Chapter 9
Green Procurement and Outsourcing

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Abstract Procurement and outsourcing are essential links in enterprises' production and operation. They have varying impacts on value chain structures, enterprises' profits, and environmental sustainability. Government environmental regulations and the growing consumer demand for green consumption have prompted enterprises to choose green procurement models. Accordingly, this chapter discusses the relationship between procurement and outsourcing and enterprises' green growth. It analyzes the strategic decision of enterprises to choose direct procurement or procurement outsourcing based on the motivation and risk factors of outsourcing. Following the theoretical analysis, a procurement game model comprising the original equipment manufacturer, contract manufacturer, and suppliers is constructed. The results show that when enterprises choose direct procurement, the wholesale price of suppliers is lower but the processing price is higher than that for outsourcing; when the market scale is small, enterprises opt for direct procurement. Moreover, procurement outsourcing is more environmentally sustainable than direct procurement.

9.1 Relationships Between Procurement, Outsourcing, and Enterprises' Green Growth Model

9.1.1 Procurement and Outsourcing

Procurement is the process whereby a company obtains raw materials, components, products, services, or other resources from suppliers to conduct its business [1]. The effective procurement of goods or services has a significant impact on a company's

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N. Wang et al., *Enterprises' Green Growth Model and Value Chain Reconstruction*,
https://doi.org/10.1007/978-981-19-3991-4_9

competitive advantage. The procurement process connects members of the value chain and ensures its quality of supply. The procurement function is vital to a company because purchased materials or commodities account for a large proportion of the value chain transaction costs [2]. Each unit (l%) reduction in procurement costs can directly contribute to the net profit by one unit (l%); the lower the profit margin, the greater the importance of reducing procurement costs. With increased globalization and advances in information technology, enterprises now have access to an ever-larger supply base for better cost and quality materials. However, the procurement process can be complex and time-consuming because of longer geographic distances, more extensive supply networks, and different geopolitical circumstances. Consequently, many enterprises outsource purchasing activities to agents such as Accenture, Global Sources, and ICG Commerce [3]. Outsourcing implies that an enterprise dynamically configures its functions and services and those of other enterprises and utilizes external resources to facilitate its internal production and operations.

Nike and UNIQLO are well-known clothing enterprises with mature procurement systems. The two companies' production and logistics services are outsourced to professional third-party companies, and the commodity labels generally mention the origin as "made in China" or "made in Vietnam." In contrast, the company itself focuses on product design and brand operation. Unlike Nike and UNIQLO, ZARA, one of the most important fashion companies worldwide, integrates design, production, distribution, and retail through its extensive retail channels. ZARA purchases most of its products from suppliers in more than 50 markets, and more than 50% of its products are made internally or in nearby factories.[1] This production model allows ZARA to respond more quickly to the market sales situation through its factories, modify the manufacturing plan, and realize more effective control. A similar situation exists in the automobile industry as well. China's NIO Automobile outsources its production activities to JAC Automobile.[2] NIO is mainly responsible for key technology research and development (R&D) and brand operation, saving on the substantial fixed costs of building factories. Owing to the low-end brand of the foundry and annual loss of performance, providing foundry services for new energy vehicle manufacturers can achieve a win–win situation for NIO and JAC Automobile. Traditional car manufacturers, such as the BYD Company, have attached importance not only to design but also to manufacturing in establishing their entire industry chain system. BYD grew sales of its "new energy" (hybrid or all-electric) passenger vehicles by more than 231% year over year in 2021, selling nearly 600,000 new energy passenger cars.[3]

Procurement and outsourcing are everyday operational decision-making activities in the global production industry. Enterprises should choose their procurement or outsourcing strategies based on their industry characteristics and competitive advantages.

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[1] https://www.inditex.cn/en/how-we-do-business/our-model/sourcing.

[2] https://seekingalpha.com/article/4429867-nio-vs-li-auto-stock-better-buy.

[3] https://www.fastcompany.com/90724485/most-innovative-companies-transportation-2022.

9.1.2 Green Procurement

Green procurement is an indispensable part of enterprises' green growth model. Unlike ordinary procurement, green procurement requires enterprises to manage all aspects of the value chain's upstream components to maximize coordination for environmental, social, and economic sustainability [4].

(1) Reasons for Enterprises to Implement Green Procurement Strategies

(a) Government Regulations

Green transformation is an essential strategy for achieving sustainable development [5]. To achieve this goal, governments worldwide have implemented environmental regulation systems to encourage enterprises to implement green production methods. The United States was the first country to embark on Government Green Procurement, mainly using federal laws and presidential executive orders as the legal basis for promoting such procurement. For example, the Resource Conservation and Recycling Act (RCRA) was promulgated by the US in 1976.[4] Executive Order 13,101 of the President of the US in 1991 "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition" requires procurement agencies to prioritize the purchase of green products and use of recycled products.[5] In April 2016, the European Commission issued a fully revised version of "Buying Green!—A Handbook" on green public procurement. This Handbook is a guidance document of the European Commission and aims to help public authorities purchase goods and services with less impact on the environment. It is also a useful reference for policy makers and companies responding to green tenders.[6] Although the Chinese government's green procurement started relatively late compared to that of developed countries, the scale of procurement has expanded year by year. With the successive introduction and continuous improvement of government procurement laws and regulations, Chinese government departments at all levels and state-owned enterprises and institutions are expanding the demand-side proportion of green procurement to promote green innovation, transformation, and upgradation of enterprises. In March 2015, China implemented the revised "Government Procurement Law of the People's Republic of China," which stipulates the development goals of protecting the environment, achieving sustainable development and building an ecological civilization. These procurement policies aim to encourage supplier R&D innovation to reduce costs and stimulate private demand for green products [6]. Wang et al. argued that the level of green technology adoption by enterprises is related to the intensity of government regulations [7]. Considering industrial compliance, supervision can promote the development of new green technologies more effectively. However, given fierce market competition, excessive radical supervision would stifle enterprises' green innovation.

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[4] https://www.epa.gov/history/epa-history-resource-conservation-and-recovery-act.

[5] https://www.wbdg.org/ffc/fed/executive-orders/eo-13101.

[6] https://ec.europa.eu/environment/gpp/buying_handbook_en.htm.

(b) Consumers' Green Preferences

Owing to the continuous deterioration of the environment and the promotion of environmental protection by governments or NGOs, an increasing number of consumers are focusing on green consumption; consumers' green preferences are the key market drivers that promote value chain sustainability [8]. According to a global survey by Accenture, more than 80% of respondents consider the greenness of a product when making a purchasing decision; therefore, companies choosing to source green raw materials can enhance their brand image and expand their market share [9]. Consequently, enterprises are motivated to choose green suppliers.

Hong et al. proposed a two-echelon supply chain model comprising manufacturers who design and produce green products and retailers who promote green products. They concluded that with an increase in consumers' green preferences, cooperation between participants can improve supply chain sustainability but is not necessarily optimal for participants [10]. Lin et al. investigated a company's best quality and pricing decisions for its by-products. They found that when green consumers emphasize the material-saving aspects of the product, the company may strategically abandon traditional consumers [11].

(2) Selection and Evaluation of Green Suppliers

Supplier selection is a critical activity in the green procurement process and crucial for reducing procurement costs and risks. Suppliers' technical level, competitive advantage, and corporate culture can affect the final product's performance. He et al. designed a hybrid e-procurement mechanism, which implements a multi-attribute combinatorial auction. They found that compared to the classical Vickrey-Clarke-Groves mechanism, the proposed mechanism improves the transactional social surplus [12]. Koh et al. investigated an auction contest for innovation procurement and showed that it is optimal for buyers to invite multiple companies under high randomness; moreover, fixed-prize tournaments may outperform auctions [13]. However, in the absence of randomness, it is optimal to invite only two companies. He et al. further explored a buyer's optimal procurement mechanism when facing two potential suppliers with capacity constraints and private cost information [14]. Birulin et al. discussed the procurement auction problem for a project with cost overruns after the production cost is affected and stated that the lowest bid auction procurement mechanism can result in an optimal combination of the lowest bid auction and the guaranteed bond to minimize the expected cost [15]. Hosseini et al. first adopted a hybrid BWM-ER method to evaluate and rank suppliers, subsequently proposing a dual-objective mathematical optimization model to address the trade-off between sustainability and economic cost under uncertain demand, capacity, and inventory [16]. Villenade et al. studied the sustainability of extended supply chains by collaborating with a sustainable development electronics company "Tronics." They concluded that having an integrated management system comprising economic, environmental, and social elements or collaborating with a network of key stakeholders of

Chinese suppliers increases the likelihood of adopting sustainable sourcing strategies [17].

In the process of enterprise's green operation, it is necessary to select suitable suppliers and evaluate whether they can bring about an increase in their performance. Aksoy et al. proposed a neural network-based supplier selection and performance evaluation system to help just-in-time production agents select the most suitable suppliers and evaluate supplier performance [18]. Dey et al. proposed the leading factors such as organizational practice, risk management, environmental, and social practice, and lagging factors of supplier evaluation and demonstrated a systematic method of identifying these factors with stakeholder participation [19]. Liu et al. indicated that supplier sustainability is crucial for supply chain sustainability, proposing a fuzzy decision-making tool for supplier sustainability performance evaluation based on TBL and testing its effectiveness in the sustainable agricultural food value chain [20]. Giannakis et al. established a sustainability performance evaluation framework for supplier evaluation and selection using the analytic network process. They found that socioeconomic indicators play the most important role in sustainable supplier selection [21]. In addition, technologies such as blockchain and the Internet of Things are widely used in green procurement activities involving supplier selection, logistics, packaging, and distribution [22]. Evaluating green suppliers is especially important for enterprise procurement and outsourcing decisions. Enterprises may switch from traditional to green procurement models only when the benefits of choosing green suppliers outweigh those of manufacturing outsourcing.

9.1.3 Impact of Procurement and Outsourcing on Enterprises' Green Growth Model

Enterprises' growth model refers to the way that enterprises achieve their goals including increasing sales, maximizing profits, or increasing market share through internal and external expansion. Green growth model requires enterprises to achieve optimal profits and coordinate economic and environmental sustainability. The primary motivation for procurement outsourcing is to improve brand owners' operational efficiency and lower procurement costs, thereby expanding production and increasing corporate profits, which represent the same goals as enterprises' growth. However, the most severe obstacle to the development of business outsourcing is the lack of suitable contract operation mechanisms upstream and downstream of the value chain, which makes it difficult to effectively coordinate the costs, risks, and incomes of the value chain members under procurement outsourcing. This results in the unsustainable operation of enterprises and hinders the formation of green growth model. In addition, the specific path, value chain reconstruction, and integration strategy direction vary across enterprises in the process of green transformation of

the growth model. Procurement and outsourcing choices involve critical decision-making processes, and innovative enterprises face rapid market demand updates that are prone to inventory backlogs. Consequently, enterprises' independent procurement and manufacturing choices may result in redundant inventory production and inventory losses. Most enterprises thus outsource production activities to professional tripartite enterprises to focus on new technologies and product development. Functional products mainly reduce operating costs through economies of scale, enabling enterprises to coordinate through long-term procurement contracts to achieve green growth.

9.2 Procurement and Outsourcing Decisions

Enterprises in different industries adopt flexible procurement or outsourcing strategies in different periods in complex and changeable external environments. For example, as the world's largest chain, Walmart Inc. once relied on the Hong Kong purchasing agent Li & Fung Group to provide comprehensive procurement services. However, in 2015, a Walmart bulletin announced that it would adjust its cooperation with the Li & Fung Group, transferring part of the procurement functions to Walmart's internal departments, but continue to use the Li & Fung Group's other services, such as quality inspection. In the same year, Kate Spade, the US handbag and clothing brand, also announced that their handbags and accessories procurement activities would be carried out by the company from the spring of 2016, with only the clothing component handed over to the Li & Fung Group to cut outsourcing orders.[7] Therefore, in pursuing green and sustainable growth, enterprises must often carry out procurement cost and profit analyses to confirm whether outsourcing is beneficial for enterprises in the long term, which determines whether they should adopt a procurement outsourcing strategy.

This section analyzes the strategic decisions of independent procurement and procurement outsourcing from the perspective of the motivation factors and risks of outsourcing.

[7] https://insideretail.asia/2015/05/27/walmart-reduces-li-fung-reliance-2/.

9.2.1 Motivation for Outsourcing

In enterprise value chain operations, it is necessary to reasonably evaluate the risks and benefits of independent procurement and outsourcing. Enterprises choose to outsource only when it increases customer value or reduces the cost of value chain operations relative to independent procurement. The main motivations for outsourcing are as follows.

(1) Capacity Concentration

Third-party enterprises can improve the value chain's profit by concentrating on the needs of multiple companies and acquiring economies of scale that a single company cannot obtain. Apple Inc. and most other mobile phone manufacturers, such as Xiaomi Corporation and Huawei Company, outsource the assembly and production of mobile phones to the Foxconn Group. Foxconn has incomparable competitive advantage in terms of electronic design and manufacturing. Outsourcing can save costs and improve product competitiveness.

(2) Risk Pooling

Outsourcing may transfer demand uncertainty to contract manufacturers. The advantage of using contract manufacturers is that they can integrate demand from different buyers, thereby reducing demand uncertainty through risk sharing. This further allows them to reduce parts inventories while maintaining or improving service levels. Especially for small and medium-sized enterprises, outsourcing can diversify the risks arising from economic, market, and financial factors through outward resource allocation. As enterprises' procurement resources and capabilities are limited, they can become more flexible and adapt to the changing external environment through the outward allocation of resources and risk sharing with external outsourcing suppliers.

(3) Focus on the Core Competitiveness of Enterprises

By carefully selecting outsourced content, an enterprise can focus on improving its core competencies such as unique talents, skills, and knowledge structures, which set them apart from competitors and can be identified by consumers. Owing to globalization, different countries and regions have diverse comparative advantages that need to be rationally utilized. The key components of electric vehicles are their power batteries. Tesla outsources power batteries to China's CATL, the largest battery manufacturer worldwide. Therefore, Tesla focuses on the power management system design. The final vehicle manufacturing is outsourced to the Tesla Super Factory in Shanghai. This efficient outsourcing model led Tesla's stock market value to exceed $1 trillion in 2021, surpassing the sum of the market values of 11 established automobile companies, including Toyota, Volkswagen, and GM, in the same period.[8]

[8] https://www.cnbc.com/2021/10/25/tesla-stock-passes-1-trillion-market-cap-traders-bet-on-more-gains.html.

(4) Improved Production Flexibility

Outsourcing can better respond to changes in consumer demand and use suppliers' technical expertise to shorten the product R&D cycle. In addition, enterprises can also obtain new technologies and innovation capabilities from suppliers. For example, Xiaomi Corporation, the fastest-growing mobile phone brand in China and the world in recent years, integrates the competitive advantages of suppliers in value chain operations, by combining Samsung's screen, Qualcomm's processor (CPU), and Sony's lens module. Through its contract agreement, Xiaomi Corporation can also obtain the starting privilege of new technologies from suppliers to improve its product demand. Owing to its excellent value chain integration ability, Xiaomi Corporation ranked third worldwide in terms of global smartphone shipments in 2021, below Samsung Electronics and Apple Inc.[9]

9.2.2 Outsourcing Risks

The uncertainty of the environment and conditions of outsourcing activities and the influencing factors that outsourcing stakeholders cannot accurately predict or control affect the operations of enterprises. Despite the many advantages of outsourcing, enterprises must realize the necessity of accounting for risk measures in outsourcing decisions. The following are the five common risk factors for outsourcing activities.

(1) Decision-Making Risks

Decision-making risks stem from two aspects. First, when making outsourcing decisions, enterprises must define which projects or functions are suitable for outsourcing, that is, the technologies that constitute their core competitiveness and those that are non-core technologies. If the selection of outsourcing projects is inappropriate, outsourcing may not achieve the expected goals and may even threaten the business security of the enterprise. Second, enterprises inevitably face supplier selection problems when conducting outsourcing activities. According to the theory of information economics, a "principal-agent" relationship is formed between enterprises and outsourcing service providers in service outsourcing. Owing to information asymmetry in the industry, companies cannot truly understand outsourcing service providers' business performance, social reputation, development status, cost structure, and other information, rendering them unable to accurately screen suitable service providers before outsourcing.

(2) Disclosure Risks

In the process of outsourcing cooperation, enterprises must disclose a large amount of information to service providers, including enterprise strategy, business indicators,

[9] https://omdia.tech.informa.com/pr/2022-feb/omdia-research-shows-galaxy-a12-is-the-most-shipped-smartphone-in-2021.

and patented technology, of which a considerable part forms the business secrets of the enterprise. As the enterprise's information is widely transmitted, the "infidelity" of outsourcing service providers may lead to the loss of enterprise information resources and disclosure of core technologies and trade secrets. For example, with the development of information technology, the financial business has gradually transformed into an information management business. Financial institutions are increasing their investments in information technology systems, considering customer demand, competitive pressure, and cost-effectiveness. Security vulnerabilities exist in outsourcing services provided by information security system providers to financial institutions. These security loopholes can easily lead to leakage, loss, and damage to customers' personal information and even to corporate reputation and legal risks, causing financial institutions and consumers to suffer substantial economic losses.

(3) Contract Risks

An outsourcing contract is an agreement between an enterprise and a third party without an affiliated relationship. The term validity of outsourcing contracts is usually five to ten years, which is a long period. It is difficult to accurately predict business needs and environmental changes during this period. Therefore, whether the outsourcing provider can complete the agreed tasks in time and while maintaining quality is uncertain. As the world's second-largest electronics manufacturing service (EMS) provider after Foxconn, the Flextronics group announced the cessation of cooperation with Huawei in May 2021 and retained Huawei's equipment and materials worth hundreds of millions of dollars because the US Department of Commerce's Bureau of Industry and Security (BIS) listed Huawei on their "entity list" and prohibited US enterprises from selling relevant technologies and products to Huawei.[10] The termination of cooperation temporarily halted Huawei's production. Businesses originally contracted by Flextronics, including Huawei's mobile phones, notebooks, tablets, and telecommunications base stations, were gradually undertaken by Chinese domestic manufacturers.

(4) Disruption Risks

With the continuous development of the global value chain, several uncertain factors inside and outside the value chain make enterprises vulnerable to disruption. The rise of offshore outsourcing has allowed multinational enterprises to enjoy the diverse comparative advantages of other regions fully. However, the long-distance industrial chain makes it difficult for enterprises to control their production and operations. Once a disruption occurs, the transmission of time and distance leads the enterprise into operational difficulties and even bankruptcy because of interrupted cash flow. Chakraborty et al. analyzed the impact of the COVID-19 pandemic on the textile industry by considering the Bangladeshi garment-manufacturing industry as a case study [23]. They concluded that the disruption of raw materials caused by the

[10] https://www.gizchina.com/2019/07/26/huawei-cut-ties-with-flextronics-for-seizing-its-equipment-worth-over-100-million/.

COVID-19 pandemic has led to a sharp increase in the production costs of clothing manufacturers, affecting clothing exports and global textile sales.

(5) Conflict of Interest Risks

Although there is a strategic partnership between outsourcing enterprises and service providers, they are two separate legal entities that seek to maximize their interests. Therefore, in real life, enterprises outsource to service providers to provide more services and reduce costs. In contrast, outsourcing service providers want to increase costs and reduce business requirements, which results in a mutual conflict of interest. In addition, because outsourcing service providers also have the technology and ability to produce similar products, enterprises' profits are likely to suffer if outsourcing service providers use their brands to compete for a market share. Niu et al. analyzed the price competition game model of original equipment manufacturers (OEMs) and their competitive original design manufacturers (ODMs). They concluded that different market environments and pricing sequences have other effects on enterprises' cooperation and competition status [24].

In conclusion, risks and benefits are interrelated. In the face of uncertain outsourcing risks, enterprises must choose outsourcing companies reasonably, sign service agreements, and introduce tripartite institutional supervision or real-time feedback mechanisms to achieve the goal of green growth.

9.2.3 Procurement Outsourcing

Choosing whether to outsource a specific set of activities or business functions is one of the most critical strategic decisions faced by companies [25]. Companies tend to outsource operations that do not have core competitive advantages in the contemporary business environment. The most discussed themes in academia and industry are procurement outsourcing. Procurement requires enterprises to fully control all purchase processes, including supplier selection, evaluation, and purchases. Fully controlled procurement can help enterprises protect core technology and better control quality, leading to stronger resilience of enterprise value chains in the face of upstream and downstream uncertainty. Procurement outsourcing means that enterprises outsource procurement functions to third-party companies. Kayis et al. found that when the supplier's production cost is private information, procurement outsourcing may be better than direct procurement if there are two layers of information distortion [26]. Wang et al. compared two outsourcing structures under three contracts: push, pull, and two-wholesale-price, and found that OEMs prefer control over the delegation structure, regardless of the type of contract [27]. Bolandifar et al. discussed the optimal component procurement strategies of two competing OEMs. They demonstrated that a larger OEM always uses delegation in equilibrium under a strategic supplier, whereas a smaller OEM may use either delegation or control [28].

In addition, consumers' green preferences and government regulations are the main factors affecting corporate procurement and outsourcing decisions. Consumers'

increasing awareness of green environmental protection urges enterprises to choose green suppliers and adopt green technologies to expand the market for their products. The government's environmental pollution regulations and green technology subsidies can also guide companies to optimize production processes, choose technical routes, and achieve the goal of green growth.

These decisions are based on a relatively stable external environment. However, as the global geopolitical situation becomes increasingly tense, tariff disputes and trade protectionism are spreading worldwide. Many multinational companies are facing unprecedented challenges in international supply, and the continuously increasing tariff costs have attracted the attention of corporate management. For the daily operation of international trade services, such as the classification of customs goods, the applicable conditions of preferential measures such as free trade agreements, and import and export compliance, these tasks are complex but crucial to controlling enterprise operating costs. The successful performance of these tasks requires companies to equip different regions of the global network with various professional skills and information systems. Therefore, outsourcing such businesses to a professional third party can significantly improve the efficiency of the enterprise. However, if the anti-globalization trend intensifies, multinational companies should seriously consider the location of suppliers, strive to increase the proportion of local production, and balance direct procurement and offshore outsourcing.

9.3 Strategic Decisions of Direct Procurement and Procurement Outsourcing

9.3.1 Introduction

Owing to the intensification of government environmental regulations, enhancement of consumers' awareness of green environmental protection, and development of innovative green technologies, an increasing number of OEMs are actively developing green products or cooperating with suppliers using green raw materials to capture the green consumer market. Improvements in green technology promote the enterprises' brand image, augmenting market demand and product sales. The garment-manufacturing industry is closely related to procurement and outsourcing. As the second-largest industry globally, the garment industry is also the second-largest polluter worldwide, second only to the petrochemical industry. For every ton of textile product, 200 tons of water are polluted; for every kilogram of cloth produced, 23 kg of carbon dioxide are emitted. Furthermore, approximately 2500 chemicals, including harmful heavy metals and some unknown persistent organic pollutants, are used in the dyeing and finishing processes of different textiles. However, the diversity of clothing products leads to apparent demand uncertainty. In the face of volatile market demand, brands often order more clothing than there

is actual demand for to ensure supply. Excessive order quantities lead to the overproduction of upstream manufacturers and may result in excess inventory owing to brands' low actual demand, thereby undermining the sustainability of the value chain. Therefore, designing reasonable procurement and outsourcing strategies can alleviate the environmental damage caused by garment manufacturing and achieve the goal of green enterprise growth.

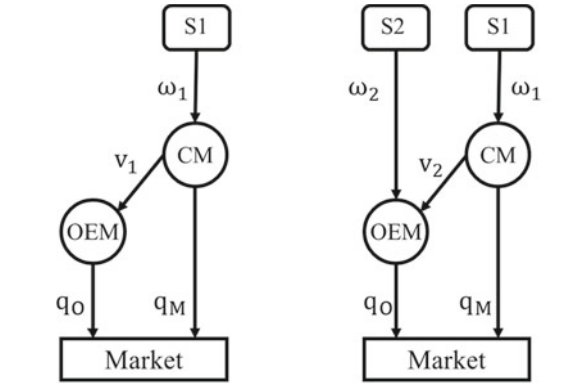
Nike has no manufacturing plants but chooses to outsource the work to contractors in the China, Philippines, Vietnam and Indonesia. Nike relies on Daphne to purchase upstream raw materials for sports shoes and outsources processing and manufacturing services to Daphne in the Chinese market. Simultaneously, Daphne sells its footwear brand in the market, forming a competitive and cooperative relationship with Nike [29]. In addition, Nike sometimes purchases its raw materials and tends to use green, renewable, and environmentally friendly materials, which are generally more expensive than ordinary materials. When enterprises adopt green technology to obtain greater market share, their sales volume will also increase. Because environmental pollution is often positively correlated with output, the increase in sales may be contrary to the goal of sustainable development. Therefore, the impact of green procurement on the coordination of environmental and economic sustainability requires rigorous theoretical analysis and practical summary. Combined with the actual situation, this section mainly focuses on the decision-making of direct procurement and procurement outsourcing in the operation of enterprises, analyzes the sustainability of the economy and environment under the two modes, and provides a reference for business decision-making.

9.3.2 Mathematical Modeling

This section establishes a simple game model to describe the decision-making process of direct procurement and procurement outsourcing in enterprise operations. Consider a three-tier supply chain comprising a component supplier, a contract manufacturer (CM), and an OEM. The CM is a professional manufacturer. The OEM (denoted as O) has no production capacity but can choose to purchase raw materials to meet green standards or hand over all production and procurement to the CM (denoted as M). Simultaneously, because of its ability to integrate the entire industry chain, the CM can also sell its own branded goods and compete with the OEM in the downstream market. Therefore, this section divides the procurement model into two structures:

(a) Procurement Outsourcing

The OEM outsources all procurement and manufacturing activities to the CM. The CM purchases raw materials from the upstream supplier S1 at a unit wholesale price



(a) Procurement Outsourcing (b) Direct Procurement

Fig. 9.1 Illustration of two procurement structures

of ω_1. The raw materials can be used for itself and for the OEM. Finally, the OEM buys the finished products from the CM at unit price v_1.

(b) Direct Procurement

To meet the requirements of government environmental regulations or consumers' green preferences, the OEM purchases green raw materials and entrusts them to the CM for processing. The unit purchase cost of raw materials independently purchased by the OEM from upstream green suppliers is ω_2, and the processing cost paid by the OEM to the CM is v_2.

The structure of the model is shown in Fig. 9.1.

The sequence of events is described as follows:

In the first stage of the game, the OEM chooses its procurement strategy. In the second stage, upstream suppliers set the unit wholesale price of their components or materials. It is worth noting that if the OEM chooses direct procurement, the two suppliers set their unit wholesale prices simultaneously. In the third stage, the CM decides the processing cost or the price of finished products, and the OEM and CM engage in quantity competition in the same market.

The firm faces a typical linear inverse demand function given by [30]

$$p_i = a - q_i - b_i q_j,$$

where p_i represents selling price of the firm i, $i, j \in \{M, O\}, i \neq j$; q_i and q_j are the selling quantities for the end market. The above inverse demand function can be derived from utility functions that are quadratic in product quantities. Specifically, parameter b_i represents the cross-effect of the change in firm i's product demand caused by a change in that of firm j. This can also represent the substitutability of the OEM's and CM's products. Without loss of generality, we assume that the OEM's products can completely replace the CM's products; however, the reverse is not true [31]. Therefore, $b_M = 1$, and $b_O = b \leq 1$. The total market potential of the CM is a.

The OEM is a strong-brand firm, and it continues to invest in green technologies and products. Therefore, the OEM can improve the consumers' willingness to pay for its products. We assume that the total market potential of the OEM is $(\theta + 1)a, \theta \in [0, \overline{\theta})$; note that $\theta < \overline{\theta} = \frac{48-26b+3b^2}{2(22-7b)}$ to guarantee all players positive profits. The marginal manufacturing cost of the CM is standardized to zero. To summarize, the inverse demand functions of the OEM and CM are

$$p_O = (1+\theta)a - q_O - bq_M$$
$$p_M = a - q_O - q_M$$

The objective function of the decision maker is as follows:

(1) Procurement Outsourcing

$$\pi_O^a = (p_O - v_1)q_O$$
$$\pi_M^a = (p_M - \omega_1)q_M + (v_1 - \omega_1)q_O$$
$$\pi_{S1}^a = \omega_1(q_O + q_M)$$

(2) Direct Procurement

$$\pi_O^b = (p_O - \omega_2 - v_2)q_O$$
$$\pi_M^b = (p_M - \omega_1)q_M + v_2 q_O$$
$$\pi_{S1}^b = \omega_1 q_M$$
$$\pi_{S2}^b = \omega_2 q_O$$

9.3.3 Model Analysis and Conclusions

Using backward induction, the game equilibrium results for the OEM and CM are as follows:

(1) Equilibrium Outcomes Under Procurement Outsourcing

Sales quantities:

$$q_O^a = \frac{a\left(8 - 11b + 3b^2 + (30 - 10b)\theta\right)}{2(7-2b)(8-3b)},\ q_M^a = \frac{a\left(48 - 26b + 3b^2 - (44 - 14b)\theta\right)}{4(7-2b)(8-3b)}$$

Profits:

$$\pi_O^a = \frac{a^2\left(8 - 11b + 3b^2 + (30 - 10b)\theta\right)^2}{4(8-3b)^2(7-2b)^2}$$

$$\pi_M^a = \frac{a^2\left[\begin{array}{l}\left(512-640b+328b^2-84b^3+9b^4\right)+\left(256-672b+376b^2-60b^3\right)\theta \\ \quad +\left(928-608b+100b^2\right)\theta^2\end{array}\right]}{16(8-3b)^2(7-2b)}$$

Unit manufacturing price:

$$v_1^a = \frac{a\left(192-152b+38b^2-3b^3+\left(104-64b+10b^2\right)\theta\right)}{4(7-2b)(8-3b)}$$

Unit material wholesale price:

$$\omega_1^a = \frac{a(8-3b+2\theta)}{16-6b}$$

(2) Equilibrium Outcomes Under Direct Procurement

Sales quantities:

$$q_O^b = \frac{a\left(22-13b+b^2+(30-6b)\theta\right)}{(7-2b)(31-5b)},\ q_M^b = \frac{a(8-b)(13-3b-2\theta)}{2(7-2b)(31-5b)}$$

Profits:

$$\pi_O^b = \frac{a^2\left(22-13b+b^2+(30-6b)\theta\right)^2}{(31-5b)^2(7-2b)^2}$$

$$\pi_M^b = \frac{a^2\left[\begin{array}{l}2752-1724b+385b^2-34b^3+b^4+\left(1824-1244b+232b^2-12b^3\right)\theta \\ \quad +\left(928-368b+36b^2\right)\theta^2\end{array}\right]}{4(31-5b)^2(7-2b)}$$

Unit manufacturing price:

$$v_2^b = \frac{a\left(192-111b+20b^2-b^3+\left(104-52b+6b^2\right)\theta\right)}{2(7-2b)(31-5b)}$$

Unit material wholesale prices:

$$\omega_2^b = \frac{a\left(22-13b+b^2+(30-6b)\theta\right)}{62-10b},\ \omega_1^b = \frac{a(13-3b-2\theta)}{31-5b}$$

From the above analysis of sales quantities, unit wholesale raw material prices, unit manufacturing prices, and profits, we can draw the following conclusions:

(1) In equilibrium, the CM lowers the wholesale price from supplier S1 under direct procurement, regardless of any values of θ and b, that is, $\omega_1^b < \omega_1^a$. In addition,

during $0 \leq \theta < \frac{72+37b-32b^2+3b^3}{2(89-64b+9b^2)}$, the OEM also lowers the wholesale price from supplier S2, that is, $\omega_2^b < \omega_1^a$. This conclusion shows that, under procurement outsourcing conditions, the wholesale prices of raw materials are always high, even if the CM orders larger quantities from supplier S1. When procurement outsourcing occurs, there is only one monopoly supplier S1, which allows it to charge a higher monopoly price, thus affecting the CM. Through further analysis, we can obtain $\omega_2^b > \omega_1^a$, when $\frac{72+37b-32b^2+3b^3}{2(89-64b+9b^2)} < \theta < \frac{48-26b+3b^2}{2(22-7b)}$. Product substitutability and market size can affect wholesale prices; therefore, the OEM can design products with different properties to avoid high purchase prices when outsourcing. This conclusion also implies that more OEMs tend to purchase independently.

(2) When $0 < \theta < \min\left\{\frac{(8-3b)(74+14b-21b^2+3b^3)}{2(346-330b+91b^2-7b^3)}, \overline{\theta}\right\}$, the unit manufacturing price of direct procurement is higher than that of procurement outsourcing, i.e., $v_2^b > v_1^a - \omega_1^a$. Note that only when b is sufficiently small, $\frac{(8-3b)(74+14b-21b^2+3b^3)}{2(346-330b+91b^2-7b^3)} < \overline{\theta}$. That means that inequality $v_2^b > v_1^a - \omega_1^a$ is always true in general. The result shows that in the case of direct procurement, the CM can only charge processing fees. To generate more profits, the CM can only charge higher manufacturing prices. Therefore, to improve the OEM's procurement outsourcing motivation, the CM can choose to reduce processing costs. In a real-world context, enterprises focusing on brand operations, such as Nike and Adidas, outsource all production and procurement activities to professional manufacturing plants to play to their unique advantages. Foxconn Group works for Apple's mobile phone business, charging only $5 per assembly fee. Through low-cost processing, it is also objectively profitable to obtain hundreds of millions of orders per year for Apple's mobile phones, thereby leading to a win–win situation.

(3) The processing price charged by the CM is an increasing function of OEM's market potential, and the growth rate of direct procurement is lower than that of outsourcing i.e., $\frac{\partial(v_1^a-\omega_1^a)}{\partial\theta} > \frac{\partial v_2^b}{\partial\theta} > 0$. This shows that huge OEM's market potential expands the flexibility of pricing. The CM is the only manufacturer in the market. In the direct procurement mode, the CM mainly charges processing fees from OEM orders, whereas the CM can benefit from manufacturing and procurement services in procurement outsourcing. As the wholesale price of raw materials increases, the CM is motivated to charge higher manufacturing prices.

(4) The sales quantities of the CM under direct procurement are greater than those under procurement outsourcing. In the case of direct procurement, the existence of an alternative supplier S2 significantly weakens the pricing ability of S1. Supplier S1 loses an upstream monopoly; therefore, raw material suppliers can only reduce wholesale prices. Thus, the CM orders more at low prices. This shows that although the OEM's direct procurement strategy can control the

source of raw materials, it may face the risk of increasing downstream market competition.

The above concerns sales and wholesale price analyses. However, enterprises are often more concerned about total profits. By comparing the profits of the OEM and CM under the two structures, we obtain:

(5) When $\theta \in \left(0, \frac{104+41b-54b^2+9b^3}{450-184b+14b^2}\right)$, the OEM tends to engage in direct procurement, and when $\theta \in \left(\frac{104+41b-54b^2+9b^3}{450-184b+14b^2}, \overline{\theta}\right)$, the OEM tends to outsource procurement. This result shows that larger market size does not imply higher profits. Only when θ is relatively small will the OEM choose direct procurement. A larger θ will lead to higher manufacturing and wholesale raw material prices, which offset the competitive benefits of new suppliers. Therefore, when choosing direct procurement or outsourcing procurement decisions, enterprises should reasonably evaluate factors such as market size and raw material prices and comprehensively consider choosing appropriate procurement modes.

The above research mainly analyzes the economic goals of enterprises. However, as government and people's awareness of environmental protection increases, enterprises should pay more attention to environmental sustainability. Referring to Krass et al. [32], we use the environmental impact (EI) index to measure environmental sustainability. Practice shows that the number of products is closely related to production, resource consumption, waste, and pollution such as packaging. Under the conditions of direct procurement and procurement outsourcing, if the OEM makes additional efforts to make products green, the pollution generated by each unit product is less, that is, $n_O < n_M$. For simplicity, we normalize n_M to 1; therefore, $n_O = 1 - e$, $e \in (0, 1)$. Therefore, $EI = (1 - e)q_0 + q_M$. Finally, we draw the following conclusions 6.

(6) The environmental sustainability of procurement outsourcing is always better than that of direct procurement; that is,

$$EI^a = (1 - e)q_O^a + q_M^a < EI^b = (1 - e)q_O^b + q_M^b$$

Combined with Conclusion 5, when θ is in a small range, the OEM tends to shift from procurement outsourcing to direct procurement, which reduces environmental sustainability. For both economic and environmental development, the government can appropriately subsidize enterprises to encourage them to outsource manufacturing or introduce new technologies to reduce the pollution of unit products.

9.4 Summary

The procurement process is a critical step in connecting the value chain members and ensuring the supply quality of the value chain. The key to the procurement decision

is to decide whether to engage in direct procurement or procurement outsourcing. Procurement outsourcing can improve enterprises' operational efficiency and reduce procurement costs, thereby expanding production and increasing profit. Direct procurement can meet the green preferences of consumers and the requirements of government environmental regulation because the firm can choose more environmentally friendly suppliers. OEMs choosing the direct procurement mode can reduce the wholesale price of suppliers; however, the processing price paid is higher than that of procurement outsourcing. For CMs, an increase in OEM's market potential can increase the processing price; when OEMs choose direct procurement, CMs can sell more products. Regardless of market size, the sustainability of procurement outsourcing is better than that of direct procurement. Therefore, the government should provide subsidies for enterprises or implement environmental regulation measures to encourage enterprises to choose greener growth models. To summarize, this chapter analyzes the advantages and risks of outsourcing. It establishes a model comprising OEMs, CMs, and suppliers, which provides recommendations for enterprise procurement or outsourcing decision-making.

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