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# Waste Gas Emission Analysis of China in 2007

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***Abstract*—The objective of this paper is to examine the waste gas emission of China in 2007. With input-output model, the total waste gas emission composed of the direct emission from the sector itself and indirect emission from the intermediate produced by other sectors was counted. A series of indicators, including direct and total waste gas emission intensity, waste gas emission multiplier and total waste gas discharge percentage of each sector were also studied. The results show Production and Distribution of Electric Power and Heat Power discharged most direct waste gas, while Household, Service and others discharging most indirect waste gas. As to the waste gas emission multiplier, Household, Service and others exert the largest influence to the whole system.**

***Keywords-input-output analysis, waste gas, emission, economy***

## I. INTRODUCTION

Since the third Industrial Revolution and with the Chinese national economic reforms being put forward, the Chinese economy developed rapidly with the application of advanced manufacturing technology and with the practice of a series of favorable policies. The gross domestic product [1] of China in 2009 was 34.05 trillion yuan (RMB), which grew to 92 times more than that of the first year of the 1978 reform. However, this great achievement is obtained at a heavy price of the country's environment and its people's health. For example, the industrial waste gas discharge of China in 1995 was 123,407 × $10^8$ $m^3$ [2] and 13 years later, this value jumped up to 403,866 × $10^8$ $m^3$ [3]. This waste gas contains $CO_2$, SOx, NOx, and others, which are harmful to the earth and to humans. $CO_2$ is well-known now as the greenhouse gas [4] while SOx has been proven to be harmful to both the community and livestock due to its properties [5] of increasing the risk of overall mortality, diabetes deaths, and exacerbating existing chronic diseases. Therefore, this calls for a serious study to inform all the economic sectors of the largest waste gas maker that brings a heavy environmental impact to the society.

The Leontief model [6] is a top-down economic technique that uses sectoral monetary transactions data to account for the complex interdependencies of industries in modern economies. The Leontief model is widely applied to study the interactions between the economy and the environment by quantifying the environmental loads within the product. For instance, Philip W. Gay and John L. R. Proops [7] studied the production of $CO_2$ emissions in the United Kingdom with the input-output models. Additionally, Julio Sánchez-Chóliz and Rosa Duarte [8] calculated the direct and indirect $CO_2$ emissions produced in Spain and abroad to assess the exports and imports of the Spanish economy. Then later, they analyzed the environmental impacts of the Spanish economy with the indexes of waste water, nitrogen, metal, BOD, NOx, Sox, and $CO_2$ [9]. In this paper, the extended input-output model is applied to examine the waste gas emission of China in 2007 and re-evaluate the waste gas discharge capacity of each sector from a unitary perspective.

## II. METHODOLOGY

An economic system consisting of n sectors can be described by the equality x=Ax+y in the input-output model, where x=($x_i$) is the production vector, y=($y_i$) is the vector of final demands, and A=($a_{ij}$) is the matrix of technical coefficients. The equation can be rewritten as $x=(I-A)^{-1}\cdot y$, where $(I-A)^{-1}$ is the Leontief inverse. Thus, the direct and indirect production of each sector required to satisfy the final demand in the economy is demonstrated. A parallel model in terms of direct and indirect waste gas emission can be developed following the approach taken by Velázquez [10]

$$g_j^{d*} = g_j^d / x_j \qquad (1)$$

$$g_j^{t*} = g_j^t / x_j \qquad (2)$$

$$G_j^{t*} = G_j^{d*} \cdot \left(I - A\right)^{-1} \qquad (3)$$

where $g_j^{d*}$ and $g_j^{t*}$ are the direct and total waste gas emission intensity of sector *j,* respectively, which represent the amount of direct and total waste gas discharged to increase a monetary unit output in sector *j*. $g_j^d$ and $g_j^t$ represent the direct and total amount of waste gas emitted by sector *j,* respectively. The term $x_j$ represents the monetary output of sector *j*.

The percentage of direct waste gas emission of sector *j* to the gross direct waste gas emission $p_j^d$, the percentage of total waste gas discharge of sector *j* to the gross total waste gas emission $p_j^t$, and the waste gas emission multiplier

$q_j$ are also studied in this paper. The equations are listed below:

$$p_j^d = g_j^d / \sum_{j=1}^{n} g_j^d \quad (4)$$

$$p_j^t = g_j^t / \sum_{j=1}^{n} g_j^t \quad (5)$$

$$q_j = g_j^t / g_j^d \quad (6)$$

To provide a more thorough understanding, the n×n matrix of total waste gas discharge intensity $\mathrm{G}^{t*\prime} = \widehat{\mathrm{G}}^{d*} \cdot (I - A)^{-1}$ was introduced to this study revealing the intersectoral waste gas discharge relationships of all sectors. Then, the new form of the n×n matrix of total waste gas ( $\mathrm{G}^{t\prime} = \mathrm{G}^{t*\prime} \cdot \hat{y}$ ) and waste gas discharge percentage $D_{\mathrm{g}}$ ( $d_{\mathrm{g}ij} = \mathrm{g}_{ij}^{t\prime} \big/ \mathrm{g}_j^t$ ) can be obtained from the prior matrix.

The waste gas emission data of agriculture used in this paper was obtained from the China First National Pollution Census Bulletin, the household and service as well as a detailed industrial waste gas production were taken from the China Environmental Statistics Annual Report 2007. For the economic data, the basic input-output table for China in 2007 was published by the State Statistical Bureau of China. A simplified 2007 input–output table with 26 sectors was created due to the data limitation of every detailed tertiary industry. The sectors of construction, transport, post, and telecommunication services, wholesale and retail trade, restaurant and hotel, real estate, leasing industry, commerce service, banking and insurance, and others were aggregated into household, service, and other sectors.

## III. Results and Discussion

Table 1 shows a series of indicators, including the quantity, percentage, and intensity of direct waste gas emission and total waste gas emission of each sector. The third column exhibits that the amount of waste gas directly emitted by the Production and Distribution of Electric Power and Heat Power (23) was greater than the discharge of the agriculture, household, and other industrial sectors. However, when indirect waste gas emission was referred, it became evident that the waste gas discharged by the agriculture(1), manufacture of general and special purpose (16), manufacture of transport equipment (17), manufacture of electrical machinery and equipment (18), manufacture of communication, equipment, computers and other electronic equipment (19), household, Service and others (26) increased greatly. This indicates that although these sectors directly emitted a small amount of waste gas for production, the intermediate products these sectors consumed with the purpose of supporting their manufacturing process discharged a large amount of waste gas during its production process. This amount of waste gas was counted as the indirect waste gas emission of the final produce sectors.

Production and Distribution of Electric Power and Heat Power (23) has the highest direct waste gas emission while Household, Service, and others (26) was the highest when compared to the total waste gas emission. This verifies that household, service, and others discharged the most indirect waste gas.

Among the industrial sectors, the Production and Distribution of Electric Power and Heat Power (23), the Smelting and Pressing of Metals (14), and the Manufacture of Non-metallic Mineral Products (13) were the three highest direct waste gas dischargers. However, when indirect waste gas was considered, the Smelting and Pressing of Metals (14) surpassed the Production and Distribution of Electric Power and Heat Power (23) to be the largest total waste gas discharger, whereas the Manufacture of Non-metallic Mineral Products (13) ranks fourth followed by the Manufacture of General and Special Purpose (16). Surprisingly, the total waste gas emission of the Chemical Industry (12), an industry with a direct waste gas emission of 36,609.4 × $10^8$ $m^3$ increased to 297,761.41 × $10^8 m^3$ exceeding the Production and Distribution of Electric Power and Heat Power (23), ranking the second largest waste gas discharger in the industrial sectors. This indicates that most of the waste gas it emitted was indirectly from the intermediate supplies by other sectors.

Moreover, after comparing the percentage variations of direct and total waste gas emission of each sector, interestingly, there were 10 sectors with percentages of total waste gas higher than the percentage of direct waste gas, while the other 16 sectors have the opposite condition. This may reflect a neglected fact that those sectors with apparently high direct waste gas emission percentages actually may not be the large waste gas discharger. This may be true when the environment impact was measured in an integrated way, which considers not only just the direct impact from the final production but also the indirect impact from the intermediates manufactured by other sectors, instead of isolating all the sectors from each other.

Furthermore, the values of column 7 and 8 represented the amount of direct and total waste gas emitted while obtaining 1 unit of outcome from the sectors, respectively. In order to obtain $10^9$ yuan of outcome, the Production and Distribution of Electric Power and Heat Power (23) ought to discharge 39.85 × $10^8$ $m^3$ of waste gas, which was the highest in column 7, while Recycling and Disposal of Waste (22) discharged the least waste gas among 26 sectors with 0.04 × $10^8$ $m^3$. Thus, the Production and Distribution of Electric Power and Heat Power (23) was the most waste gas-intensive sector followed by the Manufacture of Non-metallic Mineral Products (13) and the Smelting and Pressing of Metals (14). However, when indirect waste gas

emission was counted in, the Household, Service, and others (26) was unexpectedly the top waste gas-intensive sector followed by the Production and Distribution of Electric Power and Heat Power (23) and Smelting and Pressing of Metals (14) ranking 2nd and 3rd.

The waste gas multiplier is an indicator that demonstrates the 'drag' effect, that is, the number of times the total waste gas is discharged to increase a unit of direct waste gas of a given sector. Take Household, Service, and others (26) as an example, the waste gas emission multiplier listed in the last column was 126.34. This means that when the direct waste gas emission has increased by $1 \times 10^8$ m$^3$, the intermediate it consumed from the other corresponding sectors together would discharge $125.34 \times 10^8$ m$^3$ more waste gas at the same time, resulting in the largest waste gas emission influence to the total economic production. In contrast, the Production and Distribution of Gas (24) with the lowest waste gas emission multiplier of 1.24, actually exerts negligible drag upon the system.

TABLE 1 WASTE GAS EMISSION OF CHINA 2007

| **Sector** | $x_j$ **($10^9$yuan)** | $g_j^d$ **($10^8$m$^3$)** | $p_j^d$ **(%)** | $g_j^t$ **($10^8$m$^3$)** | $p_j^t$ **(%)** | $g_j^{d*}$ **($10^8$m$^3$/ $10^9$yuan)** | $g_j^{t*}$ **($10^8$m$^3$/ $10^9$yuan)** | $q_j$ |
|---|---|---|---|---|---|---|---|---|
| 1. Agriculture | 4,889.30 | 1,089.8 | 0.26 | 47,460.19 | 1.01 | 0.22 | 9.71 | 43.55 |
| 2. Mining and Washing of Coal | 964.50 | 2,361.2 | 0.57 | 9,035.92 | 0.19 | 2.45 | 9.37 | 3.83 |
| 3. Extraction of Petroleum and Natural Gas | 953.49 | 981.4 | 0.24 | 5,896.30 | 0.13 | 1.03 | 6.18 | 6.01 |
| 4.Mining and Processing of Metal Ores | 614.93 | 2,046 | 0.50 | 4,973.06 | 0.11 | 3.33 | 8.09 | 2.43 |
| 5. Mining and Processing of Nonmetal and Other Ores | 385.16 | 1,161.7 | 0.28 | 2,110.18 | 0.04 | 3.02 | 5.48 | 1.82 |
| 6. Manufacture of Foods and Tobacco | 4,179.04 | 7,137.8 | 1.73 | 56,582.11 | 1.20 | 1.71 | 13.54 | 7.93 |
| 7. Manufacture of Textile | 2,519.74 | 3,576 | 0.87 | 32,133.09 | 0.68 | 1.42 | 12.75 | 8.99 |
| 8. Manufacture of Textile Wearing, Apparel, Footware, and Caps, Leather, Fur, Feather and Related Products | 1,807.26 | 424.2 | 0.10 | 13,345.67 | 0.28 | 0.23 | 7.38 | 31.46 |
| 9. Processing of Timber and Furniture | 1,099.39 | 2,407.1 | 0.58 | 8,814.62 | 0.19 | 2.19 | 8.02 | 3.66 |
| 10. Manufacture of Paper and Paper Products, Printing and Manufacture of Articles for Culture, Education and Sport Activity | 1,493.30 | 6,511.4 | 1.58 | 19,103.67 | 0.41 | 4.36 | 12.79 | 2.93 |
| 11. Processing of Petroleum, Coking, Processing of Nuclear Fuel | 2,107.46 | 12,187.9 | 2.96 | 39,161.27 | 0.83 | 5.78 | 18.58 | 3.21 |
| 12. Chemical Industry | 6,199.81 | 36,609.4 | 8.89 | 297,761.41 | 6.33 | 5.90 | 48.03 | 8.13 |
| 13. Manufacture of Non-metallic Mineral Products | 2,280.44 | 67,783.7 | 16.47 | 116,199.83 | 2.47 | 29.72 | 50.96 | 1.71 |
| 14. Smelting and Pressing of Metals | 6,109.60 | 105,547.2 | 25.64 | 437,163.67 | 9.29 | 17.28 | 71.55 | 4.14 |
| 15. Manufacture of Metal Products | 1,770.55 | 2,289.1 | 0.56 | 28,412.48 | 0.60 | 1.29 | 16.05 | 12.41 |
| 16. Manufacture of General and Special Purpose | 3,948.66 | 1,859.4 | 0.45 | 106,494.02 | 2.26 | 0.47 | 26.97 | 57.27 |
| 17. Manufacture of Transport Equipment | 3,297.84 | 3,990 | 0.97 | 71,397.15 | 1.52 | 1.21 | 21.65 | 17.89 |
| 18. Manufacture of Electrical Machinery and Equipment | 2,715.50 | 773.3 | 0.19 | 55,961.44 | 1.19 | 0.28 | 20.61 | 72.37 |
| 19. Manufacture of Communication, Equipment, Computers and other Electronic Equipment | 4,119.03 | 2,349.7 | 0.57 | 98,794.69 | 2.10 | 0.57 | 23.99 | 42.05 |
| 20. Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work | 487.97 | 747.1 | 0.18 | 2,240.24 | 0.05 | 1.53 | 4.59 | 3.00 |
| 21. Manufacture of Artwork and Other Manufacturing | 618.34 | 118 | 0.03 | 2,244.92 | 0.05 | 0.19 | 3.63 | 19.02 |
| 22. Recycling and Disposal of Waste | 436.60 | 15.5 | 0.00 | 153.75 | 0.00 | 0.04 | 0.35 | 9.92 |
| 23. Production and Distribution of Electric Power and Heat Power | 3,148.60 | 125,480.3 | 30.48 | 238,979.47 | 5.08 | 39.85 | 75.90 | 1.90 |
| 24. Production and Distribution of Gas | 110.83 | 362.8 | 0.09 | 448.46 | 0.01 | 3.27 | 4.05 | 1.24 |
| 25. Production and Distribution of Water | 117.88 | 7.4 | 0.00 | 104.73 | 0.00 | 0.06 | 0.89 | 14.15 |
| 26. Household, Service and others | 25,510.68 | 23,838.72 | 5.79 | 3,011,858.70 | 63.99 | 0.93 | 118.06 | 126.34 |

TABLE 2 MATRIX OF TOTAL WASTE GAS DISCHARGE PERCENTAGE

| Sector | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.02 | 0.30 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.03 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 |
| 3 | 0.02 | 0.01 | 0.18 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.08 | 0.02 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.02 | 0.01 | 0.01 |
| 4 | 0.03 | 0.03 | 0.03 | 0.47 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.12 | 0.08 | 0.08 | 0.07 | 0.08 | 0.05 | 0.03 | 0.05 | 0.05 | 0.01 | 0.00 | 0.02 | 0.04 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0.03 | 0.01 | 0.01 | 0.01 | 0.60 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.04 | 0.03 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.00 | 0.00 | 0.01 | 0.03 |
| 6 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.39 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 10 | 0.03 | 0.01 | 0.01 | 0.01 | 0.01 | 0.05 | 0.03 | 0.04 | 0.02 | 0.49 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.02 | 0.03 | 0.01 | 0.00 | 0.00 | 0.01 | 0.03 |
| 11 | 0.06 | 0.03 | 0.04 | 0.03 | 0.02 | 0.04 | 0.04 | 0.05 | 0.03 | 0.02 | 0.36 | 0.06 | 0.01 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.02 | 0.04 | 0.04 | 0.01 | 0.01 | 0.02 | 0.05 |
| 12 | 0.10 | 0.02 | 0.02 | 0.01 | 0.02 | 0.06 | 0.09 | 0.09 | 0.05 | 0.05 | 0.02 | 0.23 | 0.01 | 0.01 | 0.02 | 0.03 | 0.04 | 0.04 | 0.06 | 0.04 | 0.06 | 0.07 | 0.01 | 0.00 | 0.02 | 0.04 |
| 13 | 0.14 | 0.13 | 0.12 | 0.05 | 0.08 | 0.15 | 0.10 | 0.13 | 0.10 | 0.07 | 0.09 | 0.10 | 0.73 | 0.08 | 0.09 | 0.11 | 0.12 | 0.14 | 0.20 | 0.14 | 0.15 | 0.14 | 0.03 | 0.02 | 0.07 | 0.30 |
| 14 | 0.07 | 0.09 | 0.10 | 0.04 | 0.03 | 0.07 | 0.06 | 0.07 | 0.07 | 0.05 | 0.06 | 0.06 | 0.03 | 0.40 | 0.24 | 0.25 | 0.21 | 0.26 | 0.14 | 0.09 | 0.15 | 0.11 | 0.02 | 0.02 | 0.05 | 0.11 |
| 15 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.38 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 |
| 21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23 | 0.39 | 0.30 | 0.39 | 0.32 | 0.18 | 0.32 | 0.37 | 0.35 | 0.25 | 0.22 | 0.28 | 0.36 | 0.13 | 0.27 | 0.33 | 0.34 | 0.30 | 0.30 | 0.32 | 0.20 | 0.32 | 0.36 | 0.87 | 0.06 | 0.65 | 0.29 |
| 24 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.00 | 0.85 | 0.02 | 0.02 |
| 25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 |
| 26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |

Table 2 presents the matrix of intersectoral total waste gas discharge percentages demonstrating the percentages of every sector devoted to the total waste gas discharge of sector *j*. It can be easily noticed that most of the waste gas discharge percentages were relatively low demonstrating that most waste gas transactions between the sectors can be ignored since the transactions were dominated by a few sectors. Among those 26 sectors, Production and Distribution of Electric Power and Heat Power (23) can be the most startling industry. It ranked first in 16 out of the 26 sectors from high to low sorts according to the total waste water emission distribution coefficient of each sector, while for the rest of the 10 sectors, it ranked second. Moreover, it contributed over 30% of the total waste water emission for the 17 sectors proving the fact that Production and Distribution of Electric Power and Heat Power (23) was the main source of waste gas. The next highlighted industries were Manufacture of Non-metallic Mineral Products (13) and Smelting and Pressing of Metals (14). The former occupied the highest discharge percentages in 2 of the sectors, second in 7 sectors, and third in 14 sectors, while the latter held the highest discharge percentages in 1 sector, second in 5 sectors, and third in 8 sectors. Interestingly, among the 26 sectors, there were 18 sectors that maintained themselves in the top three in waste gas discharge transactions with other sectors. This phenomenon can be interpreted in which the waste gas discharge multiplier was an indicator reflecting the proportional relations between the total waste gas discharge quantity and the direct waste gas discharge quality of one sector. In another way, the proportional relations between the indirect waste gas discharge quality and the direct waste gas discharge quality of one sector were also revealed. The higher the waste gas discharge multiplier one sector owned, the higher is the indirect waste gas discharge proportion other intersectoral industries contributed. For those 18 sectors, their relatively lower waste water emission multipliers expressed one fact that they consumed less waste gas discharge produced commercials to keep its normal product. In short, the dependency degrees of waste gas discharge intermediate product of those 18 sectors were lower than the others. Then it made sense that they themselves dominated the top three places in waste gas discharge transactions with other sectors.

## IV. CONCLUSION

This paper quantified the waste gas emission in China in 2007 using an input-output model. The advantage of applying this approach is that it distinguishes direct from indirect waste gas emission in the intermediate manufacturing of products by other sectors. A series of indicators were introduced in order to obtain further understanding of the waste gas emission status from different aspects. The direct and total waste gas emission intensities examined the direct and total waste gas emission for a unit of output in a given sector, respectively, whereas the waste gas emission multiplier reflected the drag effect of a sector, which complements the entire financial group. The result is Production and Distribution of Electric Power and Heat Power was the top direct waste gas maker. It discharged most of the direct waste gas among all the sectors to obtain the same unit of output, and it was also the key industry that brought huge amounts of waste gas emission to other sectors resulting in the dramatic increase of total waste gas discharge. However, when the indirect waste gas emission was added, Household, Service, and others was the highest total waste gas maker and total waste gas-intensive sector. Additionally, it will bring the largest drag effect to the given system when its direct waste gas intensity varies because it has the highest multiplier.

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