The Driving Effects of Forest Industry in China: An Input-Output Analysis

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Abstract. This paper analyses Chinese forest industry’s significance and its driving effects with the 2007’ input-output statement and the 2008’ national economic census data; and concludes that forest industry itself created GDP 330 billion RMB, while driving the GDP increase by 270 million RMB, showing an obvious driving effect. Especially the paper making industry contributed most; The industry created 4.6 million jobs, while driving the job increase by 25 million, demonstrating forest industry’s job-creating capacity and its labour-intensive characteristics. The timber processing sector particularly created 2.4 million jobs, while driving the job increase by 10 million; Forest industry drove profit increase by 520 billion RMB, of which timber processing and paper making sectors contributed significantly; The whole industry drove the wage and welfare distribution up by 460 billion RMB, of which furniture manufacturing sector accounted for the largest share with 190 billion RMB, demonstrating forest industry’s important status among all sectors and significant driving effect on economy.

1. Introduction
As climate and environment problems became increasingly worsened in recent years, more and more concerns went to those existing problems. The foremost objective of forestry development was set to protect environment and forest resource and forest harvesting was increasingly confined. The domestic regulations on forest harvest became extremely strict and more foreign countries restricted forest harvesting. Both the national and international trends challenged the development of forest industry, the processing industry with wood as raw material, but the industry in China has experienced rapid development at the very time. According to the calculation of the added value of the industry in 2007’ input-output statement, forest industry only contributed 331.5 billion RMB to GDP, taking one millionth of the whole industry’s GDP contribution. However, according to the statistics of the Human Resources and Social Security Ministry, there were 775 million jobs nationwide in 2008, and forest industry created 4.6 million, taking 0.59% of the total. The jobs were mainly created by medium and small enterprises, of which 90% were taken by migrant workers, i.e. they created jobs for 4.14 million migrant workers. In 2008, the migrant workers accounted for 225 million, taking 1.8% of the total. Economic development improved people’s purchasing power, boosted the demand for forest products and promoted the development of forest industry. Meanwhile, its great contribution to migrant workers’ employment showed the necessity and importance of developing the industry. How important is the industry? And how big the driving effect is? The paper, based on the 2007’ input-output statements of 135 sectors nationwide and 2008’ national economic census data, analyses the industry’s driving effect in terms of GDP, job creation, wage and welfare, profit, defines the extent of the industry’s driving effect, and answers the questions about how significant is the forest industry.
There were many literatures studying on industrial impact to economy with input-output statements. Munn (2001) compared forest industry’s contribution to economy in southern America and on northwest bank of the Pacific, analysed the extent of industry’s influence to local economy, and calculated the marginal impact of USD 1 industrial value on local total production value, employment, personal income and GDP. Henderson and Munn (2008) analysed furniture industry’s impact on economy in Mississippi, together with direct, indirect and inductive impacts on employment, wage, total output and added value, and provided the extent of impacts on industries affected. Geng (2009), with the 2005’ input-output statements from 62 sectors, explained Chinese timber processing and furniture manufacturing sectors’ position in national economy and correlation with other industries, through calculating the influence coefficient and induction coefficient. However, there are few literatures analysing Chinese forest industry’s driving effect. This paper, using relatively mature input-output analysis, calculates and analyses the industry’s driving effect in four aspects, including GDP, employment, wage and welfare, profit, and judges on the industry’s importance in Chinese economic development.

2. Methodology and data
The Input-Output model is used to analyse the economic interrelationship between the wood-processing industry and others. Since Leontif (1936) had made the pioneer work in the 1930s, a number of papers of IO model have been completed, such as Lin et al.(2016), Song et al.(2016), Maria(2008), John(1992). There are specific assumptions in IO model proposed by Leontief, such as constant returns to scale, linearity, sector homogeneity, and no capacity constrains which affect the model’s accuracy as pointed out by Davis(1990) and Tang et al.(2011). Due to these assumptions, this model is only reliable in the short to medium term (Tang et al., 2011).

The basis IO model consists of rows showing “who gives to whom” and columns showing “who receives from whom” in the economy as pointed out by Tang et al. (2011). From the perspective of row i, the output of sector i can be expressed as follows:

\[ x_i + x_{i2} + \ldots + x_{ij} + \ldots + x_{in} + y_i = X_i, \quad (1) \]

Where: \( x_{ij} \) = purchases by the sector j of the goods produced by sector i, \( y_i \) = sales from sector i to final demand, \( X_i \) = total output of sector i.

Technical coefficient \( a_{ij} \) can be calculated as follows:

\[ a_{ij} = \frac{x_{ij}}{X_j}, \quad (2) \]

Where: \( X_j \) = total output of sector j.

So, the Eq. (2) can be expressed as follows:

\[ x_{ij} = a_{ij} X_j, \quad (3) \]

Basing on the former equation, we rewrite Eq.(1) as follows:

\[ \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha_n X_n + y_i = X_i, \quad (4) \]

If we use matrix notation as follows:

\[ \begin{align*}
A &= \begin{pmatrix}
\alpha_{11} & \alpha_{12} & \ldots & \alpha_{1j} & \ldots & \alpha_{1n} \\
\alpha_{21} & \alpha_{22} & \ldots & \alpha_{2j} & \ldots & \alpha_{2n} \\
\ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\
\alpha_{ni} & \alpha_{n2} & \ldots & \alpha_{nj} & \ldots & \alpha_{nn}
\end{pmatrix};
X &= \begin{pmatrix}
X_1 \\
X_2 \\
\ldots \\
X_n
\end{pmatrix};
Y &= \begin{pmatrix}
y_1 \\
y_2 \\
\ldots \\
y_n
\end{pmatrix},
\end{align*} \]

Where, A is the technical coefficient matrix, X is the vector of output, Y is the vector of demand.

So, the basic IO model can be expressed as follows:

\[ AX + Y = X, \quad (6) \]

Eq.(6) can be written as follows:

\[ (I-A)X = Y, \quad (7) \]
Where, $I$ is unit matrix, the matrix $(I-A)$ is called Leontief matrix. 

Eq.(7) can be transferred as follows:

$$X=(I-A)^{-1}Y,$$  \hspace{1cm} (8)

Where, the matrix $(I-A)^{-1}$ is called Leontief inverse matrix. Eq.(8) is the solution equation of the input-output analysis.

In this paper, the final demand is further divided into final consumption, investment, net export etc. 

Eq.(6) can be further expressed as follows:

$$AX+CX+TX+FD=X,$$  \hspace{1cm} (9)

Where, $C$ is the matrix of final consumption coefficients; $CX$ is the vector of the final consumption; $T$ is the matrix of net export coefficients; $TX$ is the vector of net export; $FD$ is the vector of other final demand beside final consumption and net export, such as investment.

Both $C$ and $T$ are diagonal matrixes, they can be expressed as follows:

$$C = \begin{bmatrix} c_{11} & 0 & \cdots & 0 \\ 0 & c_{22} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & c_{nn} \end{bmatrix}, \hspace{1cm} (10)$$

$$T = \begin{bmatrix} t_{11} \\ t_{22} \\ \vdots \\ t_{nn} \end{bmatrix}, \hspace{1cm} (11)$$

Where, $c_{ii}$ measures the share of sector $i$'s final consumption in sector $i$'s output; $t_{ii}$ measures the share of sector $i$'s net export in sector $i$'s output; all of the other elements in matrixes $C$ and $T$ are 0.

Eq.(9) can be further described as Eq.(12):

$$(I-A-C-T)X=FD,$$  \hspace{1cm} (12)

Eq.(13) can be obtained from Eq.(12), provided that $(I-A-C-T)$ is a non-singular matrix:

$$X=(I-A-C-T)^{-1}\times FD,$$  \hspace{1cm} (13)

When $FD$ changes, $X$ will change at the same time as follows:

$$\Delta X=(I-A-C-T)^{-1}\times \Delta FD,$$  \hspace{1cm} (14)

Eq.(14) measures all of the economic impacts including direct, indirect and induced impacts; if $C=0$, it will just measure the direct and indirect impacts, because final consumption $CX$ is not considered. In this case, Eq.(14) can be expressed as follows:

$$\Delta X=(I-A-T)^{-1}\times \Delta FD,$$  \hspace{1cm} (15)

The difference between Eq.(14) and (15) is referred to as the induced impact:

$$\Delta X_{\text{inducing}}=((I-A-C-T)^{-1}-(I-A-T)^{-1})\times \Delta FD,$$  \hspace{1cm} (16)

The data used in this paper are based on China's Statistical Year Books, China Economic Census Yearbook, and Input-Output table. They are both released by the National Bureau of Statistical of China.

3. Overview of forest industry

Currently, Chinese forest industry is basically developing well, with main sectors as timber processing, furniture manufacturing and paper making progressed rapidly. Based on the calculation of added value in 2007’s input-output statement, forest industry created GDP over 330 billion RMB across the whole year, of which timber processing accounted for 150 billion RMB, taking half of the industry’s GDP contribution. According to the second national census in 2008, the industry created 4.6 million jobs, taking 0.59% of the total throughout the country, of which timber processing sector became the biggest contributor with 2.42 million jobs created, taking 53% of the total created by the industry. Additionally, the industry realized total profits of 105.3 billion RMB, as well as wages and welfare of 90 billion RMB, of which paper making sector accounted for the biggest profit with its 50.5 billion RMB and timber processing sector accounted for the best wage and welfare with its 41.5 billion RMB (see Table 1).

As for the calculation of indicators, it is necessary to make the following explanation. The number of employees in the table1 is the total number of employees in all enterprises in the industry. The GDP
value of the industry in the table1 is calculated by the industry’s added value from the 2007’ Input-Output Statement. Because the employment data and GDP data in different years are used, the analysis on driving effects may be influenced. The total amount of wages and welfare used in the table1 are adjusted data. Since the Second National Economic Census in 2008 only provided the total amount of the industry, with no data of each sector, and the First National Economic Census in 2004 provided data of each sector in detail, the paper’s target, the proportion of total amount of wages and welfare in the industry is estimated by the data of each sector above designed scale in 2004, and the data in 2008 is adjusted with the proportion.

In addition, in order to understand the meaning of data accurately, we need to explain the calculation method of some data. In the furniture manufacturing sector, wood furniture and bamboo rattan furniture manufacturing segment employed 629,000 people and 17,000 people respectively, taking 62% of the total employees working in the sector; And the furniture manufacturing sector employed 1.62 million people, so the sector is roughly estimated to have employed 1 million employees (in the table 1). With the gross industrial output value and main business cost of enterprise above designed scale, the proportion of wood furniture manufacturing sector and bamboo rattan furniture manufacturing sector in the industry is approximately estimated to replace the proportion of the said two furniture manufacturing sectors’ GDPs in that of the whole furniture manufacturing sector. Thus when the proportion is 60%, and the GDP realized by the furniture sector in 2007 is 114.6 billion RMB, the wood furniture manufacturing sector and bamboo rattan furniture manufacturing sector’s total GDP in 2007 is about 68.8 billion RMB (in the table 1). Wood furniture manufacturing segment and bamboo rattan furniture manufacturing segment in the furniture manufacturing sector created total profits of 7.89 billion RMB and 0.15 billion RMB respectively, taking 57.4% of the total profits realized by the sector; and the total profits of the whole sector were 21 billion RMB, and the total profits of the sector indicated in the paper were estimated roughly at 12 billion RMB (in the table 1). Wood furniture manufacturing and bamboo rattan furniture manufacturing segments took up 60% of the total amount of wages and welfare provided by the whole furniture manufacturing sector, so the total amount of wages and welfare provided by the whole sector, including wood and bamboo rattan furniture segments, referred to in the paper, is 20.6 billion RMB (in the table 1).

In the paper making and paper products sector, enterprises above designed scale in papermaking and paper products sector employed 1.52 million people, pulp and papermaking segments employed 44,000 and 763,000 people respectively, jointly taking 53.1% of the total. The papermaking and paper products sector employed 2.22 million people, and the furniture manufacturing sector is roughly estimated to have employed 1.18 million people (in the table 1). With the gross industrial output value and main business cost from enterprise above designed scale, the proportion of pulp and papermaking segment’s GDP is roughly estimated to replace its GDP proportion in the whole papermaking and paper products sector. When the proportion is 64%, and the GDP value of the sector in 2007 is 181.6 billion RMB, the pulp and papermaking segments’ GDP in 2007 is around 116 billion RMB (in the table 1). Total profits of pulp and papermaking segments were 900 million and 26 billion RMB, taking 62% of the total realized by enterprises above designed scale, and the total profits of the papermaking and paper products sector was 50.5 billion RMB, so the total profits of furniture manufacturing sector are estimated at 31.2 billion RMB (in the table 1). Paper making and pulp sector took 60% of the total, and total amount of wages and welfare provided by papermaking and paper products sector was 47.1 billion RMB, so the total amount of wages and welfare provided by papermaking and pulp sector, including pulp and papermaking segment was 28.3 billion RMB (in the table 1).

There are some clear differences between the three main sectors in the industry. Timber processing sector is obviously labour-intensive, with relatively low thresholds in terms of capital and equipment, so small- and medium-sized private enterprises usually dominate the sector, but show strong capacity in job creation; Papermaking sector, especially pulp sector, is usually capital intensive, so mainly large-scale state-owned enterprises take the majority; Furniture manufacturing sector stands in the middle between the above two sectors, which is also developing overwhelmingly. The features of the
three main sectors contribute to the differences in their impacts on GDP, employment, profit, wage and welfare, and further in the development and scale of driving effect.

Table 1 Timber processing sector, wood, bamboo, ratten, palm and grass products sector, furniture manufacturing sector, and paper-making sector’s contributions in job, GDP, profit, wage and welfare

| Industrial sector | Employees (10,000 persons) | GDP (100 million RMB) | Total Profit (100 million RMB) | Wage and Welfare (100 million RMB) |
|-------------------|---------------------------|---------------------|-----------------------------|----------------------------------|
| A                 | 242                       | 1467                | 428                         | 415                              |
| B                 | 100                       | 688                 | 120                         | 206                              |
| C                 | 118                       | 1160                | 505                         | 283                              |
| All               | 460                       | 3315                | 1053                        | 904                              |

Note: Data in Table (1) is sourced from Yearbook of Chinese Economic Census—2008 / Secondary Industry I. (2)A= Timber processing, wood, bamboo, ratten, palm and grass products sectors; B= Furniture manufacturing sector; C= Paper making and paper products sector

4. Analysis on forest industry’s driving effect

Forest industry’s driving effects include direct, indirect and inductive effect, which jointly form the comprehensive driving effects. The paper analyses and discusses those driving effects in GDP, employment, profit, wage and welfare aspects. Direct effect reflects the industry’s direct contributions to GDP, jobs, profits, wage and welfare; Indirect effect reflects the influence of commodity and service circulations among forest industry and other industries on the whole economy. Comprehensive effects include all the three effects. The paper adopted the input-output data from 135 sectors, under different conditions of labour -intensity, profitability, wage and welfare, so the comprehensive effects are the sum of all effects after adjustment. The adjustment strategy is to reflect the extent of labours intensity in different industries on the basis of total compensation coefficient, and coordinate the differences in profitability, wage and welfare with complete social net income coefficient.

The driving coefficients in the table 2 and those in Table 3, 4 and 5 are all driving effect coefficients. But those in Table 2 are direct driving effect coefficients, in Table 3 are indirect driving effect coefficients, in Table 4 are inductive driving effect coefficients, and in Table 5 are the summation of all direct, indirect and inductive driving effect coefficients. The specific calculations can be referred to Economic Impacts and Challenges of China’s Petroleum Industry—An Input-Output Analysis written by Tang et al. (2013).

4.1. Analysis on direct driving effect

The forest industry’s direct driving effect reflects its direct contribution to economic development. In Table 2, it can be found that forest industry realized GDP of over 330 billion RMB, created 4.6 million jobs, made profits of 105.3 billion RMB, provided wage and welfare of 90 billion RMB, and contributed average annual wage and welfare around 20,000 RMB per capita. Forestry is a labour -intensive industry, so it greatly contributed to employment. Timber processing sector created 2.42 million jobs, furniture manufacturing and paper making sectors created over 1 million jobs; Papermaking sector realized profits of 50.5 billion RMB, higher than that of timber processing sector and furniture manufacturing sector; Timber processing sector took the lead in providing wages and welfare with total amount of 41.5 billion RMB. Therefore, it can be seen that labour- intensive timber processing industry exerts obvious driving effect on employment, and further increases wage, welfare and profit. To provide more jobs, it is necessary and important to develop forest industry, especially timber processing sector; while capital-intensive papermaking sector is of relatively limited driving effect to employment, but of considerable driving effect to GDP and profit.

Table 2 Forest industry’s direct driving impacts

| Driving coefficient | GDP(100 million RMB) | Employee (10,000 persons) | Profit(100 million RMB) | Wage and welfare (100 million RMB) |
|---------------------|---------------------|---------------------------|------------------------|----------------------------------|
| A                   | 1.6                 | 1467                      | 242                    | 428                              | 415                              |
4.2. Analysis on indirect driving effect

Forest industry’s indirect driving effect measures the economic impacts caused by commodity and service circulations among forest industry and other industries, including impacts on other industries’ GDP, employment, profit, wage and welfare. Table 3 lists the specific indirect driving effects. On the whole, forest industry drove up other industries’ GDP by 1623.3 billion RMB, employment by 12.63 million, profit by 276.9 billion RMB, wage and welfare by 249.5 billion RMB. Among the three sectors, the papermaking sector’s driving effect to GDP ranked first with 911.7 billion RMB; timber processing sector’s driving effect to employment, profit, wage and welfare took the lead with 5.65 million jobs, 118.5 billion RMB and 96.9 billion RMB respectively; papermaking sector excelled in average GDP per capital, average profit per capita, average wage and welfare per capita in contrast with other sectors; and furniture manufacturing sector had the biggest indirect driving effect coefficient, reflecting closer relationship and stronger association between the industry and other industries and sectors. On the whole, all sectors’ indirect driving effects are obvious in forest industry. The differences between different sectors are mainly attributed to the characteristics of each sector, which may determine the scale of driving effect and impact to associated industries.

|       | Driving coefficient (100 million RMB) | Employee (10,000 persons) | Profit (100 million RMB) | Wage and welfare (100 million RMB) |
|-------|--------------------------------------|---------------------------|--------------------------|----------------------------------|
| A     | 2                                    | 3814                      | 565                      | 1185                             | 969                             |
| B     | 4.2                                  | 3302                      | 438                      | 577                              | 902                             |
| C     | 1.7                                  | 9117                      | 260                      | 1007                             | 624                             |
| All   | -                                    | 16233                     | 1263                     | 2769                             | 2495                            |

Note: the meaning of A, B and C is same with the table 1.

4.3. Analysis on inductive driving effect

Forest industry’s inductive driving effect stands for the driving effect to other industries created by its employees with consumer goods and services. As forest industry is labour-intensive, so it requires large quantity of employees and large quantity of commodities and services to meet the demand. But small and medium-sized enterprises dominate the industry, which leads to the majority of employees are migrant workers with relatively lower salary and consumption power, and influences the industry’s inductive effect to other industries. On the whole, forest industry inductively drove GDP by around 800 billion RMB, of which papermaking sector contributed 330 billion RMB, taking 41%; created 8.16 million jobs, of which furniture manufacturing sector contributed 4.09 million, taking 50%; realized profits of 140 billion RMB, with small differences among the three sectors; and provided wages and welfare of 160 billion RMB, of which furniture manufacturing sector contributed 84.4 billion RMB, taking over 50%.

All the data shows that forest industry has relatively limited inductive effects, since the employees in the industry are mainly migrant workers, who usually spend less in working place, but transfer large amount of surplus to their hometown. However, there are insufficient calculations on the impact and driving effect of the consumptions occurred at their hometown on other industries and sectors, so the calculation of inductive effect, especially that of the forest industry’s inductive effect, probably produces evidently smaller result than the true value.
4.4. Analysis on comprehensive driving effect

Forest industry’s comprehensive driving effects are the sum of all direct, indirect and inductive driving effects. By measuring the comprehensive driving effects, the forest industry’s overall driving effects to other industries can be clarified. In Table 5, it can be found that the industry’s comprehensive driving effect to GDP has reached 2.7 trillion RMB, created 25 million jobs, increased profits by 520 billion RMB, so forest industry has been playing a significant role in national economic development. Specifically, the papermaking sector contributed the most in driving up GDP by 1.3 trillion RMB, but it drove up employment only by 5 million; timber processing and furniture manufacturing sectors remarkably drove up employment by 10.69 million and 9.47 million respectively; timber processing sector drove up the profits most by 210 billion RMB; and furniture manufacturing sector greatly drove up wages and welfare.

With the above analyses on different driving effects, we can see that forest industry is of obvious driving effects, with the largest indirect driving effects and the smallest direct driving effects; No matter being direct, indirect or inductive effects, labour-intensive industry is of remarkable driving effects to employment, wage and welfare, while capital-intensive industry is of obvious and considerable driving effects to GDP and profit.

5. Conclusion

Based on the above analysis, it can be concluded that forest industry takes a vital position in our national economy. Forest industry created GDP 330 billion RMB and drove GDP increase up by 2.7 trillion RMB, demonstrating its evident driving effect, of which the papermaking sector contributed the most; Forest industry created 4.6 million jobs, taking 0.59% of the total. Those jobs were mainly taken by migrant workers, i.e. Forest industry employed 1.8% of the total migrant workers and drove employment up by 25 million persons, fully demonstrating the industry’s absorptive ability of labour force and its labour-intensive characteristics. In the industry, timber processing sector performed best, since it employed 2.4 million workers and drove employment up by 10 million; Forest industry drove profits up by 520 billion RMB, for which timber processing and papermaking sector contributed the most; The industry also drove wage and welfare distribution up by 460 billion RMB, for which furniture manufacturing sector was the biggest contributor with 190 billion RMB provided as wages and welfare. So it can be seen Chinese forest industry is of strong ability of labour absorption and evident driving effect, as well as significant advantage in creating jobs for migrant workers. Its direct driving effect is substantial, indirect driving effect is enormous and inductive driving effect is
moderate. Therefore, we should increase our support to the industry, and actively guide the industry’s transformation and development, in order to enable full exploitation of those driving effects.

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