Employment impacts of petroleum industry in China: an input-output analysis

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Abstract: China’s employment issue is catching people’s eyes at present and for a long time. Economic impacts of China’s petroleum industry on employment are divided into direct, indirect and induced impacts and they are analysed in this study by using the input-output approach. The research results suggest that petroleum industry will supply 0.0957 jobs and 0.1501 jobs given 10,000 CNY final demand added in extraction of petroleum and processing of petroleum respectively; 1,887 CNY and 2,756 CNY of employment income will be affected given 10,000 CNY final demand added in extraction of petroleum and processing of petroleum respectively; extraction of petroleum has more direct impact on both employment number and employment income given one unit output added, and processing of petroleum has more indirect and induced impact on them. The petroleum industry’s impact coefficients on both employment number and employment income have been decreasing since 1987. The proportion of direct impacts in total impacts continues to decrease, and the connection between petroleum industry and other sectors in China’s national economy has become closer than before.

Keywords: petroleum industry; employment impacts; employment income; input-output model; China.


Biographical notes: Xu Tang is an Associate Professor at China University of Petroleum, Beijing, with research interest in energy economic, resource management and energy-environment-economic system modelling.
1 Introduction

China, with a population of more than 1.4 billion, is the most populated country in the world. Therefore, it is much more difficult for China to solving the employment problem. Successive governments of China have attached great attention on this issue and placed enlarging employment in a prominent position. China achieved major progress in full employment before implementing the reform and open policy in 1978 (Rawski, 1979). However, the employment structure in rural and urban China has changed since then as one of the consequences of China’s reform, development, and opening-up (Cai and Wang, 2010). Globalisation, market competition and rapid technological change have caused unemployment in China (Luo et al., 2010).

In China’s national economic system, different industries and sectors have different impact on employment. Petroleum industry, as one of the key energy sectors which support China’s economic growth, plays an important role not only in energy security, but also in national economy and employment. Tang et al. (2011) have already analysed petroleum industry’s economic impacts on national economy. However, there are few studies to evaluate the employment impacts of petroleum industry in China. This paper seeks to address this gap. In order to study the details carefully, the petroleum industry is divided into extraction of petroleum and processing of petroleum.

2 Methodology and data

Input-output model is useful in analysing the economic relationship of linkages among sectors of an economy. Since Leontief’s (1936) pioneer work in the 1930s, numerous studies of input-output analysis have been completed, such as Ranko (1986), Wu and Chen (1990), Gowdy (1992) and Llop (2008).

As for employment impacts analysis, input-output model is wildly used in different countries and regions, such as clean energy investments in Greece (Markaki et al., 2013), coal-to-liquids (CTL) industry in China (Qi et al., 2012), renewable energy in Germany (Lehr et al., 2008), solar thermal electricity deployment in Spain (Caldés et al., 2009).
The basic input-output model can be expressed as follows:

\[ AX + Y = X \]  \hspace{1cm} (1)

where \( A \) is the technical coefficient matrix \((n \times n)\); \( X \) is the vector of output \((n \times 1)\); \( Y \) is the vector of final demand \((n \times 1)\).

Equation (1) can be written as follows:

\[ (I - A)X = Y \]  \hspace{1cm} (2)

where \( I \) is identity matrix \((n \times n)\), and the matrix \((I - A)\) is called Leontief matrix \((n \times n)\).

Equation (2) can be expressed further as follows:

\[ X = (I - A)^{-1}Y \]  \hspace{1cm} (3)

Equation (3) is the solution equation of the input-output analysis. Where, the matrix \((I - A)^{-1}\) is called Leontief inverse matrix \((n \times n)\). Leontief inverse matrix whose element \(L_{ij}\) indicates direct and indirect material inputs from sector \(i\) required to produce one more unit final demand of sector \(j\).

Beside technical coefficient matrix \(A\), complete consumption coefficient matrix \(B\) \((n \times n)\) is also widely used in input-output model. Complete consumption coefficient matrix \(B\) is the sum of direct and indirect consumption coefficients, and indicates the direct and indirect linkages between sectors. \(B\) is highly related with Leontief inverse matrix, and it can be calculated from Leontief inverse matrix by subtracting the identity matrix \(I\) as follows:

\[ B = (I - A)^{-1} - I \]  \hspace{1cm} (4)

The data used in this study are from China’s statistical yearbook and input-output table. They are both released by the National Bureau of Statistics of China. For the difference in statistical calibre, the data in China’s statistical yearbook are converted into the statistical calibre of the input-output table.

There are two types of employment data released by the National Bureau of Statistics of China every year: employed persons by the three strata of industry and employed persons in urban units by sectors. Apparently, the number of employed persons is greater than the number of employed persons in urban units, but the difference between the two employment indicators is different among sectors. For example, the difference between them in agriculture is much bigger than them in other sectors such as financial intermediation, since China is a traditional agricultural country, and lots of farmers are working in countryside and self-employed.

In order to better reflect the employment information, employed persons by sectors are used in this paper. Since the data of employed persons by sectors cannot be obtained from National Bureau of Statistics of China directly, they can be estimated according to formula (5) as follows:

\[ P_i = p_i \times r_i \]  \hspace{1cm} (5)

where \(P_i\) is the number of employed persons in sector \(i\); \(p_i\) is the number of employed persons in urban units in sector \(i\); and \(r_i\) is the employment adjustment coefficient of industry \(i\).
The National Bureau of Statistics of China announced the number of employed persons by coarse sub-industries before 2009. Taking extraction of petroleum as an example, the National Bureau of Statistics of China released the number of employed persons in mining industry, but did not release it in extraction of petroleum. Because extraction of petroleum is part of mining industry, the employment adjustment coefficient of extraction of petroleum is assumed as same as it of mining industry. Therefore, employment adjustment coefficient of extraction of petroleum $r_{\text{Extraction}}$ can be calculated as follows:

$$r_{\text{Extraction}} = \frac{P_{\text{Mining}}}{p_{\text{Mining}}}$$  \hspace{1cm} (6)

where $P_{\text{Mining}}$ is the number of employed persons in mining industry, and $p_{\text{Mining}}$ is the number of employed persons in urban units in mining industry.

The employment adjustment coefficient of other industries can also be obtained by the same way according to equation (6) above. Since National Bureau of Statistics of China only published input-output tables for 1987, 1992, 1997, 2002 and 2007, equation (6) is calculated for those IO years above in order to analyse the change of employment impact coefficients later in Tables 5 and 6 in Section 4.

3 Employment impacts of China’s petroleum industry

3.1 Model

Based on the basic principles of input-output model above, detailed models for calculating petroleum industry’s impacts on employment in China will be established in this part.

Input-output model has been used to study employment issue in other sectors such as transportation in China by Wang (2004), and Shao and Zhang (2007). Model used in these articles are the same as follows:

$$E_j = \frac{N_j}{G_j} \sum_{i=1}^{n} C_{ij}$$  \hspace{1cm} (7)

where $E_j$ is sector $j$’s total employment coefficient which measures the number of direct and indirect jobs sector $j$ can supply through direct and indirect ways given one unit value added; $N_j$ is the number of direct employees in sector $j$; $G_j$ is the total value added in sector $j$; $C_{ij}$ is the corresponding element in Leontief inverse matrix ($n \times n$).

Equation (7) has some inherent defects, although it is easy to calculate employment coefficient. There are many sectors affected by petroleum industry, and each sector has different employment character. For example, China is a traditional agriculture country and there are approximately 900 million farmers in agriculture. Therefore, employees needed for every value added in agriculture is much higher than them in other sectors obviously. Just using the element in Leontief inverse matrix in equation (7) to study the employment coefficient is not suitable for China at least.

In order to distinguish the difference of employment character among sectors and avoid the defects in equation (7), a new model is proposed in four steps as follows:
Step 1  Calculate petroleum industry’s direct, indirect and induced economic impact coefficients

In the basic input-output model, final use can be divided into final consumption, investment and foreign trade, etc. So, equation (1) can be expressed further as follows:

$$AX + CX + TX + FD = X$$  

(8)

where $A$ is the technical coefficient matrix ($n \times n$); $X$ is the vector of output ($n \times 1$); $C$ is the matrix of final consumption coefficients ($n \times n$); $T$ is the matrix of net export coefficients ($n \times n$); $FD$ is the matrix ($n \times 1$) of other final use such as investment.

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

$$
C = \begin{bmatrix}
    c_{11} & 0 & \cdots & 0 \\
    0 & c_{22} & \cdots & 0 \\
    \vdots & \vdots & \ddots & \vdots \\
    0 & 0 & \cdots & c_{nn}
\end{bmatrix}
$$

(9)

$$
T = \begin{bmatrix}
    t_{11} & 0 & \cdots & 0 \\
    0 & t_{22} & \cdots & 0 \\
    \vdots & \vdots & \ddots & \vdots \\
    0 & 0 & \cdots & t_{nn}
\end{bmatrix}
$$

(10)

where $c_{ii}$ measures the share of sector $i$’s final consumption in sector $i$’s total gross output; $t_{ii}$ measures the share of sector $i$’s net exports in sector $i$’s total gross output; all of the other elements in matrixes $C$ and $T$ are 0.

Equation (8) can also be described as equation (11):

$$(I - A - C - T)X = FD$$

(11)

$(I - A)$ is Leontief matrix, and it is reversible. Usually $(I - A - C - T)$ is reversible in practice since both $C$ and $T$ are diagonal matrixes. If $(I - A - C - T)$ is a non-singular matrix, equation (12) can be obtained from equation (11):

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

(12)

when $FD$ changes, $X$ will change correspondingly as follows:

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

(13)

Equation (13) 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 is not considered. In this case, equation (13) can be described as equation (14):

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

(14)
Equation (14) is similar with Leontief inverse matrix; however, there are also some differences between them. The Leontief inverse matrix represents direct and indirect material inputs to produce one more unit final demand of a given sector, and the final demand include final consumption, trade and investment; however, the final consumption and trade have already been excluded from final demands in equation (14). As the direct impacts of each \( FD \) in any sector are 1, the indirect impacts matrix \( \Delta X_{\text{indirect}} \) \((n \times 1)\) can be calculated as follows:

\[
\Delta X_{\text{indirect}} = (I - A - T)^{-1} - I \times \Delta FD
\]  

The difference between equations (13) and (14) is referred as the induced impacts matrix \( \Delta X_{\text{induced}} \) \((n \times 1)\) as follows:

\[
\Delta X_{\text{induced}} = (I - A - C - T)^{-1} - (I - A - T)^{-1} \times \Delta FD
\]  

The induced impacts are caused by the expansion of final demand for goods and services. If final demand changes one unit in sector \( j \), the indirect and induced economic impacts coefficients \( X_{\text{indirect} - j} \) \((n \times 1)\) and \( X_{\text{induced} - j} \) \((n \times 1)\) can be obtained from equations (15) and (16) respectively as follows:

\[
X_{\text{indirect} - j} = (I - A - T)^{-1} - I
\]

\[
X_{\text{induced} - j} = (I - A - C - T)^{-1} - (I - A - T)^{-1}
\]

((\( I - A - T \))^{-1} \((n \times 1)\) and \((I - A - C - T)^{-1} - (I - A - T)^{-1}) \((n \times 1)\) are column \( j \) in matrix \((I - A - T)^{-1} - I \((n \times n)\) and \((I - A - C - T)^{-1} - (I - A - T)^{-1} \((n \times n)\).

**Step 2  Calculate each sector’s direct employment coefficient**

Each sector’s direct employment coefficient can be calculated as follows:

\[
e_{j - \text{direct}} = \frac{N_j}{G_j}
\]  

where \( e_{j - \text{direct}} \) is sector \( j \)’s direct employment coefficient; \( N_j \) is sector \( j \)’s direct employee number; \( G_j \) is sector \( j \)’s total output (unit: 10,000 CNY).

Each sector’s direct employment coefficient can be expressed in matrix \( E_{\text{direct}} \) \((n \times 1)\) as follows:

\[
E_{\text{direct}} = \begin{bmatrix}
e_{1 - \text{direct}} \\
e_{2 - \text{direct}} \\
\ldots \\
e_{j - \text{direct}} \\
\ldots \\
e_{n - \text{direct}}
\end{bmatrix}
\]
Step 3  Calculate petroleum industry’s indirect and induced employment coefficients

The latest Chinese Input-Output table is the 2007 version, which was published in 2009. There are 42 sectors in China’s 2007 Input-Output table (Brief Version). Suppose petroleum industry is sector $j$. Therefore, petroleum industry’s indirect and induced employment coefficients $e_{\text{indirect}}$ and $e_{\text{induced}}$ can be calculated respectively as follows:

$$e_{\text{indirect}} = E_{\text{direct}}^T \times X_{\text{indirect} - j}$$  \hspace{1cm} (21) \\
$$e_{\text{induced}} = E_{\text{direct}}^T \times X_{\text{induced} - j}$$  \hspace{1cm} (22)

Step 4  Calculate petroleum industry’s employment coefficient

Petroleum industry’s employment impact coefficients including direct, indirect and inducing employment impact coefficients $e$ can be calculated separately according to the equation (23) as follows:

$$e = e_{\text{direct}} + e_{\text{indirect}} + e_{\text{induced}} = \frac{N}{G} \times \left( X_{\text{indirect} - j} + X_{\text{induced} - j} \right) \times E_{\text{direct}}^T$$  \hspace{1cm} (23)

where $N$ is petroleum industry’s direct employee number; $G$ is petroleum industry’s total output.

3.2 Calculation of employment impacts coefficients

Petroleum industry’s direct, indirect and induced economic coefficients in China can be calculated according to equations (17) and (18) as shown in Table 1.

<table>
<thead>
<tr>
<th>Economic impacts coefficient on output</th>
<th>Extraction of petroleum</th>
<th>Processing of petroleum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total impacts coefficient</td>
<td>1.9180</td>
<td>3.2747</td>
</tr>
<tr>
<td>Direct impacts coefficient</td>
<td>1.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>Indirect impacts coefficient</td>
<td>0.4720</td>
<td>1.5180</td>
</tr>
<tr>
<td>Induced impacts coefficient</td>
<td>0.4460</td>
<td>0.7567</td>
</tr>
</tbody>
</table>

Direct employment coefficient matrix $E_{\text{direct}}$ in equation (20) is calculated according to equation (19). As for petroleum industry, the direct employment coefficient of extraction of petroleum is 0.0167, and the direct employment coefficient of processing of petroleum is 0.0112. According to equation (23), employment coefficient of extraction of petroleum and processing of petroleum can be calculated as follows:

$$e_{\text{Extraction}} = e_{\text{Extraction-direct}} + e_{\text{Extraction-indirect}} + e_{\text{Extraction-induced}}$$
$$= 0.0167 + 0.0326 + 0.0463 = 0.0957$$

$$e_{\text{Processing}} = e_{\text{Processing-direct}} + e_{\text{Processing-indirect}} + e_{\text{Processing-induced}}$$
$$= 0.0112 + 0.0656 + 0.0732 = 0.1501$$
Employment impacts of petroleum industry in China

The results above suggest that petroleum industry will supply 0.0957 jobs including 0.0167 direct jobs, 0.0326 indirect jobs and 0.0463 induced jobs given 10,000 Yuan output added in extraction of petroleum, and as well as 0.1501 jobs including 0.0112 direct jobs, 0.0656 indirect jobs and 0.0732 induced jobs given 10,000 Yuan output added in processing of petroleum.

3.3 Calculation of petroleum industry’s impacts on employment income

Based on the research above, petroleum industry’s impacts on employment income in China are analysed in this part. Suppose employees in sector ‘j’ average direct employment income is \( r_{j,\text{direct}} \). Each sector’s average direct employment income can be expressed in matrix \( R_{\text{direct}} (n \times 1) \) as follows:

\[
R_{\text{direct}} = \begin{bmatrix}
  r_{1,\text{direct}} \\
  r_{2,\text{direct}} \\
  \vdots \\
  r_{j,\text{direct}} \\
  \vdots \\
  r_{n,\text{direct}} 
\end{bmatrix}
\]  

(24)

Petroleum industry’s indirect and induced impacts on employment income in China \( r_{\text{indirect}} \) and \( r_{\text{induced}} \) can be calculated based on equation (21) and equation (22) respectively as follows:

\[
r_{\text{indirect}} = \begin{bmatrix}
  e_1 \times r_{1,\text{direct}} \\
  e_2 \times r_{2,\text{direct}} \\
  \vdots \\
  e_j \times r_{j,\text{direct}} \\
  \vdots \\
  e_n \times r_{n,\text{direct}} 
\end{bmatrix}^T \times X_{\text{indirect-j}}
\]  

(25)

\[
r_{\text{induced}} = \begin{bmatrix}
  e_1 \times r_{1,\text{direct}} \\
  e_2 \times r_{2,\text{direct}} \\
  \vdots \\
  e_j \times r_{j,\text{direct}} \\
  \vdots \\
  e_n \times r_{n,\text{direct}} 
\end{bmatrix}^T \times X_{\text{induced-j}}
\]  

(26)

Therefore, extraction of petroleum and processing of petroleum’s impacts on employment income in China \( r_{\text{Extraction}} \) and \( r_{\text{Processing}} \) can be calculated respectively as follows:

\[
r_{\text{Extraction}} = r_{\text{Extraction-direct}} + r_{\text{Extraction-indirect}} + r_{\text{Extraction-induced}} = 653.44 + 532.34 + 700.94 = 1886.72
\]
The results suggest that the employment income will increase 1,886.72 Yuan and 2,756.15 Yuan given 10,000 Yuan output added in extraction of petroleum and processing of petroleum respectively. Processing of petroleum’s impacts on employment income is about 46% higher than extraction of petroleum’s. The impacts consist of direct, indirect and induced impacts, but the proportion between them varies in extraction of petroleum and processing of petroleum as shown in Table 2.

Table 2

<table>
<thead>
<tr>
<th>Impacts on employment income</th>
<th>Extraction of petroleum</th>
<th>Processing of petroleum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Impacts</td>
<td>34.6%</td>
<td>7.3%</td>
</tr>
<tr>
<td>Indirect Impacts</td>
<td>28.2%</td>
<td>51.8%</td>
</tr>
<tr>
<td>Induced Impacts</td>
<td>37.2%</td>
<td>40.9%</td>
</tr>
</tbody>
</table>

The results in Table 2 suggest that 34.6% of the employment income given one unit output added in extraction of petroleum comes from direct impacts. However, this figure is only 7.3% in processing of petroleum. Although processing of petroleum has much more impacts on employment income than extraction of petroleum, most of its impact on employment income belongs to non-direct impacts.

4 Further analysis of employment impacts of China’s petroleum industry

4.1 Distribution of the employment income in different sectors affected by petroleum industry

Table 3 and Table 4 show the top 10 affected sectors on employment income given 10,000 Yuan output added in extraction of petroleum and processing of petroleum respectively. Employees’ income affected in Table 3 and Table 4 includes direct, indirect and induced income affected.

It can be found from Tables 3 and 4 that agriculture is the most affected sector on employment income given 10,000 Yuan output added in both extraction of petroleum and processing of petroleum. The main reason is that as a traditional agriculture country, more than half of the employees in China are in the sector of agriculture. Except agriculture, the employees in wholesale and retail trades benefit most from the development of petroleum industry in China.

4.2 Analysis of the change of employment impact coefficients over time

In addition to the 2007 input-output table, 1987, 1992, 1997 and 2002 input-output tables have also been published by the National Bureau of Statistics of China. The petroleum industry’s employment impact coefficients in historical years have also been calculated by the same method as above according to other years’ input-output tables, which will benefit the analysis of the change of employment impact coefficients over time.
Employment impacts of petroleum industry in China

Table 3
The top 10 affected sectors on employment income given 10,000 Yuan output added in extraction of petroleum

<table>
<thead>
<tr>
<th>Rank</th>
<th>Sector</th>
<th>Employees’ income affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agriculture</td>
<td>436.49</td>
</tr>
<tr>
<td>2</td>
<td>Wholesale and Retail Trades</td>
<td>162.98</td>
</tr>
<tr>
<td>3</td>
<td>Processing of Petroleum</td>
<td>97.81</td>
</tr>
<tr>
<td>4</td>
<td>Transportation</td>
<td>72.40</td>
</tr>
<tr>
<td>5</td>
<td>Manufacture of General and Special Purpose Machinery</td>
<td>62.58</td>
</tr>
<tr>
<td>6</td>
<td>Hotels and Catering Services</td>
<td>57.62</td>
</tr>
<tr>
<td>7</td>
<td>Production and Supply of Electric Power and Heat Power</td>
<td>55.48</td>
</tr>
<tr>
<td>8</td>
<td>Mining and Washing of Coal</td>
<td>48.76</td>
</tr>
<tr>
<td>9</td>
<td>Banking and Insurance</td>
<td>48.31</td>
</tr>
<tr>
<td>10</td>
<td>Manufacture of Non-metallic Mineral Products, Smelting and Pressing of Metals</td>
<td>35.50</td>
</tr>
</tbody>
</table>

Table 4
The top 10 affected sectors on employment income given 10,000 Yuan output added in processing of petroleum

<table>
<thead>
<tr>
<th>Rank</th>
<th>Sector</th>
<th>Employees’ income affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agriculture</td>
<td>670.19</td>
</tr>
<tr>
<td>2</td>
<td>Wholesale and Retail Trades</td>
<td>292.71</td>
</tr>
<tr>
<td>3</td>
<td>Extraction of Petroleum</td>
<td>270.95</td>
</tr>
<tr>
<td>4</td>
<td>Mining and Washing of Coal</td>
<td>167.88</td>
</tr>
<tr>
<td>5</td>
<td>Processing of Petroleum</td>
<td>146.30</td>
</tr>
<tr>
<td>6</td>
<td>Transportation</td>
<td>137.28</td>
</tr>
<tr>
<td>7</td>
<td>Hotels and Catering Services</td>
<td>79.47</td>
</tr>
<tr>
<td>8</td>
<td>Manufacture of General and Special Purpose Machinery</td>
<td>76.40</td>
</tr>
<tr>
<td>9</td>
<td>Banking and Insurance</td>
<td>74.02</td>
</tr>
<tr>
<td>10</td>
<td>Production and Supply of Electric Power and Heat Power</td>
<td>70.51</td>
</tr>
</tbody>
</table>

Tables 5 and 6 show the change of employment coefficients given 10,000 CNY of final demand change in the extraction of petroleum and processing of petroleum since 1987, respectively.

It can be found from Tables 5 and 6 that extraction of petroleum’s total employment impact coefficients in 2007 is 96.4% lower than it in 1987 and 51.8% lower than it in 2002, and similar trend also happens on the processing of petroleum. Processing of petroleum has more employment impacts than extraction of petroleum, and also increase faster than the latter. For example, extraction of petroleum’s total employment impacts in 2007 is only 13.1% higher than it in 1992, but the increasing rate is 100.7% in processing of petroleum.
Tables 7 and 8 show the change of employment income affected by 10,000 CNY of final demand change in the extraction of petroleum and processing of petroleum respectively.

**Table 5** The change of employment coefficients given 10,000 CNY of final demand added in the extraction of petroleum

<table>
<thead>
<tr>
<th>Year</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>0.6318</td>
<td>0.8005</td>
<td>1.1926</td>
<td>2.6249</td>
</tr>
<tr>
<td>1992</td>
<td>0.2976</td>
<td>0.3792</td>
<td>0.6451</td>
<td>1.3219</td>
</tr>
<tr>
<td>1997</td>
<td>0.1076</td>
<td>0.1062</td>
<td>0.2417</td>
<td>0.4554</td>
</tr>
<tr>
<td>2002</td>
<td>0.0346</td>
<td>0.0535</td>
<td>0.1106</td>
<td>0.1987</td>
</tr>
<tr>
<td>2007</td>
<td>0.0167</td>
<td>0.0326</td>
<td>0.0463</td>
<td>0.0957</td>
</tr>
</tbody>
</table>

**Table 6** The change of employment coefficients given 10,000 CNY of final demand added in the processing of petroleum

<table>
<thead>
<tr>
<th>Year</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>0.3982</td>
<td>1.1638</td>
<td>1.7990</td>
<td>3.3611</td>
</tr>
<tr>
<td>1992</td>
<td>0.2022</td>
<td>0.6296</td>
<td>1.0668</td>
<td>1.8985</td>
</tr>
<tr>
<td>1997</td>
<td>0.0654</td>
<td>0.2373</td>
<td>0.3605</td>
<td>0.6632</td>
</tr>
<tr>
<td>2002</td>
<td>0.0288</td>
<td>0.1196</td>
<td>0.1724</td>
<td>0.3208</td>
</tr>
<tr>
<td>2007</td>
<td>0.0112</td>
<td>0.0656</td>
<td>0.0732</td>
<td>0.1501</td>
</tr>
</tbody>
</table>

**Table 7** The change of employment income affected by 10,000 CNY of final demand added in the extraction of petroleum (unit: CNY)

<table>
<thead>
<tr>
<th>Year</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>1,609</td>
<td>1,335</td>
<td>1,463</td>
<td>4,408</td>
</tr>
<tr>
<td>1992</td>
<td>1,314</td>
<td>953</td>
<td>1,323</td>
<td>3,590</td>
</tr>
<tr>
<td>1997</td>
<td>1,011</td>
<td>599</td>
<td>1,160</td>
<td>2,769</td>
</tr>
<tr>
<td>2002</td>
<td>524</td>
<td>555</td>
<td>888</td>
<td>1,968</td>
</tr>
<tr>
<td>2007</td>
<td>653</td>
<td>532</td>
<td>701</td>
<td>1,887</td>
</tr>
</tbody>
</table>

**Table 8** The change of employment income affected by 10,000 CNY of final demand added in the processing of petroleum (unit: CNY)

<table>
<thead>
<tr>
<th>Year</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>930</td>
<td>1,733</td>
<td>2,349</td>
<td>5,012</td>
</tr>
<tr>
<td>1992</td>
<td>826</td>
<td>1,620</td>
<td>2,283</td>
<td>4,729</td>
</tr>
<tr>
<td>1997</td>
<td>602</td>
<td>1,590</td>
<td>1,743</td>
<td>3,935</td>
</tr>
<tr>
<td>2002</td>
<td>491</td>
<td>1,388</td>
<td>1,411</td>
<td>3,291</td>
</tr>
<tr>
<td>2007</td>
<td>200</td>
<td>1,429</td>
<td>1,127</td>
<td>2,756</td>
</tr>
</tbody>
</table>
It can be found from Tables 7 and 8 that employment income affected by 10,000 CNY of final demand added in both extraction of petroleum and processing of petroleum have been decreasing since 1987.

Tables 9 and 10 show the change of proportion of employment income affected by the extraction of petroleum and processing of petroleum respectively.

**Table 9**  The change of proportion of employment income affected by the extraction of petroleum

<table>
<thead>
<tr>
<th>Year</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>36.5%</td>
<td>30.3%</td>
<td>33.2%</td>
<td>100%</td>
</tr>
<tr>
<td>1992</td>
<td>36.6%</td>
<td>26.5%</td>
<td>36.8%</td>
<td>100%</td>
</tr>
<tr>
<td>1997</td>
<td>36.5%</td>
<td>21.6%</td>
<td>41.9%</td>
<td>100%</td>
</tr>
<tr>
<td>2002</td>
<td>26.6%</td>
<td>28.2%</td>
<td>45.1%</td>
<td>100%</td>
</tr>
<tr>
<td>2007</td>
<td>34.6%</td>
<td>28.2%</td>
<td>37.2%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Table 10**  The change of proportion of employment income affected by the processing of petroleum

<table>
<thead>
<tr>
<th>Year</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>18.6%</td>
<td>34.6%</td>
<td>46.9%</td>
<td>100%</td>
</tr>
<tr>
<td>1992</td>
<td>17.5%</td>
<td>34.3%</td>
<td>48.3%</td>
<td>100%</td>
</tr>
<tr>
<td>1997</td>
<td>15.3%</td>
<td>40.4%</td>
<td>44.3%</td>
<td>100%</td>
</tr>
<tr>
<td>2002</td>
<td>14.9%</td>
<td>42.2%</td>
<td>42.9%</td>
<td>100%</td>
</tr>
<tr>
<td>2007</td>
<td>7.3%</td>
<td>51.8%</td>
<td>40.9%</td>
<td>100%</td>
</tr>
</tbody>
</table>

It can be found from Tables 9 and 10 that proportions of employment income affected by extraction of petroleum keep relatively stable. However, the proportion of direct employment income affected by processing of petroleum continues to decrease obviously, and indirect employment income affected has been increasing a lot. Proportion of induced employment income affected by both extraction of petroleum and processing of petroleum has been decreasing slightly since 1987.

5 Conclusions and discussions

Petroleum industry’s employment impacts are divided into direct, indirect and induced impacts in this study. A new model based on the basic principles of input-output model is established for analysing petroleum industry’s employment impacts in China. The research results suggest that petroleum industry will supply 0.0957 jobs and 0.1501 jobs given 10,000 CNY final demands added in extraction of petroleum and processing of petroleum respectively; 1,887 CNY and 2,756 CNY of employment income will be affected given 10,000 CNY final demand added in extraction of petroleum and processing of petroleum respectively. Petroleum industry’s impacts on both employment coefficients and employment income have been decreasing since 1987. Although
extraction of petroleum and processing of petroleum belong to petroleum industry, obviously in China they have different characters on employment impacts. Extraction of petroleum has more direct impact on both employment coefficients and employment income given one unit final demand added, and processing of petroleum has more indirect and induced impacts. This is because processing of petroleum has more widespread economic influence than extraction of petroleum.

Compared with developed country, China’s employment coefficients calculated in this paper have different characters obviously. It is mainly because of the different economy development model and development stage. China is the largest developing country, also is a traditional agriculture country and there are approximately 900 million farmers. The Chinese style development of dual economy has been accompanied by the transition from a planned economy to a market economy containing a labour force allocation mechanism. And the reform of statistical systems in China has lagged behind economic reform (Ravallion and Chen, 1999). That’s why employment adjustment coefficients are adopted in this paper to better characterise the employment situation in China.

Employment is the source of the people’s livelihood and a prerequisite for the improvement of people’s living standards. How to develop the labour-intensive industry scientifically and sustainably is worth more attention of the decision-makers of all levels of governments in China. A useful way is to make an overall arrangement about economic development, industrial layout and stable employment, according to different characters of direct, indirect and induced employment among industries.

As a traditional agriculture country, the employees in agriculture benefit most from the development of petroleum industry in China. However, there are a large number of surplus labours in China’s rural areas, which is not considered in this paper. The total number of migrant workers in China reached 242 million at the end of 2010. Although migrant workers in cities are principally engaged in the work of the secondary industry, they are classified as agricultural employment by the National Bureau of Statistics. Since there are huge surplus agricultural labours which are difficult to count, petroleum industry’s employment impacts on agriculture are not that kind of high, which needs further research in the future.

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