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Input–Output Analysis of China's Forest Industry Chain

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Abstract: The goal of this article is to conduct a detailed study of China's forestry industry chain and determine the effect it has on the national economy. Based on the 2018 China Input–Output Table (153 departments) and other relevant data released by the National Bureau of Statistics, as well as the input–output method established by *Wassily Leontief*, this article conducts a comprehensive and detailed analysis of China's forest industry chain and its impact on the national economy. The results show that the backward industrial chain of China's forestry industry involves 105 industrial departments. China's forestry sector purchases the most products from the tertiary industry, accounting for 56.05% of all forestry purchases. The products of the tertiary industry have a significant impact on forestry. The forward industry chain of China's forestry involves 131 industrial sectors, with China's forestry selling the most products to the secondary industry, accounting for 93.47% of all forestry sales. The forestry sensitivity coefficient is 0.767 and the influence coefficient is 0.65. The secondary industry has a significant impact on the sales of forestry products. The impact of the forward industry chain is greater than that of the backward industry chain and the impact of forestry on the national economy is quite large. Suggestions about how to expand the planting area and production scale of domestic economic forests were put forward. An increase in the added value of exported forestry products, improved service quality of the tertiary industry to forestry, and improved quality and quantity of products provided by forestry to the secondary industry are necessary.

Keywords: China's forestry; input–output method; forestry chain; forward and backward correlation; sensitivity coefficient and the influence coefficient

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1. Introduction

The concept of the industrial chain first appeared in The Theory of Labor Division by *Adam Smith FRSA*. He believed that industrial production is composed of a series of interrelated chains and specialized divisions of labor that can improve productivity. The industrial chain is the process from production to final consumption of raw materials [1]. In the 1950s, *Albert Otto Hirschman* analyzed the industrial chain from the perspective of industrial linkage effects. He believed that the industrial chain is led by industrial linkages and it is formed by the strength of industrial connections [2]. In the 1980s, Harvard Business School professor *Michael E. Porter* proposed the "value chain analysis method", which believed that a company's value creation process mainly consists of two parts: basic activities and supportive activities. The relationship between the two is interdependent and complementary, forming the behavioral "chain" of company value creation, and this "chain" is referred to as the value chain [3]. *Luis Cruz* and his colleagues emphasize that the economic contribution of forests in Spain extends beyond figures associated with afforestation and the forestry industry, such as added value and employment. This highlights the importance of studying the value chain of forest products, which encompasses the

primary end products that rely on the existence and development of forests. This value chain includes both direct and indirect products derived from timber and other forest resources. For instance, the production of "paper and paperboard products" does not directly depend on forest products. Instead, it relies on the consumption of "pulp", which is derived from wood, and ultimately, the production of paper and paperboard requires timber. Such insights into the complex relationship between forest resources and their derived products are crucial for understanding the multifaceted economic contributions of forests [4].

In recent years, Chinese scholars have explored the concept of the forestry industry chain: *Zou Fangfang* believes that the scope of the forestry industry is very broad, including related content of the three industries. With the rapid development of the economy, the connection between forestry and the three major industries is becoming increasingly close, and the close cooperation of the three major industries forms the organic whole of the forestry industry [5]. According to *Hong Chen*, the forestry industry chain is a complex industry chain that includes upstream industries such as breeding and planting; midstream industries such as processing forest products as raw materials; and downstream industries such as warehousing, logistics, and marketing [6]. According to *Zhiguang Zhang*, one of the highest value-added uses of forestry resources is pulping and papermaking. In terms of environmental protection, the best raw material for pulp is wood fiber. During the pulping process, wood pulp is cleaner and easier to treat for pollutants than straw pulp. Therefore, it is logical for the pulp industry and paper making industry to work closely together to form a mutually beneficial and interdependent industrial chain [7].

It is necessary to study the forestry industrial chain. *Ulf Johansen* from Norway pointed out that the volume of mature forests in Norway is increasing due to large-scale afforestation efforts over the past few decades. National forestry policies emphasize sustainable and efficient resource utilization, as well as regional processing. They have developed a dynamic optimization model that integrates venture capital activities with regional macroeconomic factors. This model takes into account the forestry venture capital involved in the entire process, from logging to processing and sales to end users. By supplementing survey data with statistical data (input–output tables), they derive output and value-added multipliers for regions and the country. This enables them to consider the ripple effects of venture capital activities on the economy [8]. According to *Youliang Ning*, the scale of the forestry industry is huge, but the lack of cooperation among various links and the serious lag in the construction of socialized service systems weakens China's international competitiveness [9]. According to *Jiayan He*, in order to fundamentally promote the sustainable and healthy development of the forestry industry, it is necessary to improve and optimize the structure of the forestry industry, achieve the transformation from low-end to high-end industry, expand the industrial chain to the maximum extent, enlarge the product market share, and strengthen market competitiveness [10].

Áine NíDhubháin, from Ireland, argued that the use of input–output models is rooted in the organization of data in tabular form. These tables present a snapshot of the economic structure of a country or region at a specific point in time, depicting the various flows of inputs into the production process. These flows are quantified in monetary terms and matched with corresponding outputs. In essence, the input–output model provides a clear framework for defining inter-industry linkages. It offers a visual representation of the economic landscape, showcasing the intricate relationships between different sectors and their interdependencies [11]. Many Chinese scholars often use traditional statistical indicator methods to study the forestry industry chain. *Guoshuang Tian* constructed an evaluation index system for the stability of the forestry ecological industry chain for analysis [12]. *Guofeng Wang* used the spatial econometric economic model (global Moran index, etc.) to analyze the spatial distribution and interdependence of China's forestry

production [13]. *Guangyuan Qin* analyzed the importance and driving effects of forestry in China using input–output models and the 2007 Input–Output Table [14].

In the past, there were few scholars using input–output methods to study the forestry industry chain. Their papers mainly focused on calculating and analyzing the relationship between forestry and the three industries. There was a lack of comprehensive industry correlation analysis of the forestry industry chain.

In this paper, the industrial chain refers to the form of the upstream and downstream chain relationship between the supply and demand of intermediate products formed between various industrial departments under certain economic and technological conditions. The forest industrial chain refers to the industrial chain that forestry production needs to purchase other industrial products and sell forestry products. This paper studies the impact of forestry on the national economy from the perspective of the supply chain and value chain between industries. In terms of research methods, differently from previous scholars' research, this article takes the industrial correlation effect and input–output theory as an important theoretical framework, uses input–output methods, and calculates the input and distribution coefficients of the forestry industry based on data such as the 2018 China Input–Output Table (153 departments) released by the National Bureau of Statistics to study the forward and backward industrial chain status of China's forestry production. Further, by calculating the influence and sensitivity coefficients of each industry and sorting and conducting cross analysis according to their numerical values, we can comprehensively observe the impact of forestry and the forest industry chain on the entire national economy. At the end, the conclusions and suggestions are summarized.

By calculating and analyzing, the following goals are achieved:

(1) What industrial sectors does China's forestry industry chain actually include? How much influence do these industrial sectors have in the forest industry chain?
(2) How much impact does the forest industry chain have on the national economic system?
(3) What are the problems and key elements for improvement?

2. Materials and Methods

2.1. Research Methods

This article analyzes the input–output correlation of the forest industry chain by calculating the input and distribution coefficients and the influence and sensitivity coefficients of the forest industry.

This article directly describes and analyzes the backward and forward forest industry chain through the input and distribution coefficients of the forest industry.

By calculating the input coefficient, the input correlation between forestry and various industries in the forest industry chain can be analyzed. The input coefficient refers to the proportion of the product quantity of an industry consumed or purchased by forestry in the production process in relation to the total product quantity purchased by forestry. It is used to observe the industrial chain distribution of forestry purchasing various products as production supplies. It indicates the backward correlation of forestry and its degree of impact.

The output correlation between forestry and other industries in the forest industry chain can be analyzed by calculating the distribution coefficient. The distribution coefficient refers to the proportion of the amount of products sold by forestry or distributed to another industry in relation to the total amount of product sold by forestry to all industries. It is used to observe the distribution of the industrial chain in which forestry sells its own products to various industries as production supplies and indicates the forward correlation of forestry and its degree of impact [15,16].

In this article, the products purchased and sold by forestry refer to intermediate products used in production. Intermediate products refer to the products produced in one production process and then completely consumed or changed into a different form in another production process.

In order to have a deep understanding of what role the forest industry chain is playing in China, this article analyzes the degree of forward and backward correlation influence of the forest industry chain in China by calculating the influence and sensitivity coefficient of the forest industry.

The influence coefficient (e_j) [17–19] refers to the degree to which changes in the production and demand of a certain industry have an impact on other production and supply industries. The influence coefficient formula is as follows:

$$e_j = \frac{\text{The average value of the sum of the column coefficients of a department in the Leontief inverse matrix}}{\text{The average value of the sum of all the column coefficients in the Leontief inverse matrix}}$$

If the influence coefficient $e_j > 1$, it indicates that the influence of the industry is above the average level in all industries. The greater the influence coefficient, the higher the influence degree of the industry's purchase of other industrial products, and the greater the effect is on other industries. If $e_j = 1$, it indicates that the influence of the industry is at the average level in all industries. If $e_j < 1$, it indicates that the influence of the industry is at the downstream level in all industries.

The sensitivity coefficient (e_i) [17–19] is used to study the degree to which the production and sales of an industry are affected by the production and demand of other industries. The sensitivity coefficient formula is as follows:

$$e_i = \frac{\text{The average value of the sum of transverse coefficients of a department in the Leontiev inverse matrix}}{\text{The average value of the sum of all transverse coefficients in the Leontiev inverse matrix}}$$

The sensitivity coefficient $e_i > 1$ indicates that the sensitivity level received by the department is higher than the average social sensitivity level. The greater the sensitivity coefficient is, the greater the degree of demand sensitivity that the department receives, the greater the driving effect on the national economy, and the more it has the attributes of basic industries. It has more tendency to become a bottleneck industry if $e_i = 1$. This indicates that the induction level of the industry is at the average level among all industries. If $e_i < 1$, it indicates that the sensitivity of the industry is at the downstream level among all industries.

2.2. Data Source

The Chinese government conducts a national input–output survey every five years, with the main task of comprehensively reflecting China's industrial structure and the economic and technological connections between various industrial sectors. It is credible and authoritative and is the most applicable and important method for studying the industrial chain. This year, China has issued a notice to carry out the eighth national input–output survey, and the data are expected to be released in the next year or two. Therefore, the seventh national input–output survey data used in this article are still the latest data. In December 2019, the Chinese government released the 2017 National Input–Output Table. Subsequently, based on the changes in industries in 2018, the 2018 China Input–Output Extension Table (153 industrial sectors, divided by product nature, with approximately 25,000 data) was compiled in 2020. This article analyzes the Chinese forest industry chain based on the 2018 Input–Output Table [20,21].

3. Results

3.1. Forward and Backward Correlation Analysis of Forestry Production

3.1.1. The Pulling Effect of Forestry Production on China's Economy from the Perspective of Backward Correlation

The backward industrial chain of China's forestry is the demand chain of forest products which reflects the demand for forestry to purchase other industrial products [22,23], according to China's input–output data in 2018 (Table 1). The backward industrial

chain involves 105 industrial departments. In 2018, the industries with a forestry input coefficient higher than 1% are as follows: agricultural, forestry, animal husbandry, and fishery service products (31.51%), forest products (16.52%), fertilizers (8.03%), pesticides (6.55%), agriculture, forestry, animal husbandry, and fishery machinery (5.31%), cargo transportation and auxiliary transportation activities (4.22%), monetary and other financial services (3.26%), science and technology promotion and application services (2.30%), wholesale (2.08%), insurance (1.63%), professional and technical services (1.62%), refined petroleum and nuclear fuel processing products (1.48%), and catering (1.12%). The intermediate products purchased from these industries account for 85.63% of all intermediate products required for forestry.

In China's forestry production, fertilizers, pesticides, special machinery for agriculture, forestry, animal husbandry, and fishery, and refined petroleum and nuclear fuel processing products that need to be purchased from the secondary industry account for 27.42% of the required intermediate products. The agricultural, forestry, animal husbandry, and fishery service products that need to be purchased from the tertiary industry account for the largest number—31.51% of the total purchases. The cargo transport and auxiliary transport activities, monetary finance and other financial services, science and technology promotion and application services, wholesale, insurance, professional and technical services, and catering of the tertiary industry that also need to be purchased account for 24.54% of the required intermediate products. The forestry products belonging to the primary industry as intermediate products accounted for 16.52%. It can be seen that the role of China's forestry in stimulating the national economy is in the order that the tertiary industry is bigger than the secondary industry, and both are bigger than the primary industry. The intermediate products of the tertiary industry such as agricultural, forestry, animal husbandry, and fishery service products that forestry needs to purchase from takes 56.05% of the total industrial intermediate products. It has the largest pulling effect on the tertiary industry.

Table 1. Input coefficient table of forest products in China in 2018. Unit:%.

Department Name	Influence Coefficient	Rank
Agricultural, forestry, animal husbandry, and fishing service products	31.51	01
Forest product	16.52	02
Fertilizer	8.03	03
Pesticides	6.55	04
Special machinery for agriculture, forestry, animal husbandry, and fishing	5.31	05
Road freight transportation and transportation assistance activities	4.22	06
Monetary finance and other financial services	3.26	07
Technology promotion and application services	2.30	08
Wholesale	2.08	09
Insurance	1.63	10
Professional technical services	1.62	11
Refined petroleum and nuclear fuel processing products	1.48	12
Food and beverage	1.12	13
Metalware	0.97	14
Retail	0.95	15
Water cargo transportation and transportation assistance activities	0.88	16
Electricity and heat production and supply	0.77	17
Capital market services	0.72	18
Other transportation equipment	0.63	19
Drinks	0.63	20

Table 1. *Cont.*

Department Name	Influence Coefficient	Rank
Textile, clothing, and apparel	0.61	21
Railway freight transportation and transportation auxiliary activities	0.58	22
Public management and social organizations	0.54	23
Railway passenger transportation	0.50	24
Air cargo transportation and transportation assistance activities	0.50	25
Loading, unloading, handling, and warehousing	0.49	26
Other services	0.41	27
Internet and related services	0.38	28
Telecom	0.36	29
Cultural, educational, sports, and entertainment supplies	0.35	30
Multimodal transportation and transportation agency	0.32	31
Air passenger transport	0.30	32
Post office	0.29	33
Accommodation	0.27	34
Coal mining and washing products	0.19	35
Business services	0.19	36
Pharmaceutical products	0.19	37
Urban public transportation and highway passenger transportation	0.18	38
Refined tea	0.17	39
Automotive parts and accessories	0.16	40
Home appliances	0.14	41
Daily chemical products	0.14	42
Steel rolling products	0.11	43
Production and supply of water	0.10	44
Building decoration, decoration, and other building services	0.08	45
Water conservancy management	0.08	46
Computer	0.08	47
Other general equipment	0.08	48
Education	0.08	49
Cultural and office machinery	0.07	50
Pipeline transportation	0.07	51
Glass and glass products	0.06	52
Furniture	0.06	53
Wood processing and wood, bamboo, rattan, palm, and grass products	0.06	54
Tobacco products	0.06	55
Paper and paper products	0.05	56
Culture and art	0.05	57
Gas production and supply	0.05	58
Social security	0.05	59
Alcohol and liquor	0.04	60
Knitting or crochet weaving and its products	0.04	61
Metal products, machinery, and equipment repair services	0.04	62
Textile manufactured goods	0.03	63
Other manufactured products	0.03	64
Leather, fur, feathers, and their products	0.02	65
Lease	0.02	66
Entertainment	0.02	67
Water passenger transportation	0.02	68
News and publishing	0.02	69
Sanitation	0.01	70
Other specialized equipment	0.01	71
Ecological protection and environmental governance	0.01	72
Production of radio, television, film, and film recordings	0.01	73
Rubber products	0.01	74

Table 1. *Cont.*

Department Name	Influence Coefficient	Rank
Electric machinery	0.01	75
Transmission, distribution, and control equipment	0.01	76
Pumps, valves, compressors, and similar machinery	0.01	77

Note: The data in the table are calculated and collated according to the 2018 China Input–Output Table. The input coefficients for the industries listed in the table are all above 0.01%. Due to the fact that China's Input–Output Table is structured based on product departments, the forestry sector is referred to as 'forest products' in the table, and the same logic applies to other industries.

3.1.2. The Driving Effect of Forestry Production on China's Economy from the Perspective of Forward Correlation

The forward industrial chain of China's forestry is the supply chain of forest products that reflects the sales of forestry to other industries [22,23]; it involves 131 industrial departments, according to China's input–output data in 2018 (Table 2). The industries whose forestry distribution coefficient is higher than 1% include wood processing and bamboo, rattan, palm, and grass products (38.12%), residential housing construction (14.61%), rubber products (11.35%), paper making and paper products (8.07%), forest products (5.16%), special chemical products and explosives, pyrotechnics, fireworks products (4.46%), furniture (4.23%), stadiums and other public buildings (2.98%), railway, road, tunnel, and bridge engineering construction (1.79%), architectural decoration and other construction services (1.58%), and arts and crafts (1.50%). Forestry sold its products to these industries as intermediate products, accounting for 88.69% of all intermediate products sold by forestry. The amount of forest products sold to secondary industries such as wood processing, bamboo, rattan, palm, and grass products, residential housing construction, rubber products, and paper and paper products as intermediate products accounted for 93.47% of all intermediate products. The tertiary industry accounted for only 1.37%, and the primary industry accounted for 5.16%. As far as the national economy is concerned, forestry has the largest role in promoting China's secondary industry.

Table 2. Distribution coefficient table of forest products in China in 2018. Unit:%.

Department Name	Influence Coefficient	Rank
Wood processing and bamboo, rattan, palm, and grass products	38.12	01
Residential building construction	14.61	02
Rubber products	11.35	03
Paper and paper products	8.07	04
Forest product	5.16	05
Specialized chemical and explosives, pyrotechnic and fireworks products	4.46	06
Furniture	4.23	07
Sports venues and other housing buildings	2.98	08
Railway, road, tunnel, and bridge engineering construction	1.79	09
Building decoration, decoration, and other building services	1.58	10
Handicraft article	1.50	11
Other civil engineering buildings	0.96	12
Shoes	0.44	13
Agricultural, forestry, animal husbandry, and fishing service products	0.43	14
Cultural, educational, sports, and entertainment supplies	0.40	15
Other manufactured products	0.34	16
Coal mining and washing products	0.34	17
Pharmaceutical products	0.26	18

Table 2. *Cont.*

Department Name	Influence Coefficient	Rank
Vegetables, fruits, nuts, and other processed agricultural and sideline	0.25	19
Food and beverage	0.20	20
Daily chemical products	0.18	21
Gypsum cement products and similar products	0.17	22
Synthetic material	0.15	23
Monetary finance and other financial services	0.15	24
Metalware	0.15	25
Building installation	0.13	26
Public facilities and land management	0.11	27
Building materials such as bricks, tiles, stones, etc.	0.11	28
Other foods	0.11	29
Resident services	0.08	30
Ecological protection and environmental governance	0.07	31
Drinks	0.06	32
Glassware	0.06	33
Special equipment for chemical, wood, and non-metallic processing	0.06	34
Home appliances	0.05	35
Air cargo transportation and transportation assistance activities	0.05	36
Business services	0.05	37
Other specialized equipment	0.05	38
Chemical fiber products	0.04	39
Cotton, chemical fiber textiles, and printing and dyeing finished products	0.04	40
Telecom	0.03	41
Vegetable oil processed products	0.03	42
Non-metallic mineral mining and beneficiation products	0.03	43
Non-ferrous metal mining and beneficiation products	0.03	44
Steel rolling products	0.02	45
Car	0.02	46
Alcohol and liqueur	0.02	47
Education	0.02	48
Railway passenger transportation	0.02	49
Entertainment	0.01	50
Refractory products	0.01	51
Pipeline transportation	0.01	52
Automotive parts and accessories	0.01	53
Railway freight transportation and transportation auxiliary activities	0.01	54
Accommodation	0.01	55
Refined petroleum and nuclear fuel processing products	0.01	56
Ships and related installations	0.01	57
Non-ferrous metals and their alloys	0.01	58
Non-ferrous metal rolling products	0.01	59
Metal products, machinery, and equipment repair services	0.04	60
Electricity and heat production and supply	0.04	61
Retail	0.04	62
Oven, fan, packaging, and other equipment	0.03	63
Electric machinery	0.03	64
Cement, lime, and gypsum	0.02	65
Ferrous metal products	0.02	66
Wholesale	0.02	67
Research and experimental	0.02	68
Urban public transportation and highway passenger transportation	0.02	69
Professional technical services	0.01	70
Capital market services	0.01	71

Table 2. *Cont.*

Department Name	Influence Coefficient	Rank
Graphite and other non-metallic mineral products	0.01	72
Transmission, distribution, and control equipment	0.01	73
Road freight transportation and transportation assistance activities	0.01	74
Other electrical machinery and equipment	0.01	75
Insurance	0.01	76
Feed processing products	0.01	77
Material handling equipment	0.01	78
Electric wires, cables, optical cables, and electrical equipment	0.01	79
Iron and iron alloy products	0.01	80

Note: The data in the table are calculated and collated according to the 2018 China Input–Output Table. The industrial distribution coefficients listed in the table are all above 0.01%.

3.2. Comparative Analysis of the Intermediate Product Ripple Effects of China's Forestry and Other Industries

3.2.1. How Forestry Production Affects China's Economy from the Perspective of Influence Coefficients

The influence coefficient reflects the impact of the purchase demand of each industry on other supply industries and the impact of each industry's demand chain [17,24], according to China's input–output data in 2018 (Table 3). Among China's 153 industrial departments, 79 have influence coefficients greater than 1. All 79 departments belong to the secondary industry except business services. The top 10 industries include computers, audio-visual equipment, communication equipment, radio and television equipment, radar and supporting equipment, electronic components, culture industry, office machinery, knitting or crochet knitting and its products, electrical machinery and equipment, and household appliances and other transportation equipment. There are 74 industries with an influence coefficient lower than 1, including 41 tertiary industries, 29 secondary industries, and 4 primary industries, namely, animal husbandry (with an influence coefficient of 0.773), fishery (0.717), agriculture (0.655), and forestry (0.65). The influence coefficient is ranked from large to small, and forestry ranks 144th. Forestry's influence coefficient is 65% of the average. Compared with other industries, China's forestry industry has a lower influence coefficient in purchasing intermediate products, ranking 10th from the bottom, higher than the industries of petroleum and natural gas exploitation products, retail, tobacco products, social work, education, capital market services, real estate, social security, and waste resources and waste materials recycling processing products.

Table 3. The influence coefficient of some industrial departments in China in 2018 (in descending order).

Department Name	Influence Coefficient	Rank
Computer	1.455	01
Audio-visual equipment	1.405	02
Communication equipment	1.403	03
Radio and television equipment, radar and supporting equipment	1.369	04
Electronic components	1.340	05
Culture and office machinery	1.330	06
Knitting or crochet knitting and its products	1.315	07
Other electrical machinery and equipment	1.305	08
Household appliances	1.279	09

Table 3. *Cont.*

Department Name	Influence Coefficient	Rank
Other transportation equipment	1.265	10
Special machinery for agriculture, forestry, animal husbandry, and fishery	1.210	21
Special equipment for chemical, wood, and non-metallic processing	1.150	41
Pesticide	1.149	42
Fertilizer	1.114	49
Rubber products	1.106	51
Wood processing and wood, bamboo, rattan, palm, grass products	1.098	53
Residential buildings	1.089	56
Sports venues and other buildings	1.087	57
Arts and crafts	1.082	59
Building decoration and other building services	1.058	67
Paper and paper products	1.050	70
Science and technology promotion and application service	0.995	81
Vegetables, fruits, nuts, and other agricultural and sideline food processed products	0.986	87
Professional technical service	0.963	91
Catering	0.933	98
Livestock products	0.773	132
Fishing products	0.717	139
Monetary finance and other financial services	0.699	141
Agricultural products	0.655	142
Wholesale	0.654	143
Forest products	0.650	144
Petroleum and natural gas exploitation products	0.650	145
Retail	0.642	146
Tobacco products	0.639	147
Social work	0.618	148
Education	0.610	149
Capital market services	0.601	150
Real estate	0.563	151
Social security	0.539	152
Recycling and processing products of waste resources and materials	0.451	153

Note: The data in the table are calculated and collated according to the 2018 China Input–Output Table. Since there are 153 departments and too many industries, this table only lists the industrial departments with the largest and smallest influence and relatively high correlation with forestry. The influence coefficient of the selected industrial departments are ranked from large to small as indicated in the table.

3.2.2. How Forestry Production Affects China's Economy from the Perspective of Sensitivity

The sensitivity coefficient reflects the sensitivity of each industry to other demand industries [17,24], and reflects the impact of each industry's supply chain to other demand industries, according to China's input–output data in 2018 (Table 4). Among China's 153 industrial departments, 36 have sensitivity coefficients greater than 1, of which 24 belong to the secondary industry, 10 belong to the tertiary industry, and 2 belong to the primary industry, namely, agriculture (sensitivity coefficient 4.315) and animal husbandry (1.393). The top 10 industries with high sensitivity include: power and heat production and supply, electronic components, agriculture, monetary and other financial services, business services, wholesale, refined petroleum and nuclear fuel processing products, basic chemical raw materials, non-ferrous metals, and household appliances. There are 117 industries with sensitivity coefficients lower than 1, including 80 in the secondary industry, 35 in the tertiary industry, and 2 in the primary industry, namely, fishery (sensitivity coefficient is 0.81) and forestry (0.767). The sensitivity coefficients rank from large to small, and forestry

ranks 65th. From the perspective of the sensitivity of intermediate product sales, the sensitivity coefficients of forest products are 76.7% of the average, higher than 88 industrial departments. From the perspective of the sensitivity coefficient, forestry plays a relatively large role in promoting China's economy.

Table 4. Sensitivity coefficients of 153 industrial departments in China in 2018 (in descending order).

Department Name	Coefficient Sensitivity	Rank
Electric power and heat production and supply	4.998	01
Electronic components	4.691	02
Agricultural products	4.315	03
Monetary and other financial services	4.247	04
Business services	4.221	05
Wholesale	3.520	06
Refined petroleum and nuclear fuel processing products	3.275	07
Basic chemical raw materials	3.261	08
Non-ferrous metals and their alloys	3.172	09
Petroleum and natural gas exploitation products	3.060	10
Retail	2.500	11
Road cargo transportation and auxiliary transportation activities	2.287	14
Specialized chemical products and explosives, initiatives, fireworks	2.021	20
Paper making and paper products	1.872	23
Livestock products	1.393	24
Catering	1.266	27
Wood processing and wood, bamboo, rattan, palm, grass products	1.156	31
Professional technical services	1.078	34
Rubber products	0.889	42
Fertilizer	0.863	48
Fishery products	0.810	57
Science and technology promotion and application service	0.768	63
Forest products	0.767	65
Insurance	0.751	68
Agriculture, forestry, animal husbandry, and fishery service products	0.740	70
Building decoration and other building services	0.616	87
Pesticides	0.602	89
Special equipment for chemical, wood, and non-metallic processing	0.507	108
Special machinery for agriculture, forestry, animal husbandry, and fishery	0.478	117
Furniture	0.429	131
Ecological protection and environment	0.424	132
Arts and crafts	0.417	133
News and publishing	0.397	139
Research and test development	0.355	147
Residential buildings	0.354	148
Sports venues and other buildings	0.354	149
Railway, road, tunnel, and bridge engineering construction	0.354	150
Other civil engineering buildings	0.354	151
Building installation	0.354	152
Social work	0.354	153

Note: The data in the table are calculated and collated according to the 2018 China Input–Output Table. As there are 153 departments and too many industries, this table only lists the industrial departments with the highest sensitivity, the lowest sensitivity, and relatively high relevance to forestry. The influence coefficient of the selected industrial departments are ranked from large to small as indicated in the table.

3.2.3. Comprehensive Analysis of Forestry Influence and Sensitivity

In order to study how forestry influences China's economy, this paper classifies 153 industries in China from four perspectives: large influence coefficient and large sensitivity coefficient, large influence coefficient and small sensitivity coefficient, small influence coefficient and large sensitivity coefficient, and small influence coefficient and small sensitivity coefficient [25].

The industry in which the influence and sensitivity coefficient are both more than 1 has a strong stimulating effect on purchasing intermediate products from the upstream industry. After buying from the upstream industry, it produces more types of intermediate products and sells them to the downstream industry, so it also has a big impact on the downstream industry. In China, 17 departments, including electronic components (influence coefficient 1.34, sensitivity coefficient 4.691), have large influence coefficients and sensitivity coefficients. Except for business services, these departments all belong to the secondary industry, including wood processing, wood, bamboo, rattan, palm, and grass products (1.098, 1.156), and paper making and paper products (1.05, 1.872), which are highly related to forestry.

Industries with an influence greater than 1 and a sensitivity less than 1 have a strong effect on purchasing intermediate products produced by upstream industries, but their intermediate products sold to downstream industries have a relatively weak positive influence on those industries. In China, except for water passenger transport, 62 industrial sectors, including computers (1.455, 0.81), have a large influence coefficient and a small sensitivity coefficient, which are all secondary industries. Among them, special machinery for agriculture, forestry, animal husbandry, and fishery (1.21, 0.478), special equipment for the chemical industry, wood, non-metallic processing (1.15, 0.507), pesticides (1.149, 0.602), furniture (1.143, 0.429), fertilizers (1.114, 0.863), rubber products (1.106, 0.889), railway, road, tunnel, and bridge engineering construction (1.096, 0.354), residential housing construction (1.089, 0.354), stadium and other public buildings (1.087, 0.354), arts and crafts (1.082, 0.417), and architectural decoration, decoration, and other architectural services (1.058, 0.616) are relatively related to forestry.

Industries with an influence less than 1 and a sensitivity greater than 1 have a relatively weak stimulating effect on purchasing intermediate products produced by upstream industries, but their intermediate products have a relatively strong impact on selling to downstream industries. The industries with a small influence coefficient and a large sensitivity coefficient in China include 20 industries such as power and heat production and supply (0.995, 4.998), among which 10 belong to the tertiary industry, 8 belong to the secondary industry, and 2 belong to the primary industry, including animal husbandry (0.773, 1.393) and agriculture (0.655, 4.315). Among them, industries such as professional and technical services (0.963, 1.078), catering (0.933, 1.266), refined petroleum and nuclear fuel processing products (0.905, 3.275), cargo transportation and auxiliary transportation activities (0.818, 2.287), monetary finance and other financial services (0.699, 4.247), and wholesale (0.654, 3.52) are closely related to forestry.

Industries with influence and sensitivity coefficients less than 1 are industries with weak effects. There are 54 industries with a small influence coefficient and sensitivity coefficient in China, including graphite and other non-metallic mineral products (0.999, 0.858), among which 32 belong to the tertiary industry, 20 belong to the secondary industry, and 2 belong to the primary industry, including fishery (0.717, 0.81) and forestry (0.65, 0.767). Science and technology promotion and application services (0.995, 0.768), insurance (0.826, 0.751), and agriculture, forestry, animal husbandry, and fishery services (0.799, 0.74) are relatively related to forestry. Among the industries whose influence coefficient and sensitivity coefficient are less than 1, only 5 industries have an influence coefficient less than forestry, such as tobacco products; in terms of sensitivity, 38 industries, such as water cargo transportation and auxiliary transportation activities, are smaller than forestry. It can be seen that in industries with small influence and sensitivity coefficients, although the forestry sensitivity coefficient is less than 1, its sensitivity coefficient is still greater than 38

industrial sectors. The demand for forest products from downstream industrial sectors is greater than that from forestry to upstream industrial sectors.

4. Discussion

Looking at the forestry industry chain, the data calculated by the input–output table above reflects the current situation of China's forestry industry chain under its economic and technological conditions. Based on its distribution, this article discusses the existing problems and key directions for improvement.

As far as the backward industrial chain is concerned, the intermediate product value chain of China's backward forestry industry has the greatest impact on the tertiary industry, followed by the secondary industry. Among 153 departments, the backward industrial chain in China involves 105 industrial departments, and there are 39 industries in the tertiary industry and the proportion of intermediate products from the third industry accounts for 56.05% of the total. The value and proportion of the tertiary industry chain are the highest [26]. Therefore, improving the service quality of the tertiary industry for the forestry industry has become an important issue. The current forestry socialized service system is lagging behind and the development of the forestry tertiary industry is still insufficient, so it is necessary to improve the service quality of the tertiary industry of the forestry chain, especially agriculture, animal husbandry, and fishing services. Secondly, although forestry requires intermediate products from the secondary industry accounting only for 27.42%, the backward industrial chain of forestry includes as many as 65 industries in the secondary industry. Thus, it is also important to improve the quality of the secondary industry products that invest in forestry products, accelerate technological progress, and improve the economic benefits of forestry. Thirdly, forestry requires a big proportion of self-industry services, accounting for 16.52%. Consequently, attention should be paid to the improvement of forestry's own industry services. To achieve a transition from a lower-end industrial chain to a higher-end industrial chain, a higher-level developed forestry investment structure and industrial chain should be formed.

As far as the forward industrial chain is concerned, the intermediate product value chain of China's forward forestry industry has the greatest impact on the secondary industry, followed by the primary industry. The second industry chain has the highest value and the largest proportion. Among the 153 departments, China's forestry forward industry chain involves 131 industrial sectors. The secondary industry in the forestry forward industry chain has 89 industries, and the proportion of forest products required to be provided to the secondary industry is 93.47%. Therefore, it is important to focus on the quantity and quality of products provided by forestry to the secondary industry. Forestry needs to accelerate scientific and technological research and development, create branded products, and pay special attention to improving the quantity and quality of forest products provided to industries such as wood processing, bamboo and rattan products, paper and paper products, furniture, and residential construction. It is important to promote the development of industries such as forestry biomass energy, materials, and medicine, and increase investment in ecological and leisure tourism [27]. In addition to domestically produced products, imported forest products are also included in forestry sales. Investment, consumption, and exports of Chinese forestry products account for 54.62%, 42.54%, and 2.84% of the total final use in the country, with exports having the smallest proportion. China's forest product imports are large, with a trade deficit of 96.5 billion yuan. The import volume of forest products is 73.97 times that of exports, indicating a heavy dependence on imported forest products in the economy. It is correct to expand imports to protect precious forest resources, but in the case of restrictions on certain imported wood materials, it will be necessary to continue to expand the planting area and production scale of domestic economic forests in the future and strive to increase the added value of exported forest products, forming a coordinated distribution of the forestry forward industry chain among the three industries.

From the perspective of forest production, forest cultivation remains weak; China's forest coverage reached 23.04% by the end of 2020, with a forest stock volume of 175 billion

cubic meters and a forest area of 220 million hectares. With a total investment of 452.5 billion yuan by 2019 [28], China has achieved great success in forestry development. However, the current forest coverage rate in China is still below the global average of 32%, and the per capita forest area is only a quarter of the world average. The quantity of forest products is far from meeting the needs of the national economy. Therefore, it is crucial to strengthen forest cultivation and continue expanding afforestation and greening areas, with a particular focus on Northeast China, North China, and Northwest China. It is essential to coordinate the management and construction of the mountain–water–forest–field–lake–grass–sand ecological system [29], change the planting structure of forest products, and increase the high-value timber of long-term rotation forests [30]. Furthermore, it is important to increase support and investment in forestry ecological compensation areas, protected areas, and forest management areas. Additionally, a mechanism for resource compensation and ecological compensation should be established. Accelerating technological innovation and talent development are also necessary. By expanding forest coverage, China can not only meet the growing demand for forest products but also provide more forest products to support economic development. Efforts must be made to meet the needs of the national economy for forest products.

Assessing the role of forestry in the national economy from the perspective of the forestry industry chain, both the impact coefficient (0.65) and the induction coefficient (0.767) of forestry are less than 1. This suggests the economic driving and pushing forces of forestry are weaker than the average level of all industries. From the perspective of the influence of forestry's own purchase of intermediate products, the driving effect on the national economy is relatively small. However, in terms of the sensitivity coefficient of forest product sales, the forestry sensitivity coefficient ranks higher among various industries. The demand of downstream industrial departments for forestry products is far greater than the demand of upstream industrial departments for forestry products. Also, the downstream industrial chain of forestry is longer than the upstream industrial chain. Among the industries in China with an influence coefficient and sensitivity coefficient greater than 1, wood processing and the production of wood, bamboo, rattan, palm, and grass products (1.098, 1.156), as well as paper and paper products (1.05, 1.872), have a significant correlation with forestry. In summary, forestry plays a great role in promoting the national economy when it comes to the sensitivity coefficient. The national economy has a high demand for the forest industry.

Conducting a detailed study of the upstream and downstream industry chain of the forest industry is beneficial because it provides valuable information for formulating appropriate policy measures and identifies key areas and directions for optimizing the industry chain. This research can be utilized to strengthen the planning, organization, and construction of China's forest industry chain, optimize the structure of the forest industry, improve the quality of China's forestry industry chain, and promote high-quality development in the forestry sector.

5. Conclusions

In this study, we employed the input-output method and real data from China to investigate the current status and crucial areas for improvement within the intricate forestry industry chain. By examining the backward linkages and forward inducements across all sectors of the Chinese economy, we have discovered that the forestry industry chain plays a substantial role in the national economy. Particularly, the downstream industries exhibit a significant demand for forestry products, underscoring the importance of enhancing the quality and quantity of these products. By utilizing comprehensive input-output data from 153 sectors in China, our research not only contributes to a deeper understanding of the complexities within the forestry industry chain but also provides valuable insights for policymakers and stakeholders to analyze and optimize the industry chain. Furthermore, our findings serve as a valuable reference for studying the interdependencies within other industry chains, making a meaningful contribution to the field of economic analysis.

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