sets the GSD. If the used product is successfully recycled during the GSD, the platform adopts the agency recycling method and only charges a certain fee to the buyer and seller. Otherwise, the platform reclaims ownership of the used product from the seller at a discounted price and then resells it to the manufacturer, essentially switching to a conventional recycling model. At present, some platforms have begun to try this emerging trading model, such as the "Easy to sell" business launched by China's secondary trading platform, Idle Fish, and the 30-day guarantee sale business of the Guazi used cars platform.

In this section, we consider a used product recycling platform that can be selected from different recycling models. We believe that used product recycling platforms need to choose their recycling models from the above three models. Our main objective is to develop the best recycling strategy and pricing policy for the platform. We focus on the following issues:

(1) What is the best pricing policy for the platform among the three models?
(2) How does the recycling model affect platforms, manufacturers' decisions, and consumer behavior?
(3) Which of the three recycling models is best for a new trading platform?

To answer these three questions, we built a value chain involving manufacturers, consumers, and a used product recycling platform that can choose its own business model from the three recycling models. To build effective solutions, we break down multi-user competition into multiple single-match and single-product issues.

We characterize this research question based on research models for two-sided markets, such as Rochet and Tirole [12] and Parker and Van Alstyne [13]. This study builds on existing literature on the secondary durable goods market, consumer behavior in recycling channel competition, and two-sided markets. Previous studies on recycling model selection have concluded that users' evaluations of products are influenced by recycling patterns, which are defined as consumer preferences for channels. Chiang et al. [14] first introduced the concept of consumer acceptance in their study of channel competition. They studied the channel competition between direct and retail channels and found that direct sales channels can increase suppliers' profits. Our research also refers to their approach to portraying consumer preferences. Other studies have focused on the portrayal of buyers' willingness to, rather than on sellers' portrayal of, channel preferences and product quality in two-sided markets. In this study, we adopt Armstrong's assumption that sellers' and buyers' utilities directly affect the platform's requested price for either party and total trading volume [15].

Based on the above literature, our study compares the conventional, agency, and GSD recycling models. With this comparison, we attempted to determine the optimal pricing strategy for the third-party platform in each of the three models. Our findings provide reference and management implications for companies adopting an online market model.

13.3.3 Assumptions and Models

First, we discuss the trading models of the three recycling models in monopolistic markets, as benchmarks. We start by building a value chain involving manufacturers, consumers, and a third-party used product recycling platform that is strong enough to determine the transaction prices for both customers. The platform offers three recycling models: conventional, agency, and GSD recycling. We assume that this is a single-period transaction, in which a consumer is willing to sell no more than one used product per recycle, and that both the buyer and seller are rational individuals seeking to maximize utility. The success of a transaction depends on the consumer's decision to sell $u_s \geq 0$ and the manufacturer's decision to recycle $u_b \geq 0$. Thus, the expected profit of the platform can be estimated as the possible revenue minus the various costs incurred. The structures of these three models are illustrated in Fig. 13.5.

Both consumers and manufacturers will have certain expectations for the residual value of the used products. They will have different value preferences for the same used product due to various factors. For a used product of value v, the consumer will only choose to recycle the product if the consumer's expectation from recycling the used product is higher than the expected value of the product they retain. This expectation can also be called the consumer's "willingness to recycle". We use $\alpha_i, i = 1, 2, 3$ to express the consumer's "willingness to recycle" in different recycling patterns. Similarly, a rational manufacturer will only decide to recycle the product if the expected value of the recycled product is greater than the cost

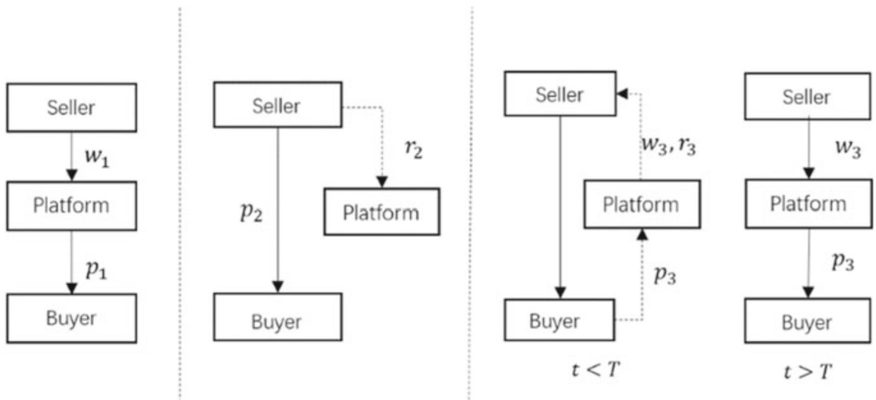

Fig. 13.5 Three recycling models

of recycling. It can also be called the manufacturer's "willingness to pay". We use the parameter $\beta_i, i = 1, 2, 3$ to indicate the manufacturer's "willingness to pay". $i = 1, 2, 3$ represents conventional, agency, and GSD recycling, respectively. We define u_{si} and u_{bi} as the utility that consumers and manufacturers, respectively, can derive from transactions on the three platforms. When utility is not positive, neither the seller nor the buyer will complete the transaction. According to research by Meredith and Akinc [16], we assume that both buyers and sellers are price-sensitive when evaluating used products. The number of bilateral users is normalized to 1. Without losing universality, we assume that the buyer and seller's preferences for the expected value of the product are independent, evenly distributed between 0 and 1, and follow the distribution density function $f(v) = 1$. All parameters involved in the model are normalized to between 0 and 1. Recycling platforms need to ensure that both buyers and sellers get positive utility before setting the transaction price.

(1) Conventional Recycling Model on Third-party Platforms

In the third-party platform conventional recycling model, the platform first needs to assess the value of the used product, then provide the consumer with a recycled price w_1. If the consumer agrees to sell the used product, ownership of the product passes to the platform. Finally, the manufacturer recycles the used product from the platform at the price of p_1.

The utility of the manufacturer-side user can be expressed as:

$$u_{b1} = \beta_1 v - p_1$$

Similarly, the utility of the seller can be expressed as:

$$u_{s1} = w_1 - \alpha_1 v$$

If the product cannot be sold, the platform will bear the loss w_1. A successful transaction depends on the seller's decision to sell ($u_{s1} \geq 0$) and the buyer's decision to buy ($u_{b1} \geq 0$). Thus, the profit of the platform can be estimated as possible sales revenue minus possible losses:

$$\begin{aligned} \pi_1 &= P(u_{s1} \geq 0) \cdot (P(u_{b1} \geq 0) \cdot (p_1 - w_1) - P(u_{b1} < 0) \cdot w_1) \\ &= \int_0^{\frac{w_1}{\alpha_1}} f(v)\mathrm{d}v \left(\left(\int_{\frac{p_1}{\beta_1}}^{1} f(v)\mathrm{d}v \cdot (p_1 - w_1) \right) - \int_0^{\frac{p_1}{\beta_1}} f(v)\mathrm{d}v \cdot w_1 \right) \end{aligned}$$

$$\max_{p_1, w_1} \pi_1 = \frac{w_1}{\alpha_1}\left[\left(1 - \frac{p_1}{\beta_1}\right)p_1 - w_1\right]$$

(2) Agency Recycling Model on Third-Party Platforms

In the third-party platform agency recycling model, the platform first evaluates the recycling price of the used product, according to its quality and recycling value.

Consumers post information about used products at recycling prices p_2 on the platform. Manufacturers recycle these products from consumers. Then, the platform charges consumers a share r_2 of the recovered price as an agency fee. In this case, the platform does not own used products, and only provides a place for buyers and sellers to trade.

The utility of the manufacturer-side user can be expressed as:

$$u_{b2} = \beta_2 v - p_2$$

The utility of the seller can be expressed as:

$$u_{s2} = p_2 - r_2 p_2 - \alpha_2 v$$

The profit function that can be obtained by the recycling platform can be expressed as:

$$\begin{aligned}\pi_2 &= P(u_{s2} \geq 0) \cdot (P(u_{b2} \geq 0) \cdot r_2 p_2 - P(u_{b2} < 0) \cdot 0) \\ &= \int_0^{\frac{(1-r_2)p_2}{\alpha_2}} f(v)\mathrm{d}v \left(\int_{\frac{p_2}{\beta_2}}^{1} f(v)\mathrm{d}v \cdot r_2 p_2 \right) \\ \max_{p_2} \pi_2 &= \frac{(1-r_2)p_2}{\alpha_2} \left(1 - \frac{p_2}{\beta_2}\right) r_2 p_2\end{aligned}$$

(3) GSD Recycling Model on Third-party Platforms

In the GSD recycling model, if the product is sold during the GSD, T, the platform will act as an agency recycler, and only the agency fee r_3 is charged. If the product fails to sell within this period, the platform will purchase it from the seller at wholesale price w_3, become a conventional recycler, and continue to sell the product to the manufacturer at sales price p_3. w_3 and p_3 are set and announced to consumers before the GSD begins. This setting is derived from Gan's [17] probability of a commodity being sold, which increases with the time it is on the market. To simplify the model, we set the probability that the product will be sold during the GSD to be proportional to the length of time. When T is normalized, the probability of the product being sold during the GSD is defined as $P(t \leq T) = T$, and the probability of selling after the GSD is $P(t > T) = 1 - T$.

In this case, the manufacturer-side user gets the desired utility for:

$$u_{b3} = \beta_3 v - p_3$$

The utility obtained by the seller is:

$$\begin{aligned}u_{s3} &= P(t \leq T)(p_3 - r_3 p_3 - \alpha_3 v) + P(t > T)(w_3 - \alpha_3 v) \\ &= T(p_3 - r_3 p_3) + (1 - T)w_3 - \alpha_3 v\end{aligned}$$

Table 13.1 Recycling strategies for third-party recycling platforms

Optimal recycling strategy	Conventional recycling	Agency recycling	GSD recycling
w	$\frac{\beta_1}{8}$	–	$\frac{\beta_3-4\beta_3T+4\beta_3Tr_3}{8(Tr_3-2T-T^2r_3+T^2+1)}$
p	$\frac{\beta_1}{2}$	$\frac{2\beta_2}{3}$	$\frac{\beta_3}{2(Tr_3-T+1)}$
π	$\frac{\beta_1^2}{64\alpha_1}$	$\frac{4\beta_2^2(r_2-r_2^2)}{27\alpha_2}$	$\frac{\beta_3^2}{64\alpha_3^2(Tr_3-T+1)^2}$
u_s	$\frac{\beta_1}{8}-\alpha_1 v$	$(1-r_2)\frac{2\beta_2}{3}-\alpha_2 v$	$\frac{\beta_3}{8(Tr_3-T+1)}-\alpha_3 v$
u_b	$\beta_1 v-\frac{\beta_1}{2}$	$\beta_2 v-\frac{2\beta_2}{3}$	$\beta_3 v-\frac{\beta_3}{2(Tr_3-T+1)}$

The profit function that can be obtained by the recycling platform can be expressed as:

$$\begin{aligned}\pi_3 = {} & P(u_{s3}\geq 0)\cdot((P(u_{b3}\geq 0)\cdot(P(t\leq T)\cdot r_2 p_2 \\ & + P(t>T)(p_3-w_3))) - P(u_{b3}<0)P(t>T)w_3)\end{aligned}$$

$$\max_{p_3,w_3}\pi_3 = \frac{T(1-r_3)p_3+(1-T)w_3}{\alpha_3}\left\{T\left(1-\frac{p_3}{\beta_3}\right)r_3p_3+(1-T)\left[\left(1-\frac{p_3}{\beta_3}\right)p_3-w_3\right]\right\}$$

(4) Comparison of the Three Recycling Models

In this section, we compare the profits, selling prices, and utility of the platforms using the different recycling models. The advantages and disadvantages of the three models are also discussed.

The profits of the specific recycling strategy and platform under the different structures are listed in Table 13.1. The best recycling strategy for a platform depends on a comparison of the agency rates, GSD, and bilateral user recycling preferences.

(5) Channel Selection of Consumers in Competitive Markets

In a highly competitive secondary market, we assume that three platforms offer three recycling models. Consumers are free to choose the channel through which to sell their used products. Each channel initially has a corresponding recycling manufacturer. The market structure is shown in Fig. 13.6.

In a competitive market, for a seller who chooses conventional recycling, the utility benefits he receives from recycling must meet three conditions simultaneously: $u_{s1}>0\cap u_{s1}>u_{s2}\cap u_{s1}>u_{s3}$. Similarly, the utility of a seller who chooses to sell on an agency recycling channel must meet three conditions simultaneously: $u_{s2}>0\cap u_{s2}>u_{s1}\cap u_{s2}>u_{s3}$. The utility of a seller that chooses to sell on a GSD channel must meet three conditions: $u_{s3}>0\cap u_{s3}>u_{s1}\cap u_{s3}>u_{s2}$. By calculation, we use $v_{12}=v(u_{s2}=u_{s1})$, $v_{13}=v(u_{s3}=u_{s1})$, $v_{23}=v(u_{s2}=u_{s3})$ to

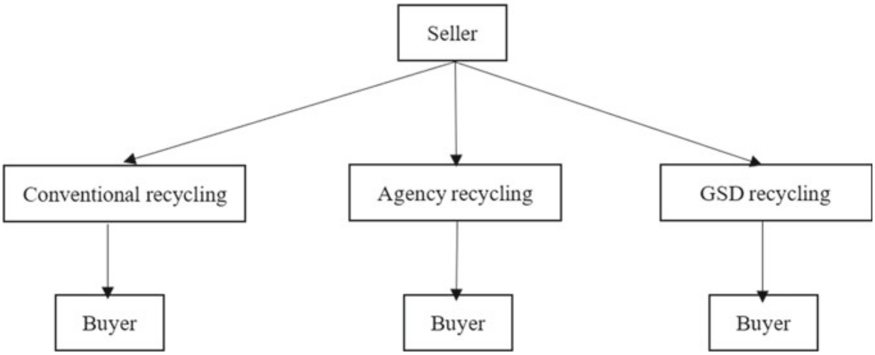

Fig. 13.6 Competitive secondary recycling market structure

represent the value of the three channels when consumer utility is equal. According to the following calculations and comparisons, there are six possible structures in this market after the introduction of competition.

Scenario 1: When $v_{23} > v_{13}$, $U_{s3} = (0, v_3) \cap (0, v_{13}) \cap (v_{23}, 1) = \emptyset$, this represents a loss of market competitiveness in the GSD model.

When $r_2 > 1 - \frac{3\beta_1\alpha_2}{16\beta_2\alpha_1}$, the conventional and agency recycling platforms form a dual-channel competitive market (Fig. 13.7).

When $r_2 < 1 - \frac{3\beta_1\alpha_2}{16\beta_2\alpha_1}$ occurs, agency recycling platforms monopolize all potential seller consumers, and the other two third-party platforms lose their market competitiveness (Fig. 13.8).

Scenario 2: when $v_{23} < v_{12} < v_{13}$.

When $r_3T - T + 1 > \frac{\alpha_1\beta_3}{\alpha_3\beta_1}$, all three recycling platforms exist in the market, but the market share varies according to the size of user preferences. When $v_2 > v_{23}$, the agency recycling platform can engage all inefficient sellers that the other two

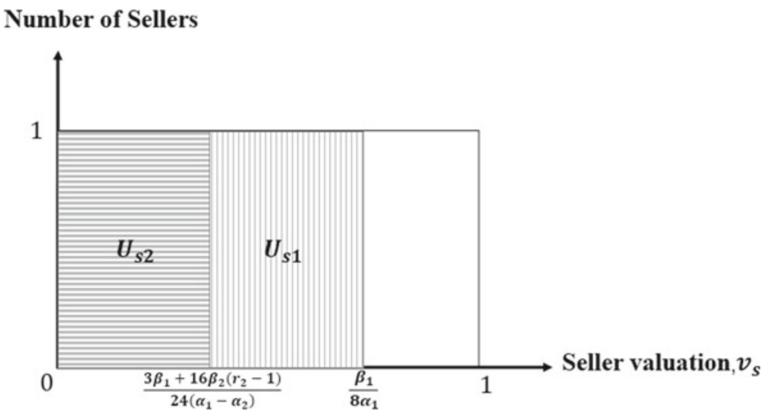

Fig. 13.7 Dual-channel competition between conventional and agency recycling platforms

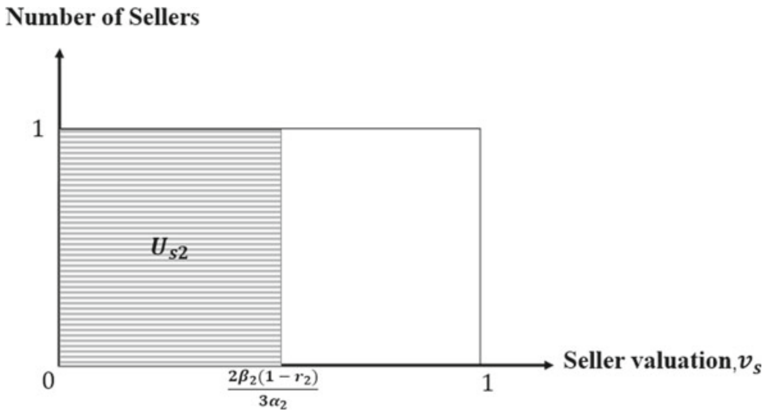

Fig. 13.8 Agency recycling platform monopoly

recycling platforms cannot attract. In contrast, when $v_2 < v_{23}$, the agency recycling platform cannot engage all low-end sellers; therefore, the market may form two competitive models (Figs. 13.9 and 13.10).

When $r_3T - T + 1 < \frac{\alpha_1\beta_3}{\alpha_3\beta_1}$, the conventional recycling platform loses its market competitiveness. The agency and GSD recycling platforms will form a dual-channel competitive market. Simultaneously, when $v_2 > v_{23}$, the agency recycling platform can engage all inefficient sellers that the GSD recycling platforms cannot attract. In contrast, when $v_2 < v_{23}$, the agency recycling platform provider cannot engage all low-end sellers; therefore, the market may form two competitive models (Figs. 13.11 and 13.12):

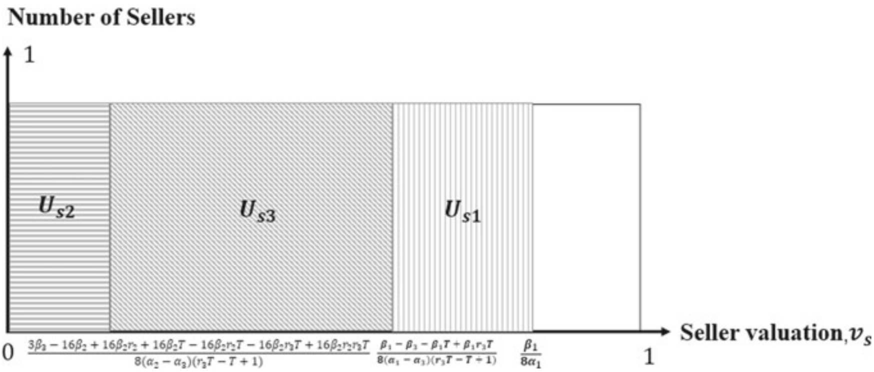

Fig. 13.9 The first situation of the multi-channel competition where three platforms coexist

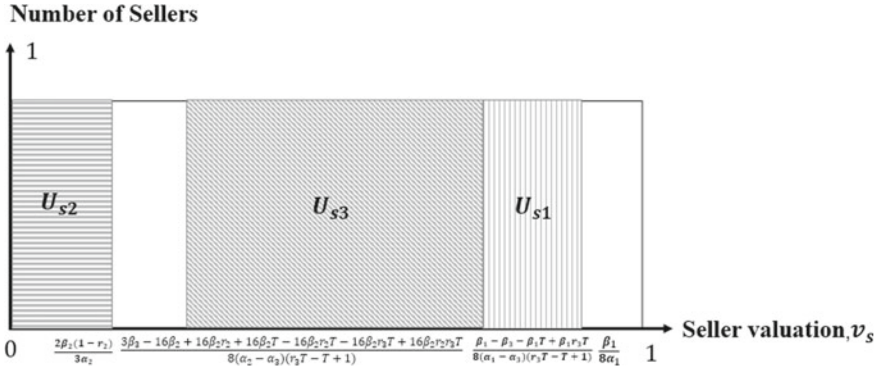

Fig. 13.10 The second situation of the multi-channel competition where three platforms coexist

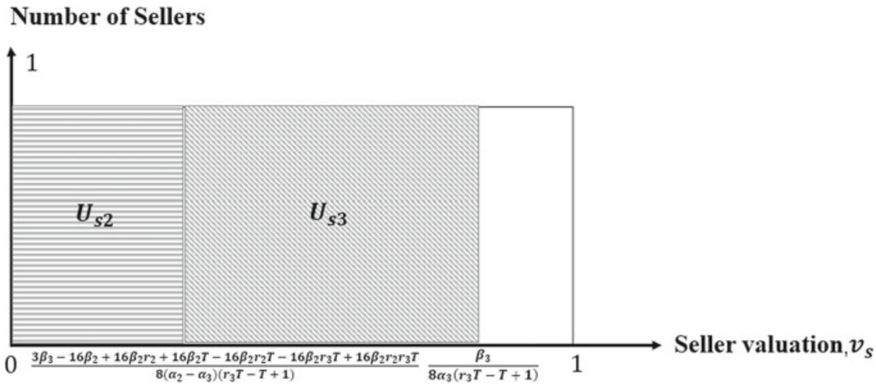

Fig. 13.11 The first situation of the dual-channel competition between the GSD and agency recycling platforms

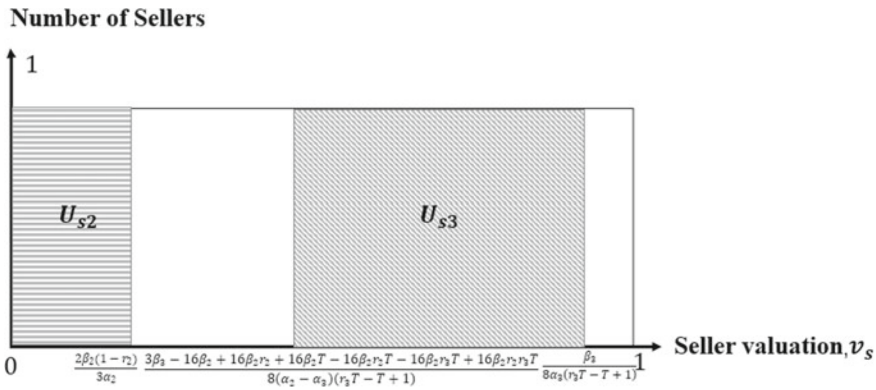

Fig. 13.12 The second situation of the dual-channel competition between the GSD and agency recycling platforms

13.3.4 Analysis and Conclusions

This study first introduces different recycling models, such as the third-party platform conventional, agency, and GSD recycling, into the decision-making of the platform. It studies the pricing behavior adopted by the three models based on their advantages and disadvantages in the online recycling platform of used products. For example, third-party platform conventional recycling reduces the manufacturer's transaction risk, while third-party platform agency recycling increases the probability of high-priced recycling for consumers. Furthermore, this study considers a competitive market environment to explore competition among the three platform recycling models. It differs from previous research on the platform economy in that it uses the concept of two-sided markets to compare the three types of competition. By comparing the three recycling models, we obtain the best decisions for the platform. We also find that these three channels have different competitive advantages in attracting consumers with different preferences or from different market segments.

The main conclusions are as follows:

(1) Third-party platforms that use agency recycling should not attempt to set extremely high agency rates, even if they occupy a near-monopoly position in the market. Doing so could hurt consumers' and manufacturers' willingness to recycle on the platform. However, the agency rate should not be reduced too much; doing so will hurt the profit margin of the platform. The platform should set a modest agency rate to maintain its optimal profits and market share. It should provide more services to help buyers and sellers identify the value of used products more accurately and increase consumer acceptance.

(2) Regardless of which recycling model the third-party platform chooses, the recycling price and the profit of the platform increases with an increase in the manufacturer's willingness to recycle and decreases with a decrease in the consumer's willingness to recycle. This result illustrates the importance of enhancing the bilateral users' willingness to recycle. For example, the platform could develop a more robust quality assessment and pricing system that enables sellers to estimate the quality of their used products more accurately. The platform should also provide buyers with as much product information as possible, to enhance their trust in the information provided. These methods can help the platform increase its price and profit margins.

(3) The implementation of the GSD recycling model is determined by the relationship between the GSD and the agency rate. Within a certain threshold determined by the agency rate, extending the GSD increases the profitability and recovery rate of the recycling platform. For sellers, the GSD model eliminates the risk of failed recycling of used products, and low fees increase the recovery profits. Therefore, the GSD model can be a platform that absorbs more consumers in a competitive market, seizes market share, and further promotes the restructuring of the product recycling value chain.

(4) In a competitive market, the platform can choose more targeted recycling channels based on consumers' willingness to recycle. As previously mentioned,

these three models have different market segments for bilateral users. The new GSD model mainly captures the market share of the conventional and agency recycling models. The conventional recycling model may even be excluded from the used product recycling market. This reflects the competitive advantage of the emerging platform economy in used market recycling and proposes the direction of the value chain reconstruction of Internet recycling enterprises.

Our research has practical implications for recycling platforms that determine their trading model. As discussed in the context of this study, platforms can establish a direct connection between manufacturers and consumers, as consumers increasingly choose to trade their used products on online marketplaces. However, when dealing with consumers with different levels of market acceptance, the same recycling model may not be profitable for third-party platforms. Therefore, a platform's choice of recycling mode requires further research.

13.4 Summary

This chapter mainly studies resource recycling, which is circular in the enterprises' green growth model. Resource recycling is an important element for enterprises to achieve green transformation and growth and an important link in the upgrade and reconstruction of enterprise value chains. The driving forces that promote the implementation of resource recycling and circular economy by enterprises include consumers' environmental protection concepts, government environmental protection rules, Non-Governmental Organizations' environmental protection calls, and the reconstruction and upgrade of the value chain. Combined with the historical context, this chapter builds an online market model. We study the recycling competition of a used product recycling trading platform using a new business, technology, and model of "Internet + green recycling." We propose management insights and suggestions for enterprises to achieve green transformation and value chain reconstruction.

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