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The impact of energy and air emissions in a changing economic structure: Input-output approach

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Abstract. Carbon dioxide (CO_2) emissions are considered as one of the main sources of climate change. The problem recently arises when we want to identify which are the most caused to CO_2 emission or even which are the most environmentally harmful sectors. This paper presents an attempt for trying to estimate air emission when changing economic structure. The methodology used in the study is based on Miyazawa's concept of the inter-relational income multiplier, it was designed to analyse the structure of income distribution by final demands in the standard Leontief's system.

Keywords: Vietnam, input-output analysis, CO_2 emission, economic structure.

1. Introduction

Climate change has the potential to significantly affect national and regional economies. Climate change is currently on the main stream of economic research and particularly in input-output environmental analysis. This analysis is increasingly becoming an important tool for measuring economic and environmental effects of sustainable development policy.

Input-output analysis deals with inter-industrial relationships. This analysis describes and explains the level of output of each sector of a given national economy in terms of its relationship to the corresponding levels of activities in all other sectors. In the 1970s the basic model was introduced in an article by Leontief [1]. His paper explained how such "externalities" can be incorporated into the conventional input-output picture of a national economy. According to Leontief 1970's study, the environmental impact of final consumption was expressed as an undesirable externality of the production process, the CO_2 emission is a by-product of regular economic activities. In each of its many forms CO_2 emission is related in a measurable way to some particular consumption or production process.

Vietnam has enjoyed a great deal of rapid economic growth in recent decades, due to the opening-up of a market-oriented economy system. There are however, controversies over environmental issues as side-effect of speedy growth, which have been reported widely nationally. A great deal of research has extensively considered environmental issues as a threat, which may impose negative impacts on the benefits of growth itself, or which may keep

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current economic trends from being sustainable (Bui and Nguyen) [2].

Our research is an attempt to try to estimate air emission in a changing economic structure. The methodology of this paper is based on Miyazawa's concept of the inter-relational income multiplier. It was designed to analyse the structure of income distribution by final demand in the standard Leontief system. These ideas were also incorporated in the familiar social accounting system developed by Stone [3], Pyatt and Rose [4]; and in parallel developments of demographic-economic modelling associated with Batey and Madden [5]. Moreover, this study is the linkage between input-output extension and vector of air emission follow Leontief's system.

This study draws on Miyazawa's [6] extended input-output analysis and, in particular, focuses on the estimates of 1) The inter-relational income multiplier for the demographic-economic modelling, and, 2) the impact on CO_2 emission of time.

The study also measures the change in CO_2 emission by sectors from 2005 to 2007. The economic structure of 2005 is based on the input-output table of 2005, the economic structure of 2007 is based on the input-output table of 2007. The input-output tables of 2005 and 2007 are at 2005's price. These tables will aggregate 4 sectors (1) Electricity, (2) Energy, (3) Manufacturing and construction, (4) other sectors. The data on CO_2 emission was found on the website "Earthtrends" [7].

2. Methodology

2.1. Demographic-Economic framework

In some sense, Miyazawa's system may be considered the most economical in term of the way it extends the familiar input-output system as follow:

$$\begin{pmatrix} X \\ T \end{pmatrix} = \begin{pmatrix} A & C \\ V & 0 \end{pmatrix} \begin{pmatrix} X \\ T \end{pmatrix} + . \begin{pmatrix} f \\ g \end{pmatrix} \qquad (1)$$

Where:

X is a vector of output, T is a vector of total income, and includes income from production and over-production (property income and transfer income). T also may be a matrix of income groups. A is a sub-matrix of direct intermediate input. V is a matrix of value-added ratios of income groups; C is a corresponding matrix of consumption coefficients, f is a vector of final demand, excluding household consumption. g is a vector of the exogenous income of income groups. Sonis and Hewings [8] extended this framework using the following perspective:

$$\begin{pmatrix} X \\ T \end{pmatrix} = \begin{pmatrix} (I-A-CT)^{-1} & BCK \\ KVB & K \end{pmatrix} \begin{pmatrix} X \\ T \end{pmatrix} .. \begin{pmatrix} f \\ g \end{pmatrix} \qquad (2)$$

Where:

$B = (I-A)^{-1}$ is the Leontief inverse matrix

$(I-A-CT)^{-1}$ is an enlarged Leontief inverse matrix. The elementary of this matrix includes direct impact, indirect impact and induce effects from household consumption. These impacts contain elements which are large than those of the $(I-A)^{-1}$ matrix, because they include extra output required to meet consumption.

BCK is a consumption multiplier matrix.

KVB is a income multiplier matrix.

K is a matrix of the Miyazawa inter-relational income multiplier.

2.2. Hybrid input-output extended

Called:

$$U = \left\langle \frac{(I - A - AT)^{-1}}{KVB} \middle| \frac{BCK}{K} \right\rangle$$

From equation (2) we have:

$$\begin{pmatrix} X \\ T \end{pmatrix} = U . \begin{pmatrix} f \\ g \end{pmatrix} \qquad (3)$$

The basic relation of environmental-economic linkage is shown in equation form as follows:

$$E = Ej.U.\left\langle \begin{matrix} f \\ g \end{matrix} \right\rangle \quad (4)$$

E is a matrix of value of emission by production and consumption and Ej is a matrix of emission coefficient that was discharged by economic activity and household consumption.

In the hybrid IO model, it is possible to estimate the total amount of each type of waste produced when a unit of final use is produced. Total waste here is understood as direct waste generated in the process of producing one unit, and waste generated indirectly in the production process of an industry which used other industry's products for their input. So we can estimate the total waste, demand for using waste and the waste left when final demand or GDP is changed, such as waste dispersed into the environment can be estimated when GDP increase 1%.

3. Empirical study

3.1. Electricity and energy requirement for a unit increase of final products in 2005 and 2007

Table 1 shows that the requirement of electricity for a unit of final use increased from 1.25 in 2005 to 1.29 in 2007. The surprising thing is that this is increasing by itself as a direct impact. So we can say that was the cause of the electricity demand increasing due to the loss of production processing.

Table 1. Electricity requirement for a unit increasing of final products in 2005 and 2007

(Unit: Times)

	2005			2007		
	Total impact	Direct	Indirect	Total impact	Direct	Indirect
Electricity	1.07864	0.05894	1.01970	1.16910	0.13803	1.03107
Energy	0.05314	0.03972	0.01342	0.02180	0.01050	0.01130
Manu. & Construct	0.06111	0.01921	0.04190	0.04841	0.01285	0.03556
Transportation	0.02761	0.00380	0.02381	0.02166	0.00321	0.01845
Others	0.03018	0.01268	0.01750	0.03219	0.01525	0.01694
Total	1.25070	0.13436	1.11634	1.29315	0.17983	1.11332

Source: The authors calculated based on the Vietnam input - output table, 2007.

The energy requirement increase for a unit of final demand was about 5% from 2005 to 2007. This increase was due to the transportation sector.

Table 2. Energy requirement for a unit increasing of final products in 2005 and 2007

(Unit: Times)

	2005			2007		
	Total impact	Direct	Indirect	Total impact	Direct	Indirect
Electricity	0.18614	0.14514	0.04100	0.13036	0.08822	0.04213
Energy	1.08802	0.05681	1.03121	1.10989	0.07007	1.03982
Manu. & Construct	0.12413	0.03396	0.09018	0.10198	0.02369	0.07829
Transportation	0.27321	0.22494	0.04828	0.43869	0.36069	0.07800
others	0.07950	0.04008	0.03942	0.06353	0.02710	0.03643
Total	1.75101	0.50092	1.25008	1.84445	0.56977	1.27467

Source: The authors calculated based on the Vietnam input - output table, 2007.

3.2. Estimating CO_2 emission in 2007

In Table 3 the data on CO_2 emission in 2005 at Earthtrends [7] the CO_2 emission was estimated by sector for 2007. In Table 4 is the economic structure from input-output tables for Vietnam in 2005 and 2007 [9],. We can see that the CO_2 emission growth is much higher than the growth of GDP so. GDP growth from 2007 to 2005 is about 132% compared to be total CO_2 emission growth of about 144%.

Table 3. The CO_2 Emission in 2007 (Unit: Billion ton)

	2005	2007	Change
Electricity	11.95	17.85	149.3%
Energy	0.29	0.19	66.0%
Manu. & Construct.	15.02	20.88	139.0%
Transportation	12.43	19.47	156.6%
Others	5.14	6.46	125.7%
Household consumption	3.17	4.18	132.0%
Total	48.00	69.02	143.8%

Source: The authors calculated based on the Vietnam input - output table, 2007 and data from http://earthtrends.wri.org/pdf_library/data_tables/cli2_2005.pdf.

Table 4. GDP by economic sector and Households Expenditure (Unit: Bill.VND)

	2005	2007	Change
GDP	818,455	960,933	117.4%
Electricity	27,211	38,531	141.6%
Energy	96,695	63,735	65.9%
Manu. & Construction	243,122	321,153	132.1%
Transportation	19,007	20,866	109.8%
Others	432,421	516,648	119.5%
Household consumption	542,489	715,913	132.0%

Source: The authors calculated based on the Vietnam input - output table, 2007.

Table 5 shows when increasing a unit of household consumption lead to the highest CO_2 emission levels (44%). Household consumption of electricity lead to the highest CO_2 emission levels in the 5 sectors. Export will be also lead to rather high CO_2 emission levels.. But the surprise is that export energy will lead to very high CO_2 emission levels (97% in total CO_2 emissions induced by final demand). So, export energy is not only a loss of national resources but the cause of high CO_2 emission levels.

Table 5. CO_2 emission induced by factor of final demand (Unit: %)

	C	I	E	Total
Electricity	60.34	11.99	27.67	100
Energy	3.06	0.20	96.75	100
Manu. & Construction	24.50	22.98	52.52	100
Transportation	49.02	15.27	35.70	100
Others	48.93	17.53	33.54	100
Total	43.96	17.05	38.98	

Note: C is consumption, I is gross capital formation and E is export.

4. Conclusion

In the three years from 2005-2007 the growth of the economy was rapid but not appropriate. The electricity sector lost a greta deal in the production process while this sector had a very high growth in CO_2 emission. GDP increased by 17.4% from 2005-2007 while CO_2 emission increased by 43.8% - about 2.5 times the GDP growth rate. The transportation sector had the highest difference between the value-added growth rate and the CO_2 emission rate (value growth rate is 119.5%, CO_2 emission growth rate is 56.6%). The CO_2 emission of the other energy sectors has decreased by 34% over 2 years due to the value added of this sector which has also decreased by 34.1% during this period.

Regarding households, consumption increased by 32% in the period of 2005-2007, and with a 32% increase in CO_2 emission.

By using the data on the Vietnamese economy and carbon dioxide emissions for 2005, we estimated the inter-relational income multiplier for the demographic-economic modelling, and the impact on CO_2 emission by time. This way also measures the changing of CO_2 emission by sectors from 2005 to 2007.

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Tác động của năng lượng và phát thải khí đến thay đổi cấu trúc kinh tế: Tiếp cận từ bảng cân đối liên ngành

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Tóm tắt. Phát thải carbon dioxide (CO_2) là một trong những nguyên nhân chính dẫn đến biến đổi khí hậu. Vấn đề nảy sinh gần đây khi chúng ta muốn xác định nguyên nhân chính gây ra phát thải CO_2 hoặc ngành nào gây hại nhất tới môi trường. Bài viết cố gắng ước lượng phát thải khí khi thay đổi cấu trúc kinh tế. Phương pháp luận mà nghiên cứu sử dụng dựa trên khái niệm của Miyazawa về các nhân tử thu nhập và mở rộng bảng I/O kiểu Miyazawa, hệ số này được thiết kế để phân tích cấu trúc phân phối thu nhập khi có sự thay đổi về nhu cầu cuối cùng hệ tiêu chuẩn Leontief.