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Environmentally-Extended Input Output Tables – Integrated Analysis for Low Carbon Development in Indonesia

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Abstract:
Low carbon development is a paradigm of forward-looking economic development that encompasses low-emission and climate-resilient economic growth. The government of Indonesia has integrated the climate change issues into the 2020-2024 National Medium-Term Development Plan. Therefore, there is a need for a statistical tool to analyse the impact of some policies to both economic growth and environmental pressure simultaneously. This paper conducts an overview in producing environmentally-extended input-output table (EE-IOT) for Indonesia. The construction of EE-IOT integrates economic statistics from input-output tables as well as environmental statistics from physical flow accounts compiled using System of Environmental-Economic Accounting (SEEA) framework. The integrated statistics in the EE-IOT is used to evaluate the effects of the change in demand resulted from particular policies on the increase of carbon dioxide emission in addition to the growth of gross domestic product.

Keywords: CO_2 emission; environmental accounting; input-output model; multiplier analysis

1. Introduction:

The Government of Indonesia has declared to integrate climate action into the country's national development plan, which aims to incorporate greenhouse gas (GHG) emissions reduction targets into the low carbon development policies. The policies are expected to be internalized into the 2020-2024 National Medium-Term Development Plan.

Currently, Indonesia has an unconditional nationally determined climate target of 29 percent less emissions in 2030 compared with baseline. Therefore, the policy-makers should formulate new low carbon policies that encompasses low-emission and climate-resilient economic growth. The process of formulating the low carbon development policies requires various data and information on the economy as well as on the environment. An integrated statistical framework is needed to help the policy-makers to have better understanding the interconnection between economic sectors and the environment.

This paper aims to compile Environmentally-Extended Input-Output Tables (EE-IOT) for Indonesia by integrating economic statistics from standard input-output tables with environmental statistics from physical flow accounts, particularly air emission accounts, which is compiled based on 2012 System of Environmental-Economic Accounting (SEEA). This paper also conducts simple analysis using the EE-IOT to determine the key economic sectors to lead the development into low carbon pathway.

2. Methodology:

The Environmentally-Extended Input-Output Table (EE-IOT) is a standard economic input-output table extended to environmental flows. The data set combines information on economic flows measured in monetary units with information on environmental flows, such as flows as natural inputs or flows of residuals, that are measured in physical units. It enables more comprehensive and integrated analysis in terms of sustainable economic development. In relation with low carbon development, the multiplier analysis of EE-IOT could be used to analyse the effects of certain policies not only on economic output but also on environmental pressures, such as carbon dioxide emissions.

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The construction of EE-IOT requires both economic input-output tables and environmental accounts with the same classification. This paper used the most recent input-output tables published by BPS-Statistics Indonesia who regularly produces the input-output tables every five years. In order to obtain the information on carbon dioxide emissions as the environmental flows in the EE-IOT, the compilation of air emission accounts is needed.

Air emission accounts record the flows of gaseous and particulate materials from the economy into the environment. The compilation of air emission accounts used the energy-first approach as Indonesia has compiled energy flow accounts based on energy balances using 2012 System of Environmental-Economic Accounting Central Framework (SEEA-CF). The information of energy use by industry is used as the basis for calculating carbon dioxide emissions from fuel combustion. The calculation of carbon dioxide emissions used emission factor from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

In addition to emissions from fuel combustion, the carbon dioxide emissions are also generated from non-combustion activities, such as industrial processes and product use (IPPU), agriculture, and waste. The data on those non-combustion emissions are obtained from national greenhouse gas inventories. However, the data still need to be allocated by industry with the same classification as the emissions from fuel combustion activities. Both the emissions from fuel combustion activities as well as the emissions from non-combustion activities are aggregated to obtain the carbon dioxide emissions by industry.

The EE-IOT compiled by integrating input-output tables and air emissions accounts could be used to build a model to estimate the total environmental pressures (r_{tot}) as a function of the intensity of the environmental pressure in each industry (δ), the domestic output of each industry (L_d) and the various sources of final demand (y_d), including household consumption, capital formation, and exports. The formula to estimate the total environmental pressure is given below.

$$r_{tot} = \delta \cdot L_d \cdot y_d$$

where

r_{tot}	total environmental pressure (scalar)
δ	intensity of environmental pressure (vector 1 by j)
L_d	Leontief inverse of use of domestic output (matrix j by j)
y_d	final demand of domestic output (vector j by 1)

For the purpose of low carbon development plan, the multiplier analysis was undertaken on the EE-IOT to describe the effects of a unit increase in final demand to the increase in economic output as well as in carbon dioxide emissions. This analysis used environmental multiplier (α) which was derived by multiplying the intensity of the environmental flow for each industry (δ) by the structure of output for each industry (L).

$$\alpha = \delta \cdot L$$

Another analysis that could be undertaken using the EE-IOT framework is to identify the key economic sectors. It used inter-industrial linkage analysis, such as backward linkage and forward linkage. Backward linkage indicates the interconnection of a particular industry to other industries from which it purchases inputs, meanwhile the forward linkage indicates the interconnection of a particular industry to other industries to which it sells its output.

The backward linkage is calculated from the Leontief inverse $(I - A)^{-1}$ where A is an input coefficient matrix. The backward linkage of the sector j (BL_j) is calculated using the formula below.

$$BL_j = \sum_{i=1}^{n} l_{ij}$$

On the other hand, the forward linkage is calculated from the Ghosh inverse $(I - B)^{-1}$ where B is an output coefficient matrix. The forward linkage of the sector i (FL_i) is calculated using the formula below.

$$FL_i = \sum_{j=1}^{n} g_{ij}$$

The identification of the key sector is undertaken by identifying a sector with both normalized backward linkage (NBL) and normalized forward linkage (NFL) has value more than 1 respectively. The NBL_j and NFL_i are computed as:

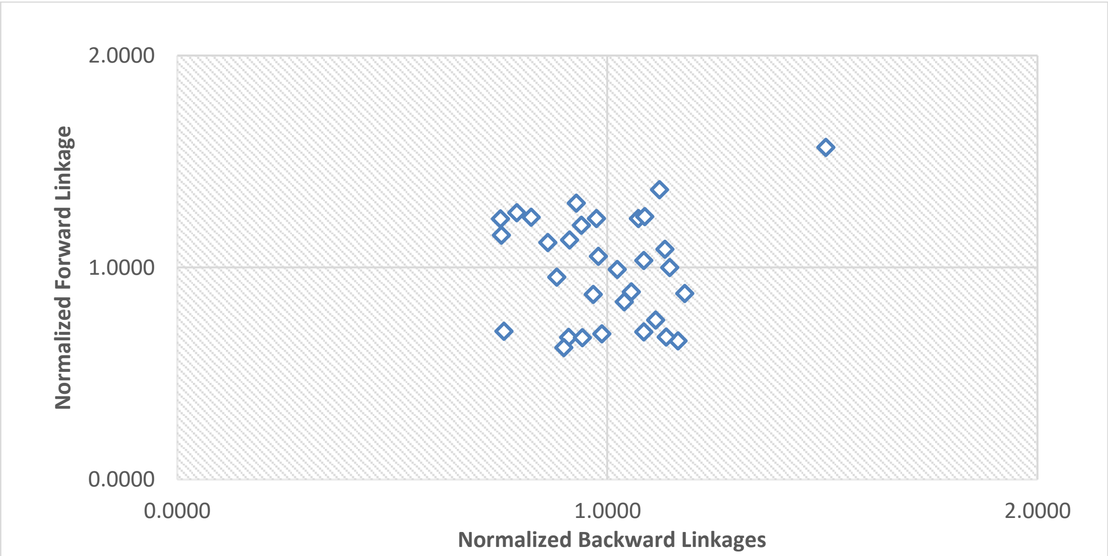
$$NBL_j = \sum_{i=1}^{n} l_{ij} \,/\, \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} l_{ij}$$

$$NFL_i = \sum_{j=1}^{n} g_{ij} \,/\, \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} g_{ij}$$

3. Result:

The calculation of normalized backward linkage as well as normalized forward linkage for each economic sector in the EE-IOT resulted in 7 key sectors which has the value of both NBL and NFL more than 1 as presented in the figure 1 below.

Figure 1. NBL an NFL of each Economic Sector in the EE-IOT



The key sectors often become the main sectors targeted by the policy makers to where to increase the final demand. The increase in final demand in those key sectors would increase their own output, and eventually more capable to improve the overall economic sectors. However, by using the EE-IOT framework, the policy makers not only make decisions based on economic information but they also could consider the environmental factors, such as the increase of carbon dioxide emissions resulted from the increase of output. Table 1 below presents the output multiplier as well as carbon dioxide emission multiplier of the seven key sectors.

Table 1. Output Multiplier and CO_2 Multiplier of Key Sectors

Sectors	NBL	NFL	Output Multiplier	CO_2 Emission Multiplier
Electricity and gas supply	1.5075	1.5671	2.5592	0.8060
Manufacture of rubber and plastics products	1.1450	1.0007	1.9438	0.0461
Manufacture of basic metals	1.1339	1.0870	1.9250	0.1254
Manufacture of paper, paper products, printing and reproduction of recorded media	1.1213	1.3679	1.9035	0.0658
Manufacture of other non-metallic mineral products	1.0867	1.2413	1.8448	0.2819
Other manufacturing, repair and installation of machinery equipment	1.0842	1.0337	1.8406	0.0619
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1.0719	1.2311	1.8197	0.1308

Table 1 above shows that while some sectors have high output multiplier, they might also have relatively high carbon dioxide emission multiplier. It indicates that when economic development was driven by sectors with high output multiplier and carbon dioxide emission multiplier, the rise on economic growth might also accompanied by the increase of environmental degradation. For example, the electricity and gas supply sector has output multiplier and carbon dioxide emission multiplier of 2.5592 and 0.8060 respectively. Therefore, an increase in final demand of IDR 1 million for electricity and gas supply, the output of this sector would rise IDR 2.5592 million. However, it would also create 0.8060 ton of carbon dioxide emission to the atmosphere. It would be better for the environment, in terms of carbon dioxide emission, to increase the final demand for rubber and plastic products as it is also one of the key sectors but with less carbon dioxide emission multiplier.

4. Discussion, Conclusion and Recommendations:

In conclusion, the EE-IOT provide an integrated framework to analyse the interconnection between economic sectors and environmental flows. It enables the policy-makers to consider the trade-offs between economic growth and environmental degradation in order to achieve the low carbon development.

However, there are many aspects on environmental degradation that needed to take into accounts. This paper has only included information on carbon dioxide emissions as the additional environmental flows within the EE-IOT framework. There are still other greenhouse gases which emissions also harms the environment, such as methane and nitrous oxide. The environmental flows not only comprise air emission, but also water emission, energy use, water use, waste generation, and natural inputs. Therefore, it is recommended to compile physical flow accounts for those environmental flows using the SEEA framework, which is in line with System of National Accounts (SNA) framework, so that the information on environmental flows would be already has the same concepts, definitions, coverages, and classifications. Thus, that information could be integrated directly into the standard input-output tables to construct more comprehensive EE-IOT.

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