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The Change of CO2 Emission on Manufacturing Sectors in Indonesia: An Input-Output Analysis

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Abstract. The objective of this paper is to evaluate the change of CO2 emission on manufacturing sectors in Indonesia using input-output analysis. The method used supply perspective can measure the impact of an increase in the value added of different productive on manufacturing sectors on total CO2 emission and can identify the productive sectors responsible for the increase in CO2 emission when there is an increase in the value added of the economy. The data used are based on Input-Output Energy Table 1990, 1995 and 2010. The method applied the elasticity of CO2 emission to value added. Using the elasticity approach, one can identify the highest elasticity on manufacturing sector as the change of value added provides high response to CO2 emission. Therefore, policy maker can concentrate on manufacturing sectors with the high response of CO2 emission due to the increase of value added. The approach shows the contribution of the various sectors that deserve more consideration for mitigation policy. Five of highest elasticity of manufacturing sectors of CO2 emission are Spinning & Weaving, Other foods, Tobacco, Wearing apparel, and other fabricated textiles products in 1990. Meanwhile, the most sensitive sectors Petroleum refinery products, Other chemical products, Timber & Wooden Products, Iron & Steel Products and Other non-metallic mineral products in 1995. Two sectors of the 1990 were still in the big ten, i.e. Spinning & weaving and Other foods in 1995 for the most sensitive sectors. The six sectors of 1995 in the ten highest elasticity of CO_2 emission on manufacturing which were Plastic products, Other chemical products, Other fabricated metal products, Cement, Iron & steel products, Iron & steel, still existed in 2010 condition. The result of this research shows that there is a change in the most elastic CO2 emission of manufacturing sectors which tends from simple and light manufacturing to be a more complex and heavier manufacturing. Consequently, CO_2 emission jumped significantly.

INTRODUCTION

Manufacturing is usually blamed as one of the major source of CO2 emission due to industrialization. Indonesia as one of emerging market economies accelerated its development through industrialization. Manufacturing is the backbone of industrialization and these sectors become growth machine.

There is still a debate whether economic growth and CO_2 emission has positive relationship. Some researchers showed that CO_2 emission is not sensitive to average economic growth (Holtz-Eakin and Seldena, 1995; Zhan and Cheng, 2009). However, to some extent, there is diminishing marginal propensity to emit (MPE) carbon dioxide as GDP per capita rises. On the other hand, Zhan and Cheng (2009) found that neither carbon emissions nor energy consumption leads economic growth in China.

Fei, Donga, Xuea, Liang, and Yang (2011) examined that there is a positive long-run cointegrated relationship between real GDP per capita and CO_2 emission. It seemed that generally carbon emission will increase as income grows such as demand of carbon-intensive goods and services like air transport and also car transport in many developing countries (Giorgetti, 2007).

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Indonesia as a developing country, of course, faces similar problems like other developing countries. Imansyah et. al. (2013) found that the growth of CO_2 emission during 1990-1995 is 92.82%, from 33,704.31 thousand tons to 64,987.37 thousand tons. The acceleration of economic development to achieve a higher GDP growth in order to increase income of people can cause a higher CO_2 emission.

Previously, the Government of Indonesia devised a National Action Plan on Green House Gas Emission Reduction called the RAN-GRK and set up the greenhouse gas reduction to 26% in 2020 in each sector with national action of self-effort and to 41% reduction with international support. Under the Intended Nationally Determined Contribution (INDC), Indonesia agreed to reduce carbon emissions to 29% in 2030.

One of these efforts is to reduce in manufacturing sectors that become the major contributor of CO_2 emission. Ministry of Industry has identified that there are eight manufacturing sectors as the highest contributors of CO_2 emission to the green-house gas effect which are cement, steel, pulp and papers, petrochemical, fertilizer, ceramic, textiles, and food and beverage sectors in which these sectors use energy more than 6000 TOE [5]. Therefore, these eight sectors were determined as sectors to be the highest priority to be reduced. However, not only the highest contributor sectors to be the target of policy action, but also the most sensitive sectors of CO_2 emission due to the increase of income.

Generally, the identification of key sector of CO_2emission can help the policy maker to mitigate climate change policy by intervening on the key sector of CO_2 emission in manufacturing. The objective of this paper is to identify the most elastic sectors of CO_2 emission in manufacturing due to the increase of income or value added. The period of study is 1990-1995 and 1990-2010.

1. Literature Review

The energy use of carbon-based fuel becomes a major concern in recent years because the CO_2 emission is the key factor in the greenhouse effect and the resulting climate change. Many researches tried to identify the production structure using energy of carbon-based fuel to estimate the contribution of CO_2 emission of energy use by using input-output analysis (see for example Tunç, Türüt-A_ık and Akbostancı (2006); Alcántara and Padilla (2006); Mukhopadhyay (2002a; 2002b).

Input-output analysis is one of powerful analytical tool that can be used to estimate the contribution of CO_2 as well as the impact of energy use in CO_2 emission in disaggregated sectors. There have been many studies to analyze energy use and the impact of CO_2 emission in the input-output analysis context (see Lee, Lin and Lewis (2001); Casler and Rose (1998); Matthews, Weber and Hendrickson (2008); Hondo, Sakai and Tanno (2002); Hikita, Shimpo and Shukla (2007)). However, the studies varied in terms of approach, sectors and region.

Mukhopadhyay (2002a) studied on the sources of CO_2 emission changes in India and he found that CO_2 emission from fossil fuels, emission from coal consumption account for almost 65%. He also found that the primary factors for the increase of CO_2 emissions changes in the rate of added value and changes in final demand during 1973-74 to 1996-1997. However, he argued that the effects of CO_2 intensity observed as a reducing factor.

Indonesia as the fourth largest population in the world becomes important factor in contributing CO_2 emission. Indonesia as developing country, of course, will face high demand of energy to accelerate its development. Consequently, CO_2 emission will increase significantly if there is no technology development in reducing CO_2 emission or energy saving. Price of energy also plays an important role in reducing energy use. For example, during the financial crisis, the use of energy declined substantially and consequently the CO_2 emissions drop. However, this is not the case, as Indonesian development needs more energy. Based on the estimation of Boden, Marland and Andres (2009) from Carbon Dioxide Information Analysis Center, the increase of CO_2 emission per capita was significant, even though the CO_2 emission per capita was relatively low compare to those of other developed countries and emerging market economies. Therefore, Indonesia has to reduce CO_2 emissions by using energy saving technology or introducing renewable energy sources.

In Spain, Alcantara and Padilla (2006) found that the productive sectors that deserve more attention are electricity and gas, land transport, manufacture of basic metals, manufacture of non-metallic mineral products, manufacture of chemicals, manufacture of coke, refined petroleum products and nuclear fuel, wholesale and retail trade, and agriculture. These sectors become the key sectors of CO_2 emission. In Brazil, Imori and Guilhoto (2010) also found that the key sectors cover machinery industries, electric equipment, transportation equipment, textiles and construction sectors.

Meanwhile, Indonesia faces lack of energy supplies such as electricity to accelerate the development. The impact of development is the increase of income. However, the increase of income causes the increase of energy use as well. Alcantara and Padilla (2006) found that the increase of income cause energy demand as well as the growing of CO_2 emissions. Therefore, the policy of generating income should take into account the design of energy and the impact of CO_2 emission. Grubb, Butler and Feldman(2009) argued that there is a relationship between income and CO_2 emissions. However, they found that the relationship between income and CO_2 emission is highly complex and cannot be generalized. In one hand, they found that the growth of GDP per capita was likely associates with the growth of CO_2 emissions, and the amplitude can significantly and depends on other factors specific to each country. On the other hand, the growth of income and CO_2 emission in OECD countries has been stabilizing, declining and increasing CO_2 emission per capita. Therefore, the results are mixed.

In the case of Turkey, the domestic production process contributing to 66% of CO_2 emission in 1996 and sectors that most responsible for those emission are manufacturing industry, energy and mining, other services, and agriculture and animal husbandry (Tunç, Türüt-A_ık and Akbostancı, 2006). Technology plays an important role in reducing CO_2 emission in the production process. Okushima and Tamura (2010) found that technological change is a great importance for curtailing energy use and CO_2 emissions in Japan. They argued that CO_2 emission increased during 1970-1995 primarily because of the economic growth. In contrast, the effects such as technological change for labor or energy mitigated the increase in CO_2 emissions. Meanwhile, the foreign trade may contribute to CO_2 emission like in Brazil due to trade liberalization (Machado, 2000).

In the US, CO_2 emission decreased by 2.38% during 1972 and 1982 (Casler and Rose, 1998). However, the use of a more pollutant energy like coal increased. The result is not a good example for developed country that should use a less pollutant energy used in their production process. Their finding also provided some doubt on the strength of autonomous conservation. The actual conservation was due to price pressure than previously thought during 1972 to 1982. They indicated that even though economic growth alone would have generated an increase in CO_2 emissions, this source was more than offset by the changes in the mix of final demand, inter-fuel substitution, and the KLEM (capital labor energy material) substitution.

Regarding the Indonesian context as one of the emerging market economies, the energy uses with a lower price energy source due to subsidy is rational choice in its policy. In contrast with the US case as a developed country that is still using a lower price energy source like coal, and Indonesia is likely to follow this pattern as well. Therefore, the identification of the energy use precisely will help the policy maker to adopt an appropriate policy to reduce CO_2 emission especially in the key sectors of CO_2 emission.

2. Methodology

The method developed by Alcantara and Padilla [7] will be used in the analysis of the paper. This method can identify the key sector of CO_2 emission. This concept is derived from the concept of key sector of Rasmusen (1956) and Hirschman (1958). Based on that concept, the key sectors are regarded as the most highest impact determined by the multiplier effects of final demand. However, the concept of Alcantara and Padilla (2006) emphasize on the supply perspective rather than demand perspective. With regard to this approach, Alcantara and Padilla (2006) identify the relationship between CO_2 emissions and income generation (in this term, the value-added generated inside a country). The term of key sectors means the highest impact on CO_2 emission due to the increase of income (value-added).

By using this method, one can identify the most sensitive sector in producing CO_2 emission due to the rising of income. This concept is based on the concept of elasticity. This method adapted from Alcántara and Padilla (2006) with the parameter and variable are as follows:

x: (n x 1) total production vector.

v: (n x 1) valued added vector.

A: (n x n) technical coefficient matrix.

s: (n x 1) value added coefficient matrix. This is to show the relationship between value added of sector i (vi) and production of sector i; that is : vi/xi.

u: (n x 1) unitary vector.

c: (n x 1) vector of sectoral direct emissions.

C: scalar that shows level of total CO_2 emission

^: diagonal vector, Thus, it denotes a matrix whose out-of-the diagonal elements are zeros.

(‘) contain of transposition of matrix or vector.

Input-output table used in this paper based on the developed by BPS (Central Statistics Agency). The most recent energy input-output tables are available on 1990 and 1995. As it is discussed previously, the discussion is based supply side input-output table. Therefore, the identity of supply equation is as follows:

$$x = \hat{x}A'u + v \quad (1)$$

Both sides (1) is divided by $\hat{x}^{-1}$ then, it can be obtained:

$$u = A'u + s \quad (2)$$

Therefore, it can be written as follows:

$$u = (I - A')^{-1} s \quad (3)$$

Those expressions are related to production sectors. The distribution is based on productive structure and the weight of income produced from related production itself. If **c**isa vector emitting of CO_2 as defined previously. If both side of equation 3 is multiplied by **c** vector, it will be obtained:

$$c = \hat{c}(I - A')^{-1} s \quad (4)$$

If**g'**=(g1,...,gn) is the distribution of total emission to all productive sectors *n*, then $\sum_{i=1}^{n} g_i = 1$

Then **c** vector c can be rewritten as follows:

$$c = Cg \quad (5)$$

Then

$$c = C\hat{g}(I - A')^{-1} s \quad (6)$$

By multiplying for both side of (6) with **u'**, then it can be obtained:

$$C = Cg'(I - A')^{-1} s \quad (7)$$

The proportional of α in value added will cause, *ceteris paribus*, the increase in total emission:

$$\Delta C = Cg'(I - A')^{-1} s\alpha \quad (8)$$

By dividing both side with total emission of C, it will obtained

$$C^{-1}\Delta C = g'(I - A')^{-1} s\alpha \quad (9)$$

By diagonalizing **s** in (9) it will be obtained a vector as follows:

$$\varepsilon' = g'(I - A')^{-1} \hat{s}\alpha \qquad \varepsilon' = g'(I - A')^{-1} \hat{s}\alpha \quad (10)$$

The characteristic of element εj shows the proportional of change in (direct and indirect) total sectoral emission related to the proportional change of income. This can be interpreted as elasticity. In fact, proportional change of α in income is equal to the ratio of Δvi/vi for each sector. Thus, ε´vector can be rewritten as follows:

$$\varepsilon_i = \frac{\Delta C / C}{\Delta v_i / v_i} = \frac{\Delta C}{\Delta v_i} \frac{C}{v_i} \quad (11)$$

Therefore, the element of vector obtained from (10) represent the proportional change of total emission if any percentage change in value added of each sector. In other words, income elasticity of total emission where can be regarded as measurement of sectoral impact. For a more accurate interpretation, g vector should be diagonalized and it is assumed that α = 1%:

$$E^v = \hat{g}(I - A')^{-1} \hat{s} \quad (12)$$

Characteristic of matrix element E^v, E^v_{ij}, shows the percentage increase of emission in sector i (to total emission) in responding to 1% increase of value added which produce in sector j and can interpereted as elasticity.

The summation of column sector $\sum_{i}^{n} E_{ij}^{v}$ j represents percentage variation in CO_2 emission that emit in economy due to growth of 1% value added in sector j (total impact). The summation of each sector emission (direct impact) $\sum_{j}^{n} E_{ij}^{v}$ shows that the sectoral distribution emission and as an indicator of 1% increase of total impact can cause on emission of each sector (direct impact. The data of these research based on Energy Input-Output Table 1990, 1995 and 2010 produced by Central Statistics Agency.

3. Empirical Results

The contribution of the tenmost elastic in manufacturing sector in intermediate production value is 23.60% of total production among 76 sectors in 1990. The contribution of CO_2 emission is only 4.46% for those 10 sectors. This means that these sectors are minor contributor of CO_2 emission. Meanwhile, in 1995, the contribution of the ten most elastic of manufacturing sectors in production value is 26.61%. However, the contribution of CO_2 emission in these sectors is 20.24% %. In relative term, CO_2 emission jumped substantially by 5 times.

In 2010, the contribution of the ten most elastic manufacturing sectors is 9% of total intermediate production value. However, the contribution of CO_2 of these sectors is 87.13%. This means that only ten sectors in manufacturing contributed almost 90%.

TABLE 1. Manufacturing Sector Elasticity, Percentage Intermediate Value, Valued Added, Final Demand and CO2 Emission in 1990

Rank No.	No Sector	Sector	Global Impact	Direct Impact	Intermediate	VA	FD	CO2 emissions
1	20	Spinning & weaving	0.012090	0.01965	3.77%	1.35%	1.84%	1.97%
2	15	Other foods	0.006160	0.01826	13.78%	3.24%	9.79%	1.83%
3	19	Tobacco	0.001449	0.00195	1.93%	1.89%	2.35%	0.19%
4	22	Wearing apparel & oth. fabrct. txt. prdc.	0.001081	0.00180	1.55%	0.54%	1.42%	0.18%
5	16	Animal feeds	0.001035	0.00059	0.39%	0.18%	0.02%	0.06%
6	17	Tea and coffee	0.001027	0.00114	0.34%	0.39%	0.42%	0.11%
7	14	Meat & meat products	0.000685	0.00061	1.67%	0.39%	0.95%	0.06%
8	18	Beverages	0.000598	0.00056	0.18%	0.13%	0.13%	0.06%
9	21	Knitting	0.000346	0.00086	0.23%	0.10%	0.26%	0.09%
10	13	Dairy products	0.000206	0.00056	0.35%	0.08%	0.27%	0.06%
		Total			**23.60%**	**8.11%**	**16.93%**	**4.46%**

Source: BPS, Input-Output Energy Table 1990, calculated by authors.

TABLE 2. Manufacturing Sector Elasticity, Percentage Intermediate Value, Valued Added, Final Demand and CO2 Emission in 1995

Rank No.	No Sector	Sector	Global Impact	Direct Impact	Intermediate	VA	FD	CO2 emission
1	32	Petroleum refinery products	0.028900	0.007088	2.32%	1.23%	0.75%	0.71%
2	31	Other chemical products	0.026524	0.007716	2.16%	1.08%	0.48%	0.77%
3	24	Timber & wooden products	0.023218	0.046757	2.84%	1.24%	1.42%	4.68%
4	40	Iron &steel products	0.019267	0.022842	0.96%	0.70%	0.14%	2.28%
5	38	Oth. non-metallic mineral prdc.	0.017458	0.035648	0.49%	0.31%	0.08%	3.56%
6	20	Spinning & weaving	0.016831	0.024700	3.52%	1.66%	1.77%	2.47%
7	26	Pulp, paper & paper products	0.015376	0.022471	1.49%	0.64%	0.46%	2.25%
8	15	Other foods	0.014110	0.035215	12.83%	4.55%	10.16%	3.52%
9	36	Cement	0.013017	0.028168	0.33%	0.18%	0.00%	2.82%
10	50	Other machinery & equipment	0.010154	0.000890	1.72%	0.63%	2.73%	0.09%
		Total			**26.61%**	**11.41%**	**15.26%**	**20.24%**

Source: BPS, Input-Output Energy Table 1995, calculated by authors.

TABLE 3. Manufacturing Sector Elasticity, Percentage Intermediate Value, Valued Added, Final Demand and CO2 Emission in 2010

Rank No.	No Sector	Sector	Global Impact	Direct Impact	Intermediate	VA	FD	CO2 Distribution
1	35	Plastic products	0.071967	0.289035	1.20%	0.39%	1.09%	
2	31	Other chemical products	0.070339	0.001257	2.44%	1.03%	1.00%	0.13%
3	43	Other fabricated metal products	0.060107	0.155343	2.12%	1.25%	0.48%	15.53%
4	36	Cement	0.051737	0.125791	0.35%	0.25%	0.01%	12.58%
5	40	Iron & steel products	0.045083	0.181516	0.39%	0.12%	0.08%	18.15%
6	39	Iron and steel	0.041302	0.108620	0.18%	0.07%	0.05%	10.86%
7	32	Petroleum refinery products	0.034075	0.000003	1.41%	2.06%	1.28%	0.00%
8	26	Pulp, paper &paper products	0.006396	0.009700	1.11%	0.65%	0.79%	0.97%
9	45	Other elect. machin. & apprts	0.004974	0.000629	3.59%	1.99%	3.37%	0.06%
10	50	Other machinery& equipment	0.003823	0.000191	1.02%	0.36%	1.94%	0.02%
		Total			**9.20%**	**5.82%**	**4.77%**	**87.13%**

Source: BPS, Input-Output Energi Table 2010, calculated by authors.

The highest CO_2 emission in manufacturing sectors are Spinning and weaving, Other foods, Tobacco, and Wearing apparels and other fabric textiles in 1990. It seems that manufacturing sectors just began with food and textiles related sectors reflecting basic need of developing country to fulfil domestic demand as import substitution industry in 1990. These sectors are the most elastic/sensitive to income or value added changes in producing CO_2 emission. However, it might be that other sectors in manufacturing have not developed yet. These ten sector only produce CO_2 emission less than 5% of the total CO_2 emission.

These ten of the most sensitive sectors contribute 23.60% of intermediate production value and 16.93% of final demand value. This means that the technology used had not emitted high CO_2. Sectors with high sensitivity to income change means that the increase of income will increase CO2 emission in a higher proportion.

The highest elasticity of CO_2 emission in manufacturing sectors are Petroleum refinery products, Other chemical products, Timber and wooden products, Iron and steel products, and Other non-metallic mineral products in 1995. This indicated that manufacturing sectors experienced structural change from simple and light technology manufacturing shift to a more medium technology and a more complex such as petroleum refinery products and chemical product manufacturing. As the more advance technology used, intermediate production valued and final demand relatively did not change very much in terms of the proportion value which were 26.61% and 15.26%, respectively. However, CO_2 emission in these sectors jumped to 20.24%. This indicated that these sector with a more advance technology produced more CO_2 emission. It might that the technology needs more energy and consequently it produced more CO_2 emission.

In 2010, the ten most sensitive sectors in manufacturing are Plastic products, Other chemical products, Other fabricated metal products, Cement, Iron and steel products, Iron and steel etc (see Table 3). These sectors are a more complex and continuum to heavy industry compared to that of 1995 the condition. However, the value of intermediate production is only 9.20% and even the value of final demand is only 4.77%. On the other hand, the CO_2 emission of these sectors was 87.13%. This means that other sectors consisting of 66 sectors including manufacturing only account for about 13% CO_2 emission of total CO_2 emission. Sectors with the highest contributor of CO_2 emission are Plastic products, Other fabricated metal products, Cement, Iron and steel products and Iron and steel. These chemical and heavy industries produced more than 10% of each sector. Even, Plastic products manufacturing contributed to 28.90% of total CO_2 emission.

The comparison of two periods of 1990 and 1995 showed that only two sectors are still in top ten sectors with the highest elasticity in emitting carbon dioxide. These two sectors are Spinning & weaving and Other foods. Using two periods (1990 dan 1995), one can identify the trend. However, because of the radical structural change, it is important to note that most of light manufacturing for food and textiles and related products had shifted in terms of their sensitivity and replaced by other slightly heavier manufacturing such as Petroleum refinery products, Other chemical products, Timber & wooden products, Iron& steel products. The comparison of these two periods with only 5 years showed that there was great structural change.

Compared to other periods, 1995-2010, there are six sectors that still existed in 1995 and 2010. The sectors are Other chemical productsCement, Iron &steel products, Petroleum refinery products, Pulp, paper &paper products and Other machinery & equipment.

There are two explanations to this phenomenon. First, the manufacturing sector technology of those sectors relatively unchanged. Second, manufacturing sector post Asian financial crisis did not develop anymore. Yusuf and Sumner (2015) argued that there was a premature deindustrialization post Asian Financial Crisis 1997/1998.

In 2010, ten key sectors of the most sensitive of CO_2 emission due to income change are Plastic products, Other chemical products, Other fabricated metal products, Cement, Iron & steel products, Iron &steel etc (see Table 3).

Percentage of CO_2emission is 87.13%of total CO_2 emission. The amount of CO_2 emission of manufacturing sectors is 10,185,356 thousand tones in 2010. During 15 years of 1995-2010, the trend shows that six sectors are still in the ten most sensitive sectors in CO_2 emission due to income change, Other chemical productsCement, Iron & steel products, Petroleum refinery products, Pulp, paper &paper products and Other machinery & equipment.

4. Conclusion and Policy Implication

Generally, during 1990-1995, CO_2 emission in the key sector increase significantly which jumped from 4.46% to 20.24% in 1995. Only two sectors are still in the key sectors. These two sectors areSpinning & weaving and Other foods.There was a significant structural change between these periods.

However, during 15 years of 1995-2010, CO_2 emission in the ten key sector increases significantly from 20.24% in 1995 to 87.13% in 2010. During these periods, the trend shows that six sectors are still in the ten most sensitive sectors in CO_2 emission due to income change. These six sectors have global impact in the highest ten sectors during the period of 1995-2010. It is important to note that some sectors have high global impact such as Plastic products with global impact at 0.071967. This means that if there is any income change of 1% will increase CO_2 emission 0.072%. The result shows that the most sensitive sectors are Plastic products, Other chemical products, Other fabricated metal products, Cement, Iron &steel products, Iron & steel are the sectors with the highest elasticity of CO_2 emission due to income change. This means that the increase of income will increase CO_2 emission due to the increase of those industries.

Therefore, policy maker can concentrate on sectors with the high response of CO_2 emission due to the increase of value added. The approach shows the contribution of the various sectors that deserve more consideration for mitigation policy. This policy can be concentrated to business players as they are producers on goods and services to use technology with lower CO_2 emission. It is suggested that demand perspective of the key sectors of CO_2.

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REFERENCES

1. Alcantara, Vincent and Emilio Padilla, *An Input-Output Analysis of the "Key" Sectors in CO2 Emissions from a Production Perspective: An Application to the Spanish Economy* (http://www.eacb.uab.es. (2006).
2. Boden, Tom, Gregg Marland and Robert J. Andres,*National CO2 Emissions from Fossil-Fuel Burning, Cement Manufacture and Gas Flaring: 1751-2006, Indonesia* (Carbon Dioxide Information Analysis Center, see http://cdiac.ornl.gov/trends/emis/ido.html, 2009).
3. Casler, Stephen D and Adam Rose, *Carbon Dioxide Emissions in the US Economy: a Structural Decomposition Analysis* (Environmental and Resource Economics, April 1998, Volume 11, Issue 3-4; 1998), pp. 349-363.
4. Fei , Li, Suocheng Dong, Li Xue, Quanxi Liang, and Wangzhou Yang,*Energy Consumption-Economic Growth Relationship and Carbon Dioxide Emissions in China* (Energy Policy, Volume 39, Issue 2, February 2011), pp. 568–574.
5. Giorgetti, Annabelle, *A Discussion on Cecoupling Economic Growth from the Emissions of Carbon Dioxide* (Environment Waikato Technical Report 2007/02, see http://www.waikatoregion.govt.nz/PageFiles/6131/tr07-02.pdf, 2007).

6. Grubb, Michael, Lucy Butler and Olga Feldman, *Analysis of the Relationship between Growth in Carbon Dioxide Emissions and Growth in Income*, see http://www/econ.cam.ac.uk/faculty/grubb/publications/GA.pdf.
7. Hikita, Koichi et. al., *Making Input-Output Tables for Environmental Analysis for India: 1993/94 and 1998/1999*(paper presented at the 16th International Input-Output, 2007).
8. Hirschman, A.O, *The Strategy of Economic Development* (Yale University Press, New York,1958).
9. Holtz-Eakin, Douglas, and Thomas M. Seldena, *Stocking the fires? CO_2 Emissions and Economic Growth* (*Journal of Public Economics*, Volume 57, Issue 1, May 1995), pp. 85–101.
10. Hondo, Hiroki, Shinsuke Sakai and Shiro Tanno,*Sensitivity Analysis of Total CO2 Emission Intensities Estimated Using Input-Output Table* (*Applied Energy*, Vol. 72. 2002), pp. 689-704.
11. Imansyah, M. Handry et. Al, *The Key Sectors in CO2 Emission in Indonesia: Input Output Analysis* (*Jurnal Ilmu Administrasi dan Organisasi,* January 2013*),* at http://journal.ui.ac.id/index.php/jbb/article/viewFile/1867/1462.
12. Imori, Denise and Joaquim Jose Martins Guilhoto, *Brazilian Productive Structure and CO2 Emissions*, (http://mpra.ub.uni-muenchen.de/30695/ MPRA Paper No. 30695, posted 4. May 2011 20:45 UTC: 2010).
13. Lee, Cheng, Sue J. Lin and Charles Lewis, *Devising an Integrated Methodology for Analyzing Energy Use and CO2 Emissions From Taiwan's Petrochemical Industries*(*Journal of Environmental Management*, Vol. 63, 2001), pp. 377-385.
14. Machado, Giovani Victoria, *Energy Use, CO2 Emissions and Foreign Trade: an IO Approach Applied to the Brazilian Case* (paper at 13th International Conference on Input-Output Techniques, 21-25 August 2000, Macerata, Italy, 2000).
15. Matthews, H. Scott, Christopher Weber, Chris T. Hendrickson, *Estimating Carbon Footprints with Input-Output Models* (paper presented at International Input-Output Meeting on Managing the Environment in Seville (SPAIN), July 9 - 11, 2008. at http://www.upo.es/econ/IIOMME08).
16. Mukhopadhyay, Kakali, *Sources of CO2 Emission Changes in India during 1973-74 to 1996-1997: A Structural Decomposition Analysis* (paper at 14th International Conference on Input-Output Techniques, October 10-15, 2002, Quebec University, Montreal Canada, 2002a).
17. Mukhopadhyay, Kakali*, An Input-Output Study of the Relationship Between Information Sector, Energy Use and CO2 Emission in the Indian Economy during 1973-74 to 1996-97* (paper at 14th International Conference on Input-Output Techniques, October 10-15, 2002, Quebec University, Montreal Canada, 2002b).
18. Okushima, Shinichiro and Makoto Tamura, *Multiple Calibration Decomposition Analysis: Energy Use and Carbon Dioxide Emissions in the Japanese Economy, 1970–1995* (*Energy Economics*, Volume 32, Supplement 1, September 2010), pp. S41–S46.
19. Rasmussen, P.N, *Studies in Intersectorial Relations*(North-Holland P.C, Amsterdam, 1956).
20. Tunc, G. Ipek, Serap Turut-Asik and Elif Akbostanci, *CO2 Emission vs CO2 Responsibility: an Input-Output Approach for Turkish Economy* (http://www.erc.metu.edu.tr/menu/series06/0604.pdf. 2006).
21. Yusuf, Arief Anshory and Summer, Andy, *Survey of Recent Developments* (Bulletin of Indonesian Economic Studies, Vol. 51. No. 3 December 2015).
22. Zhang, Xing-Ping, and Xiao-Mei Cheng, *Energy Consumption, Carbon Emissions, and Economic Growth in China* (Ecological Economics, Volume 68, Issue 10, 15 August 2009), pp. 2706–2712.