Analysis on Industrial Correlation of China: Considering the Energy Resources based on Green Accounting

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Abstract. The discussions of linkage analysis for human’s economic activities, the natural resources and environment under sustainable development have received increased attention by the international society, especially after Japan’s nuclear leakage. Based on the green input-output theory, the authors compile the China green input-output tables using the data of Input-Output Tables of China. For the industrial correlation purpose, this paper uses the table to analyse the national economic linkage effect and the foreign trade energy-pollution effect in the context of sustainable development in China. Then this paper compares the results with that basing on traditional tables. This paper aims at providing the development direction and objective for the industrialization and promoting the sustainable development.

1. Introduction
The discussion of linkage analysis for human’s economic activities, the natural resources and environment under the framework of sustainable development has received increased attention by the international society, especially after Japan’s nuclear leakage. It’s necessary relationship between economic development and environment. Nevertheless, traditional national accounting is based on marketing principle. It only considers the pure economic system and regards resource and environment as inexhaustible and worthless. Green accounting not only considers the relation between energy-environment and economic activities, but also regard for the correlation between stock and flow.

For the relationship between economic development and environment, some economists introduce environment factors into traditional input-output analysis and build a series of input-output models including resource and environment factors. Young (2000) estimates industrial emission in Brazil from 1985 to 1996 caused by foreign trade using input-output analysis. Mette et al. (2005) introduces household consumption choice and lifestyle, energy consumption and emission into traditional input-output analysis and builds a new input-output accounting system. Furthermore, evaluates the environmental performance by DEA (data envelopment analysis). Shimada (2016) build Korea energy input output tables and analyse the energy policy in Korea.

The application of resource-environment input-output model is gradually popular in theory under sustainable development. Based on the theory of marginal opportunity cost and input-output analysis...
Lei (1995) builds green input-output accounting (GIOA) integrating resources, economic and environment factors. GIOA compressively reflects the interaction between economic activity and resource-environment based on Leontief input-output accounting. Comparing with traditional ones, GIOA provides more objective basis for macro decision under sustainable development and industry structure adjustment. At present, lots of researchers approve the theory of GIOA. Wu et al (2009) compile the input-output tables of China in 2005. In the view of integrating resource, economy and environment, under the sustainable development of China during recent ten years (1992-2002) beginning at Rio Summit, Lei (2010) comprehensive accounts the resource-economy-environment situation of China in 1992, 1995, 1997, 2000 and 2002 and briefly analyses.

In the view of sustainable development, it’s an academia urgent issue in building a new green accounting system. The application into practice in national accounting extremely urge as well. The authors compile the China green input-output tables using the data of Input-Output Tables of China. For an applicable purpose, we use the table to analyse the national economic linkage effect, FDI induced effect and the foreign trade energy-pollution effect in the context of sustainable development in China. This paper aims at providing the development direction and objective for the industrialization and promoting the sustainable development.

Differing from traditional input-output analysis, this paper indicates the environment pollution and wastage recycling, and also we can evaluate the sustainable development more efficiently according to the tables. First, we found green economy plays an active part in economic regulatory mechanism. In particular, it can reduce the shock of economic overheating. Second, we retort the viewpoint which is upgrading industries and job enlargement are clearly contradictory according to the analysis of FDI induced effect. Third, we admit China has made certain achievements on low carbon economy. However, we still afford more environmental costs, especially implicit energy costs in non-energy and indirect pollution cost in manufacturing.

2. Green Input-Output Model
The green input-output model (as Table 1) introduces the environment pollution and wastage emission, and indicates the influence of economy on natural and environment aspect comprehensively. It reflects the internal relation between each sector, each production and natural environment. Therefore, green input-output model plays a very important role in sustainable development.

| Energy used | Energy dept. | Energy1 dept. | Energy2 dept. | Other dept. | Pollution dept. | Final output | Total output |
|-------------|--------------|---------------|---------------|-------------|----------------|--------------|--------------|
| Energy used | U_{ij}^{e}   | U_{ijp1}      | U_{ijp2}      | U_{ijp3}    | U_{ijw}        | Y_{i}^{e}    | X_{i}^{e}    |
| Energy 1 dept. | Q_{ij}^{e1} | Q_{ijp11}     | Q_{ijp12}     | Q_{ijp13}   | Q_{ijw1}       | Y_{i}^{p1}   | X_{i}^{p1}   |
| Energy 2 dept. | Q_{ij}^{e2} | Q_{ijp21}     | Q_{ijp22}     | Q_{ijp23}   | Q_{ijw2}       | Y_{i}^{p2}   | X_{i}^{p2}   |
| Other dept. | Q_{ij}^{e3} | Q_{ijp31}     | Q_{ijp32}     | Q_{ijp33}   | Q_{ijw3}       | Y_{i}^{p3}   | X_{i}^{p3}   |
| Pollutant emission | W_{ij}^{e} | W_{ijp1}      | W_{ijp2}      | W_{ijp3}    | W_{ijw}        | N_{jw}       | Z_{jw}       |
| Total value added | N_{j}^{e}  | N_{j}^{p1}    | N_{j}^{p2}    | N_{j}^{p3}  | N_{jw}        | N_{jw}       | Z_{jw}       |
| Total input | Z_{j}^{e}   | W_{j}^{p(s)}  | W_{j}^{p(s)}  | W_{j}^{p(s)}| W_{j}^{w}      | W_{j}^{w}    | W_{j}^{w}    |

Data Sources: Zhao Xinna (2018)

3. Industrial correlation analysis
3.1. National economic linkage effect analysis

Response coefficients reflect the output of a department for others. That is to say, when other departments increase one unit final use in national economy, some department receives the degree of demand response. Larger coefficient means more output to satisfy final demand increasing. It indicates the department’s restriction degree for national economy increasing. So we call it “bottleneck” which response coefficient is more than one. The departments pass the average level. Differing from traditional input-output analysis, green input-output tables indicate the environment pollution and wastage recycling, and so the response coefficients of bottleneck departments decrease. However, those of good departments increase. It means green economy plays an activity role in national economic coordination and promotion. Especially in economic overheating period, it can reduce the impact on departments.

As table 2, six industry including Manufacture of Metal Products (15), Manufacture of Electrical Machinery and Equipment (18) are bottleneck industries. Except Extraction of Petroleum and Natural Gas (03), green accounting always plays an active role in reduce the restriction degree. Meanwhile, it exposes Extraction of Petroleum and Natural Gas (03)’s tough perspective. In a way, green accounting reflects a true economic restriction degree comparing with traditional ones. For some industries having lower restriction degree, green accounting can expose their potential restriction degree, especially Production and Distribution of Gas (24), Construction (26), Manufacture of Nonmetallic Mineral Products (13). All the results indicate a truth that the span among industries is smaller.

| Dept. | Response coefficient (Ei) | Dept. | Influence coefficient (Fi) |
|-------|--------------------------|-------|---------------------------|
|       | Green | Traditional |       | Green | Traditional |
| 15    | 1.7401 | 1.7499 | 18    | 1.3210 | 1.3233 |
| 18    | 1.7256 | 1.7359 | 15    | 1.2709 | 1.2725 |
| 12    | 1.6714 | 1.6805 | 12    | 1.2157 | 1.2163 |
| OM    | 1.5705 | 1.5783 | 08    | 1.1985 | 1.1988 |
| 11    | 1.3155 | 1.3199 | 26    | 1.1949 | 1.1959 |
| 03    | 1.1272 | 1.1235 | OM    | 1.1574 | 1.1585 |
| 01    | 0.9940 | 0.9927 | 13    | 1.1161 | 1.1167 |
| OS    | 0.9786 | 0.9793 | 11    | 1.0688 | 1.0688 |
| 23    | 0.9179 | 0.9173 | 23    | 1.0320 | 1.0311 |
| 27    | 0.8436 | 0.8416 | 24    | 1.0161 | 1.0152 |
| 08    | 0.8000 | 0.7955 | 06    | 0.9770 | 0.9749 |
| 31    | 0.7862 | 0.7844 | 02    | 0.8979 | 0.8981 |
| 06    | 0.7575 | 0.7548 | 27    | 0.8603 | 0.8597 |
| 02    | 0.7146 | 0.7110 | OS    | 0.8158 | 0.8158 |
| 32    | 0.6852 | 0.6823 | 03    | 0.7786 | 0.7793 |
| 13    | 0.6297 | 0.6236 | 31    | 0.7663 | 0.7651 |
| 24    | 0.3753 | 0.3687 | 1     | 0.7159 | 0.7148 |
| 26    | 0.3670 | 0.3607 | 32    | 0.5967 | 0.5953 |

Influence coefficients reflect the dependence of one industry’s demand increase on the whole production level. That is to say, when one industry increases one unit final use in national economy, others receive the degree of demand spread. Larger coefficient means more stimuli to other industries. Comparing with the data based on traditional tables, we found the stimuli effect in industries with larger influence coefficients become smaller after considering the energy and environment influence.

However, those of smaller influence coefficients become larger. In particular, ten industries of the eighteen have a larger influence coefficient above one, especially Manufacture of Electrical Machinery and Equipment (18), Manufacture of Metal Products (15), Chemical Industry (12). It indicates the influence from these industries exceed the average influence. The final demand increases in these industries promote the national economy development. Meanwhile, it takes more demand stimuli and more linkage spread on other industries. In contrast, the third industry with less energy consumption has
disadvantage of stimulus effect. However, green accounting reflects the real stimulus effect growing, especially in Manufacture of Foods and Tobacco (06), Hotels and Catering Services (31), Financial Intermediation (32).

In conclusion, we found the final demand increases in industries with larger response coefficient and influence coefficient promote national economic developing more quickly, but the energy use and direct pollution emission in these industries are larger either. Comparing with the results based on traditional input-output tables, we analyse the linkage effect in national economy based on green input-output tables. For one thing, it proves the asymmetry between low carbon development and pure economic growth in short period. It because traditional economic data doesn’t consider the connotative environment cost. In other words, traditional economy develops with environment pollution and energy consumption, it leads to ecological destruction. For another thing, green accounting reflects the development potential of each industry. So green accounting is a disruptive development trend, a long investment theme and an inevitable choice of future.

3.2. Foreign trade energy-pollution effect analysis

Ecological flow of resource intensive products causes the environment cost transfer from developed country to other countries. Efficient imports and exports structural adjustment contribute to reduce energy consumption and pollution emission. For one thing, it can improve the quality of foreign trade, and even that of whole economic growth. For another thing, it promotes energy saving and emission reduction. Foreign trade energy-pollution coefficients are made of energy coefficients and pollution coefficients. It means the gap between export energy consumption/pollution emission and import energy consumption/pollution emission. If the coefficient is less than zero, it means the export energy consumption/pollution emission is lower than that of import, and vice versa. Drawing lessons from the way of Yuting Dang (2010), we calculate in order to avoid the influence of price shift and macro economy imbalance.

First, we analyse every industry's energy use situation. We can get complete energy use coefficient from the Cumulative Input Coefficients table of green input-output table (material-value style). When we compile the green input-output tables, we suppose Mining and Washing of Coal (02), Extraction of Petroleum and Natural Gas (03) use energy directly. So only the two industries’ direct energy use coefficients are not zero. Then the complete coal use in (02) is 91.768 ton/million yuan. The complete petroleum use and the complete natural gas use in (03) are separately 6.23 ton/million yuan and 11.02 SCM/million yuan.

Second, we calculate the foreign trade coal, the foreign trade petroleum and the foreign trade natural gas with coefficients of China in 2007 as table 3. Overall, the foreign trade energy use coefficients are negative. It means China is really effective in developing low carbon economy. However, we deem, in the view of non-energy industries, China affords more environmental costs for trade counties.

| Dept. | Foreign Trade Energy coefficients | Dept. | Foreign Trade Energy coefficients |
|-------|-------------------------------|-------|-------------------------------|
|       | Coal  | Petroleum | Natural gas | Coal  | Petroleum | Natural gas |
| 24    | 0     | 0         | 0          | 26    | 5.52E-07 | 5.71E-08 | 1.01E-09 |
| 13    | 8.98E-06 | 4.99E-07 | 8.83E-09 | 01    | -2.82E-06 | -4.23E-07 | -7.48E-09 |
| 06    | -2.25E-07 | -2.83E-08 | -5.00E-10 | 32    | -5.95E-08 | -9.04E-09 | -1.60E-10 |
| 03    | -2.02E-05 | -4.74E-05 | -8.39E-07 | 27    | 7.00E-06 | 2.31E-06 | 4.09E-08 |
| 02    | -1.37E-06 | -4.21E-09 | -7.45E-11 | 31    | 5.44E-06 | 7.85E-07 | 1.39E-08 |
| 23    | -8.67E-06 | -4.39E-06 | -7.76E-08 | OM    | -1.17E-05 | -1.33E-06 | -2.36E-08 |
| 08    | 3.36E-05 | 3.91E-06 | 6.91E-08 | 15    | 1.38E-05 | 1.26E-06 | 2.23E-08 |
| 11    | 6.82E-07 | 2.15E-08 | 3.80E-10 | 12    | -2.48E-05 | -4.00E-06 | -7.08E-08 |
| 18    | -9.04E-06 | -9.67E-07 | -1.71E-08 | OS    | -1.58E-06 | -2.13E-07 | -3.76E-09 |
| Non-energy | 1.92E-05 | 1.85E-06 | 3.27E-08 | Amount | -1.04E-05 | -5.00E-05 | -8.84E-07 |
Above all, the high energy consumption caused by export and import in non-energy industries is the main factor of high energy consumption in foreign trade. The implicit energy output of non-energy products is gradually replacing the dominant output of energy products.

Besides that, we analyze every industry’s pollution emission situation. Familiar with that of energy consumption, we can get complete pollution emission coefficient from the Cumulative Input Coefficients table of green input-output table (material-value style). As the results, the direct pollution coefficients in some industries are smaller, but the indirect ones are larger. So it exists greater danger. Taking Manufacture of Electrical Machinery and Equipment (18) as an example, we found the indirect pollution emission coefficients of three wastes in (18) exceed 90% of complete pollution emission coefficients (waste water is 93.3%, waste gas is 99.7%, and solid wastes is 99.4%). Second, we calculate the foreign trade pollution emission coefficient of three wastes in 2007 as table 4.

| Dept. | Waste gas | Waste water | Solid waste | Waste gas | Waste water | Solid waste |
|-------|-----------|-------------|-------------|-----------|-------------|-------------|
| 11    | 6.33E-08  | 7.41E-07    | 1.44E-07    | 0         | 0           | 0           |
| 23    | -2.21E-07 | -1.13E-05   | -9.53E-07   | 6.15E-07  | 1.34E-05    | 1.48E-06    |
| 06    | -4.37E-09 | -6.22E-07   | -2.23E-08   | 9.55E-07  | 4.17E-05    | 5.60E-06    |
| 08    | 1.70E-06  | 2.48E-04    | 7.56E-06    | -8.93E-10 | -6.38E-08   | -1.40E-08   |
| 03    | -1.25E-06 | -4.43E-05   | -4.50E-06   | 1.05E-06  | -8.65E-05   | -5.37E-06   |
| 18    | -1.73E-07 | -8.82E-06   | -8.86E-07   | -5.96E-07 | -6.11E-05   | -6.15E-06   |

Overall, China pays a high price for unit export value. It leads to environment pollution and ecological deterioration, especially emission of waste water and waste gas. We only consider the three wastes in industry departments. So there are twelve industries totally.

4. Conclusion
As a disruptive development trend, green economy becomes a commanding height of global economic competition in the future. Energy issues have aroused extensive attention worldwide. So the balance between energy recovery, environment conservation and economy development is the key of sustainable development. The development in China affords double pressures of international emission and national development. So the energy structure adjustment and the change of economic growth mode inevitably occur. Researching on the relation between energy, environment and economic development is not only of important value in theory, but also of important value in practice. No matter the scope of theory system, or the method, the green input-output accounting corresponds with the idea of sustainable development. Green input-output analysis integrates resources, economic and environment factors. Based on China green input-output tables, we analyse three hot topics and advise as below.

In the view of overall economy, we suggest industries adjustment should distinguish. For industries with larger response coefficient and influence coefficient, we should comprehensively consider and count the cost. For industries with strongly indirect environment influence, we should properly control their development speed. For industries with larger restriction on national economy and lower energy and lower pollution, we should adopt positive policy to promote their development. Market mechanism is a good tool for us to spur the industry structure transition, such as tax reform, green credit, environmental insurance and ecological compensation. All of that ensure economy to move towards sustainable development.

At last, China affords more energy consumption and pollution emission transfer in foreign trade from all over the world. In a long way, it’s necessary to strengthen environment regime. At the time of opening to the world, we suggest to lower the export of high energy use and high pollution emission and subsidize industries with low energy use or low pollution emission by taking environmental tariffs. Meanwhile, we suppose to limit investment in resource intensive industries reasonably, and raising the threshold of entry. In a short way, it’s important to coordinate the relation among foreign trade, environment and
economic development and focus on industry structure adjustment by introducing advanced technologies and equipment abroad to raise resource utilization and environmental management level. In the view of technologies and science, we advise to develop the products’ structure into low carbonization.

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