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Industry Chain Straw: Concept and Cases

Zilan Xu, Honglin Xie, Feitong Liu and Xinyi Li

School of Economics, Hefei University of Technology, Hefei 230601, China

Abstract

As a predominantly agricultural country, China is rich in crop straw resources. By designing the industrial chain straw, the comprehensive utilization of crop straw resources can promote, which is significant for reducing environmental pollution, increasing farmers' income, promoting a green economy, and sustainable agricultural development. Based on the classic four conceptual dimensions of the industrial chain, this paper further analyzes the industrial chain straw, summarizes the main characteristics of the industrial chain straw, and analyzes the reasons for its formation. At the same time, this article introduces the relevant use status and advantages of straw in the energy, chemistry, and building materials industry chain in detail.

Keywords

Industrial Chain Straw; Comprehensive Utilization; Characteristics; Case Analysis.

1. Theoretical Basis

1.1. Industry Chain

Adam Smith's *The Wealth of Nations* described theories about the industrial chain as "industrial production is a series of roundabout chains of production based on the division of labor"([1] Wei Ran, 2010). Hirschman's Economic Development Strategy interpreted the industrial chain's relevant ideas as a *correlation effect*. These early studies only came into being the embryos of industrial chain thoughts. It was not until 1985 that the industrial chain, as a proprietary economic concept, was proposed by Yao Qiyuan et al. ([2] Zhang Haizhou et al., 2020).

With the continuous advancement of modern economics research, scholars gradually defined the industrial chain as a relatively macro concept in industrial economics. Its essence is to describe a cluster enterprises structure with certain internal connections. People interpret the concept of industrial chain from a narrow and broad sense. It only refers to the linked structure of economic activities, economic processes, production stages, or brokerage business from the narrow sense. In contrast, in the broad sense, the concept includes the combination of four dimensions in the industrial chain: value chain, enterprise chain, supply and demand chain, and spatial chain ([3] Wu Jinming and Shao Chang, 2006). This series of chains' interconnection and mutual influence form the complex industrial chain.

1.2. Industry Chain Straw

As a major agricultural country, China has abundant crop straw resources. Designing the straw industry chain can promote the comprehensive utilization of straw resources, which is also of great significance for reducing environmental pollution, increasing farmers' income, and promoting the sustainable development of the green economy and agriculture.

The traditional straw industry chain mainly comprises four parts: straw recycling, feed processing, farming, organic fertilizer returning to the field. Since each link is dependent on the delivery of the product, a parallel combination of straw products forms between them. With the improvement of the technology and the demand for green products in the urbanization process, the new utilization direction of the straw industry chain has been vigorously developed, such

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as fertilizer, fuel, and base material, and extracting straw can make more uses. Then energy industry chain, delicate chemical industry chain, and building materials industry chain has been derived.

2. Theoretical Analysis of Industry Chain Straw

2.1. Connotation

This section will further analyze the industry chain straw with the help of the four classic conceptual dimensions of the industrial chain: "value chain, enterprise chain, supply and demand chain, and space chain ([2] Zhang Haizhou et al., 2020)" to reveal its theoretical connotation.

2.1.1. Value Chain

The value chain is the empowerment of the straw industry. The value chain of the straw industry chain manifests as straw recycling business activities carried out by related node enterprises with the same theme, different contents, and related experience, which start from the entire industry chain. It realizes the continuous value-added process of the entire industry chain in the agricultural dimension. Besides, the value chain may overlap with others in enterprises, spaces, products, services, and links.

2.1.2. Enterprise Chain

Enterprise chain is the integration of production and agriculture. These enterprises are all the product providers in the industrial chain straw. The common feature of such enterprises is the integration of production and agriculture. They rely on resources and environment, facilities and equipment, production processes, Etc., to activate these elements' potential reuse function through technical means, and realize the agricultural value creation of the original industry chain in the way of production and agriculture integration.

2.1.3. Supply and Demand Chain

In the straw industry chain, environmental protection is the purpose of governments at all levels. Shared prosperity and rural revitalization are the expectations of straw suppliers. The supply and demand chain mainly refers to various environmental protection activities, goods, and services provided in the straw industry chain.

2.1.4. Spatial Chain

A spatial chain means that the line should be reachable. Dominated by factors such as the geographical distribution of agriculture, the accessibility of the enterprise chain, and the degree of connection, the spatial chain is the coupling of supply and demand in space. It requires that the spatial distribution of the core links of the industrial chain should be within the reachable space of the enterprise utilization line.

2.2. Main Features of Industry Chain Straw

As one of the industrial chains, the characteristics of industry chain straw mainly include integrity, hierarchy, and directivity.

2.2.1. Integrity

The constituent unit of the industry chain straw is a collection of economic activities related to each other. The completeness reflects in three aspects: first, the completeness of the straw industry structure, which reflects in the processing and sales in the internal structure. The second is the integrity of the complementary level within the straw industry chain, which focuses on the degree of production resources self-sufficiency, the circulation system, the ability to inspect the quality of processed products. The third is the completeness of the support and guarantee ability of the straw industry chain, mainly measured from five aspects: funding,

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support of scientific research personnel, legal and policy guarantee, training, and brand building.

2.2.2. Hierarchy

The social division of labor causes the formation of the industrial chain, which is the expression of the processing depth of straw resources. The efficient straw utilization industrial chain is straw recovery, feed processing, aquaculture, organic fertilizer returning to the field ([4] Ran & Wei, 2021). From straw recovery to processing, and then to secondary utilization, the more the chain moves down, the more pronounced the capital-intensiveness and technology-intensive is; the more upward it moves, the more pronounced the labor-intensive and resource-intensive is. At the same time, the hierarchy reflects in the regional aspect. The processing at the lower end of the chainring concentrates in developed areas, and it is engaged in the deep processing of straw products. However, the steps at the upper level of the chain-link require low technology skills but high in the labor force, so the processing of these steps is mainly concentrated in underdeveloped areas, mainly engaged in labor-intensive economic activities such as resource exploitation.

2.2.3. Directivity

An enterprise's competitive advantage comes from heterogeneous resources owned and controlled by the enterprise, valuable, scarce, irreplaceable, and difficult to imitate ([5] Liu, 2009). The straw industrial ring needs to be spatially oriented to minimize the necessary input, making it inevitably concentrated or scattered in different economic areas. This spatial orientation mainly includes a. *Resource endowment directivity*. Enterprises and processors have to recycle raw materials and consider the cost, and then they will choose the best space location which can achieve their goal. It shows spatial dispersion and pronounced directivity due to the uneven distribution of resources in various regions. b. *Directivity of the division of labor area.* The geographical division of labor resources makes each region have its professional production direction. Straw industrial chains have the characteristics of pursuing the benefits of the professional division of labor, which determines that they will not produce in only one place. c. *Directionality of region traditional economic activities.* Region traditional economic activities usually embody region-specific resource endowments and regional economic characteristics. Due to cultural and historical reasons, the path of relevant economic activities depends on others.

2.3. Reasons for the Formation of Industry Chain Straw

2.3.1. Industrial Endogenous Development Demands

The total output of crop straw in China shows an increasing trend, and the comprehensive utilization of straw is an important measure to promote the environmental-friendly development of agriculture. At present, the annual output of straw in China has reached more than 900 million tons, and the total utilization rate has reached more than 82%. The comprehensive utilization pattern of straw has taken shape: fertilizer is the primary method, feed and fueling promote steadily. Base materialization and raw materialization are auxiliary. However, compared to developed countries, China's comprehensive utilization of straw is still in its infancy, with a low degree of industrialization and a relatively weak technical foundation. Therefore, forming an efficient and complete industrial chain is bound to be conducive to the deep development of the straw industry.

2.3.2. Upstream and Downstream Industrial Linkage Development

The utilization of straw is related to the planting industry in the upward direction and the breeding industry in the downward direction. Meanwhile, it radiates to drive the agricultural products processing industry. The development of the upper reaches of the straw industry is directly related to the production cost of the straw industry, which indirectly affects the

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development of the straw market. The demand situation of the downstream straw industry is closely related to the development space of the straw market, which affects the market price and market demand of straw industry products. The demand status of the straw downstream industry is closely related to the development space of the straw market, which affects the market price and market demand of straw industry products. The straw industry's development prospect and status are closely related to it. Straw is not only raw material but also fuel. It relates to production, life, and ecology. It is an important way for farmers to increase their income and employment.

2.3.3. Technological Innovation Leads to the Development

At present, the straw collection, storage, and transportation service system are still in their infancy. There are many phenomena such as complex to harvest, challenging to store, and difficult to store and transport. It indicates that the innovation in the straw industry chain lies in the research and promotion of new technologies and methods for comprehensive utilization of straw. In promoting the comprehensive utilization of straw, the further strengthening of scientific and the continuous expansion of technology application are injecting new vitality into ecological agriculture while ensuring the sustainable development of the straw industry chain.

2.3.4. Government Policies Support Development

The Central Committee of the Communist Party of China requires expanding the scale of straw, returning to the field, and encouraging advanced technology development to seek the comprehensive utilization of straw with high efficiency. In the past 15 years, the Chinese government has issued nearly 40 relevant documents emphasizing the comprehensive utilization of straw and other issues. The Central Committee of the Communist Party of China requires expanding the scale of straw, returning to the field, and encouraging advanced technology development to seek the comprehensive utilization of straw with high efficiency. The support policies of governments at all levels have further promoted the formation and development of industrial chain straw.

3. Case Study

3.1. Energy-based Industrial Chain

Biomass energy is an integral part of the future energy structure which will be economically developed. As a crop by-product, crop straw contains many cellulose and biomass energy resources. Its industrial chain is of strategic importance to drive the development of China's agricultural handicraft industry at this stage ([6] Liu Tongli, 2020). Due to the limitation of technical cost and other constraints, rough utilization is the leading way of straw's energy-based utilization. In contrast, the comprehensive utilization mode is minor. The energy-based industrial chain can divide the different straw raw materials utilizing ways into two main paths: fueling or raw materialization.

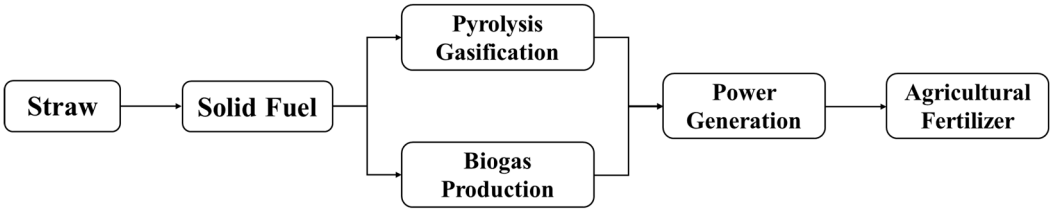

Fig 1. Straw fueling industry chain

Fueling produces solid fuel as the starting point and uses the gas from combustion or fermentation for power generation through straw pyrolysis gasification or biogas production.

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At the same time, the products of straw combustion or fermentation will be used secondarily as agricultural fertilizer after simple processing. It can replenish the soil with potassium, and organic matter can also improve soil quality. According to this industry chain, straw can achieve a great degree of energy utilization combined with several technologies.

Using a straw to make paper and composite material processing are the ways to straw raw materialization. Many industrial production chains using straw as raw material have been derived, promoting social employment while making full use of straw resources. Meanwhile, straw can also become tea. Straw can be consumed as dry tea after the screening, cleaning, and drying, which promotes the development of agriculture and tertiary industry, also the whole industrial chain.

Currently, the raw material market for the straw energy industry chain is relatively abundant. As a large population and agricultural country, China's mass production produces a large amount of agricultural waste, and straw is one of them, which provides sufficient raw materials for the raw material market. However, due to the limitations of cost, technology, human capital, and production equipment, the primary use of straw energy is relatively single, the industrial chain expanding direction is limited, and the development of the product market is relatively slow. However, the consumer market of straw energy is developing rapidly. With the acceleration of China's industrialization, straw energy occupies a place in the fuel market by its renewable, low sulfur content, and other characteristics. Various products produced by straw as raw materials also stand firm in the product market because of low carbon environmental protection, sustainability, and other advantages. The consumption market of the straw energy industry chain has a broad prospect.

3.2. Straw Fine Chemicals

The straw chemical industry chain is still in its infancy, and the development of chemicals is still in the stage of laboratory research. The vast majority of the chemical components' extraction is still in the exploration and process pre-development stage, also the related emerging materials' development. Researchers only put a few technologies into the factory for experiments. The research in this area focuses on the chemical composition of rice straw and sesame straw.

In the upstream of the straw, the chemical industry chains are mainly companies that collect and store straws and carry out simple chemical treatment work, i.e., raw material production companies. The total annual average production of straws such as rice, wheat, and corn stalks in China's major grain crop cultivation regions is 230 million *t*, 170 million *t*, and 390 million *t*, respectively ([7] Chai, R., 2019). Straw harvesting and storage companies also packaging material manufacturers are upstream of the straw chemical industry chain.

There are large-scale branches in the middle of the straw chemicals industry chain, mainly scientific research companies. Most of them have high technology content that processes straw at different levels, such as straw return and composting, straw to energy, and straw to board making ([8] Song Zhanqian, 2015). Take sesame as an example, sesame can produce millions of tons of straw every year, more than 50% of the waste gas and impurities are extracted from it by sodium hydroxide, and 47% of the comprehensive cellulose, which is present in large quantities in all kinds of crop straws. It is one of the most abundant renewable and biodegradable energy substances globally.

With the advancement of technology, various types of straw gradually broke through at different levels. Rice straw stalks are produced in huge quantities every year, the pharmaceutical costs of putting them into daily drug-making are low, and the process is much more environmentally friendly. Scholars have found that straw heterodimer, obtained by pretreatment with SO3 microthermal explosion followed by dilute alkali and bleaching treatment, has strong feasibility for application as a medicinal aid ([9] Li Shuangfeng, 2019). In contrast, corn straw contains more lignin and cellulose than other wheat straws, containing

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higher carbon content. The prepared biochar has a high degree of aromatization and better thermal stability. Experts are also studying this, and they believe that shortly corn straw may significantly reduce the rate of direct carbon dioxide emissions into the air from people's lives. These studies are in the midstream of the straw chemical industry chain.

Downstream companies are mainly responsible for making finished products, marketing, and selling. The finished products are sold through both direct sales and distributors to reach the masses of consumers through the market.

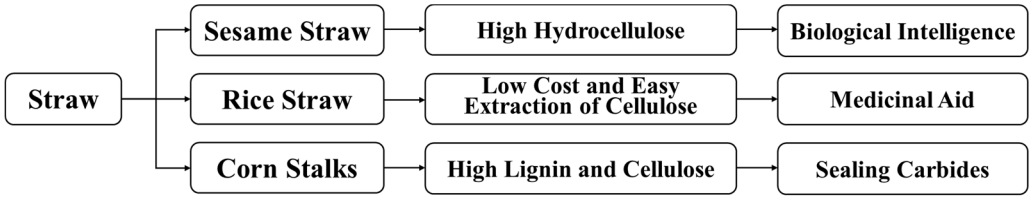

Fig 2. Comprehensive utilization of straw

3.3. Straw Building Materials Industry Chain

Straw building materials refer to crop straw as the primary raw material, adding auxiliary materials and reinforcing materials, according to a specific ratio, through physical, chemical, or a combination of the two, the formation of a particular function and structural characteristics of the building materials collectively. After scientific design and manufacture of straw building materials with sound insulation and warmth, fire and moisture, pressure and shock resistance, impact resistance, non-toxic and harmless, space-saving features, and can replace conventional building materials, reduce the load on the wall, and firmly connected with the plate, masonry, cement, Etc. Because of its renewable use and non-polluting qualities, it is considered an indispensable raw material for the future of construction. Straw building materials have three advantages: vast source, energy-saving, and environmental protection. It performs outstandingly and super practically at a relatively low construction cost. It avoids over-exploitation of resources such as wood and steel. It provides an effective method for the rational use of straw so that the environmental ecology and social governance problems caused by straw burning can be fundamentally solved. At the same time, it plays a vital role in reducing energy consumption in the construction industry, also promoting the industry's green low-carbon development. The application field of straw building materials is vast and can meet the needs of different building materials. At present, the main varieties of straw building materials are artificial straw panels, straw building decorative panels, straw composite wall panels, straw bricks, straw blocks, Etc. It is widely and effectively applied indoors and outdoors, as shown below.

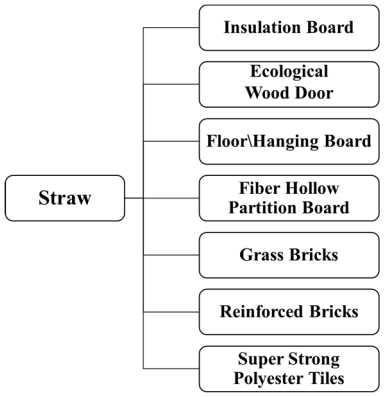

Fig 3. The main varieties of straw building materials

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Board-shaped straw building materials are the most common, made of straw as the primary raw material, through cutting, extrusion, and heating processes, adding different auxiliary materials. The most common ones are strawboard, oriented structure wheat strawboard. The more common green building materials industry chain lies in the following figure. ([10]Ma Yan, 2018).

Fig 4. Green building materials industry chain

The progress of science and technology and capital support provides suitable conditions for developing straw building materials. People's knowledge of straw building materials is becoming much more with the enhancement of environmental protection awareness. Straw building materials gradually come into view and are accepted by the public, forming a particular market space and strong market competitiveness. It will have broader promotion and application prospects in the future, and the industrial chain will better extend.

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References

[1] WEI Ran. A Review on the Theory Origin and the Research Status of Industry Chain[J]. Vol. 31(2010) No.06, p.140-143.

[2] ZHANG Haizhou, LU Lin, HE Yanan. Industry chain tourism: Concept and cases. World Regional Studies[J]. Vol. 29(2020) No.05, p.1006-1016.

[3] WU Jinming, SHAO Chang. Research on the formation mechanism of industrial chain--"4+4+4" model[J]. China Industrial Economics. Vol.21(2006) No.04, p.36-43.

[4] RAN Jia. WEI Desheng. Shunbang Agricultural Machinery pioneered an efficient industrial chain model for comprehensive utilization of straw[J]. Farm machinery. 2021 No.06, p.20-21.

[5] LIU Gui-fu. Theoretical model of the formation mechanism of the industrial chain[J]. Henan Social Sciences. Vol. 17(2009) No.01, p.49-52.

[6] LIU Tongli, ZHAO Lixin, MENG Haibo, et al. Research and optimization of evaluation methods for straw energy utilization technology[J]. Environmental Engineering. Vol. 38(2020) No.08, p.195-200.

[7] CHAI Rushan, WANG Qingyun, YE Xinxin, et al. Nitrogen resource quantity of main grain crop straw in China and the potential of synthetic nitrogen substitution under straw returning[J]. Journal of Agro-Environment Science. Vol.38(2009) No.11, p.2583-2593.

[8] SONG Zhanqian. Construct a straw efficient utilization system to realize the whole industrial chain of straw utilization[J]. Science & Technology Review. Vol.33(2015) No.04, p.1.

[9] LI Shuangfeng, WANG Huai, CHEN Jiali, et al. Effect of rice straw holocellulose on disintegration of aspirin tablets. CIESC Journal. Vol.11(2019) No.70, p.4420-4427.

[10] MA Yan, YIN Huilin, ZHANG Chunguang, et al. Application and development status of straw in Chinese building materials[J]. Henan building materials. Vol.101 (2018) No.05, p.379-380.