An Integrated Framework for Multi-Purposes Socio-Economic Analysis Based on Input-Output Model

Bui Trinh[1], Kiyoshi Kobayashi[2], Nguyen Van Huan[3],Pham Le Hoa[4]

Abstract

This study is developed in favor of the relationship between economic growth and the environmental account. Our aim is to link such developmental concerns like economics, environmental, natural resources, culture and society into an integrated accounting framework base on expanded input-output model.

I. Introduction

The development of Vietnam has been enjoying a great deal of rapid economic growth in recent decades, which is thanked to the opening of market-oriented economy system. It is, however, controversies over environmental issues as side-effect of speedy growth have been reported national wide. A great number of research has extensively considered environmental issues as a threaten reason, which might impose negative impacts on the benefits of growth itself, or that may keep current economic trends from being sustainable. Through the development of environmental accounts, the country can track and analyze how its economy and its environment depend on each other in the growth process. The accounts make it possible to identify policy choices that will allow growth to occur without harming the environment or harming humans through environmental degradation, and will ensure that current growth patterns will not be reversed because of the environmental harm they cause.

Environmental accounts are systems that link environmental statistics to the data in the national income accounts. By structuring these two data systems in the same way, it is possible to monitor the economy and the environment in tandem, observing parallels in their evolution. Environmental accounts also make it possible to analyze how the growth of the economy affects the environment, and how the design of environmental policy affects the economy. This makes the accounts an essential tool in the effort to maintain the country's growth trends without harming its environment.

The methods for building environmental accounts have been designed through collaboration among the national income accounting offices of about twenty countries, in a process coordinated by the United Nations Statistics Department. The most recent results, termed the System of Economic and Environmental Accounting (SEEA), were released in 2003. The SEEA is a broad and flexible system organized so as to be compatible with the 1993 System of National Accounts, the accounting system used to build national accounts throughout the world. It tracks physical data on pollution discharged into the environment as an outcome of economic activity and use of natural resources in production. It also tracks monetary parallels to those measures; how much we are spending to protect the environment, the value of resources used, and changes in the value of the natural resources left to us. It calculates several environmentally adjusted

[1]Expert on input – output compilation and analysis at Vietnam National Account Department, 2, Hoang Van Thu Street. Hanoi – Vietnam, email: buitrinhcan@gmail.com
[2] Professor at Kyoto University, Japan email address: : kobayashi.kiyoshi.6n@kyoto-u.ac.jp
[3] Researchers at CSDP (Centre for sustainable development policy studies), Floor 14, No. 1, Lieu Giai Str, Ba Dinh Dist, Ha Noi, Viet Nam, email address: huan.nguyenvan@gmail.com.
[4] Researcher at finance consultant company, email:hoatrinhbui@gmail.com

measures of output and savings, although the emphasis of the SEEA is on the underlying data rather than the adjusted indicators.

This study is developed in favor of the relationship between economic growth and the environmental account. Our aim is to link such developmental concerns like economics, environmental, natural resources, culture and society into an integrated accounting framework base on expanded input-output model.

II. Methodology.

Research Background

Environmental accounts are a framework for linking statistical data about the environment to the statistical data on the economy, structured according to the System of National Accounts (SNA) (CEC *et al* 1993). Efforts to build environmental accounts began in the 1970s in several European countries working independently of each other. In Norway, influenced by the Club of Rome's publication of *Limits to Growth* (Meadows et al. 1972), public officials became concerned about the depletion of their natural resources, on which their economy depended heavily. Responding to this concern, the Norwegian Statistical Office developed accounts to track use of their forests, fisheries, energy and land, which were input into national models used for macroeconomic planning.

The Netherlands was also a leader in the development and adoption of environmental accounting. Their work, led by the national income accountants rather than the statisticians, focused on adding physical data on pollutant emissions by industrial sector to the national accounts, creating what they called the National Accounts Matrix Including Environmental Accounts (NAMEA). This approach has since been adopted by Eurostat, implemented in many European countries, and integrated into the environmental accounting approaches recommended by the United Nations.

One of the influential early works on environmental accounting was a study of Indonesia undertaken by the World Resources Institute (WRI). (Repetto et al. 1989) The authors used data on Indonesian natural assets to estimate what GDP might have been in that country had natural resources been depreciated in the accounts as manufactured assets are. They then compared the resulting growth rates with growth rates based on the conventional accounts, to show that growth appeared to be much lower if the impact on natural resources was taken into account. Although this work has been subject to considerable methodological criticism, it has reached many readers who would never read the more technical reports of Eurostat or the national statistical offices, and did a great deal to stimulate interest in the field.

Organized international efforts to share knowledge of environmental accounting and develop rules analogous to the SNA began in the 1980s, through the work of UNEP, the World Bank, and the UN Statistics Department. This led to the publication, as an annexed to the 1993 SNA, of the first "interim" manual on environmental accounting, referred to as the SEEA, or system of economic and environmental accounting. (UN 1993) During the 1990s the SEEA was revised through efforts of the UN, Eurostat, and other international efforts, leading to development of the so-called 2003 SEEA. [5] (UN *et al* 2003)

[5] The SEEA 2003 may be found on the web at http://unstats.un.org/unsd/envAccounting/seea.htm

Many efforts have been launched to test and implement the SEEA approach in both developed and developing countries, through Eurostat, the United Nations, the World Bank, and bilateral agencies. In Asia, the Korean and Philippine national accounts offices built accounts that closely followed the new recommended structure. Thought the crux of the SEEA approach kept constant, its actual implementation had been observed in a number of variations. For instance, The Philippine accounts focused more heavily on forests and other natural resources, while the Koreans placed somewhat more emphasis on pollution, consistent with the economic structures of the two countries. Japan also did considerable SEEA-based work, linking their accounts to larger economic models. The Taiwanese national accountants developed SEEA-based accounts as well, also placing primary emphasis on pollution. The variations in usage of the SEEA were believed to be locally consistent with the economic structures of each countries.

In the Philippines two separate account projects were undertaken. One, with UNDP support and carried out in the National Statistical Coordination Board, followed the SEEA approach. The other, with USAID support and carried out in the Department of Environment and Natural Resources, followed an approach developed by economist Henry Peskin, which is more closely rooted in economic theory and less in the national accounts structure than is the SEEA. This approach differs from the SEEA in several key respects. One is that it includes within the accounts themselves the estimated value of non-marketed environmental services and of the harm caused to the environment by economic activity. Another is that it includes all changes in asset values – including changes not due to economic activity – in depreciation in order to calculate net domestic product and other “net” macroeconomic indicators. (Peskin and de los Angeles 1998) The Philippines is the only place where this approach has been tried, although it has been recommended in the United States by a blue ribbon panel created in the 1990s to advise Congress on environmental accounting. (Nordhaus and Kokkelenberg. 1999) Work on the Peskin approach ended in 2000 with the end of USAID funding; the SEEA work is ongoing.

The institutional framework for the implementation of environmental accounts has varied from country to country. Because the SEEA is a part of the national income accounts, the expectation is that environmental accounts will be implemented by the office responsible for national accounting, with data input from the institutions responsible for environmental protection, natural resource management, and other activities. The SNA is a complex system; ensuring that the environmental accounts are fully compatible with it can otherwise entail a fairly steep learning curve for any other government agency or research group. However, in many countries the national accounts department does not want to move into environmental accounting. In some developing countries they are still engaged in strengthening their conventional accounts, and their staff feel environmental accounts would be a distraction from higher priority activities. In other countries, the fact that environmental accounting is still an annexed to the accounts rather than being an approved part of the 1993 SNA leads the national accounts office to consider it a low priority. In still other countries, the national accountants may not want to invest the time required to learn about environmental issues, and are happy for a different department to move ahead in this area

The Basic I-O Model

An Input - Output relationship for an economy can be expressed in matrix form as:

$$X = A.X + Y \quad \text{or} \quad X = (I - A)^{-1}.Y \qquad (1)$$

in which:

X : nx1 vector of gross output, with X_j being the gross output in each production sector;

A: nxn technical coefficient matrix, where $a_{ij} = X_{ij} / X_j$, $(\sum X_i = \sum X_j)$

Y : nx1 vector of final demands, with Y_j is total final demand for sector i;

I : identity matrix; and

$(I - A)^{-1}$: Leontief inverse matrix.

Elements of the Leontief inverse are output multipliers. Each row-element indicates value of the change of a sector's output due to a unit change in final demand for the sector's output. A low column sum reveals a weak industrial inter-linkage; otherwise, it shows a sector's strong dependence on the other sector's output to meet a unit increase in final demand for its output. Sector with the largest multiplier provides the largest total impact on the economy.

One common use of the I-O framework is to examine the effects of an exogenous change in final demands (for example, an increase in population that causes an increase in household demand). These effects are determined from the following:

$$dX = (I - A)^{-1}.dY \qquad (2)$$

where:

dX = changes in sectoral gross output; and

dY = projected changes in final demands.

Thus, if an increase in population causes final demand by the household sector to double, equation (2) could be used to determine the changes in production, dX , necessary to supply this extra demand, dY .

The Linkage Model

1. Let V^* be a matrix of direct residual coefficients of production on land, environmental pollution and coefficients of direct impact on natural resources, culture and society. V^* is a (mxn) matrix, with m= m_1+ 6 and n is number of economic activities.

The following economic and social indicators are used as proxies for each of the impact variables:

a) Impact on lands can be represented by the area of land used.
b) Impact on environmental pollution can be represented by amounts of pollutants discharged into the environment (BOD, COD, DO, DIN, DIP, CO_2, SO_2, NO_x, …).
c) Impact on natural resources can be represented by amounts of exploited mineral (coal, crude oil…).
d) Impact on culture can be represented by number of relics damaged due to production activities.
e) Impact on society can be represented by three variables: first, the number of people suffering from diseases which are caused by production activities (we call them professional diseases); second, the number of employees (human resource) mobilized for those production activities; and third, the value of capital loan borrowed from rest of the world (foreign capital resource).

V^* is then decomposed into its components as follows:

a) V_{kj}^* (k=1→m_1), determined as the amount of pollutants generated per (currency) unit of output of each sector.
b) V_{kj}^* (k=m_1+1) determined as the amount of natural resources exploited per unit of output of exploitation sectors;
c) V_{kj}^* (k=m_1+2) is determined as the area of land used per unit of output of each sector.
d) V_{kj}^* (k=m_1+3) determined as the number of cultural relics damaged per unit of output of each sector.

e) V_{kj}^* (k=m_1+4) determined as the number of people suffering from professional diseases per unit of output of each sector.

f) V_{kj}^* (k=m_1+5) determined as the number of employees mobilized per unit of output of each sector.

g) V_{kj}^* (k=m_1+6) determined as the value of capital loan from rest of the world per unit output of each sector.

Thus, the total impacts on land, pollution, natural resources, culture and society, foreign capital requirements of the productive economic activities are given by:

$$V = V^*.X \qquad (3)$$

Or $$V = V^*.(I - A)^{-1}.Y \qquad (4)$$

Each element in matrix V is the total impact on residuals generated per (currency) unit of final demand.
V*1 is matrix of direct residuals coefficient generated by abating activities

2. Changes in impact variables due to a change in final demand can be found by using:

$$dV = V^*.(I - A)^{-1}.dY \qquad (5)$$

Substituting equation (3) into equation (5):

$$dV = V^*.dX \qquad (6)$$

Equation (5) may be used to estimate changes in pollution, depletion of natural resources, land use, damage of cultural relics, number of people suffering from professional diseases, number of jobs employed and capital loan requirements from the rest of the world due to changes in final demands. Equation (6) may be used in the case of projected changes in gross outputs.

3. Estimation of Feedback Effects:

Let ϕ^1 be the (n x m) feedback matrix, with n sectors; m determined as in V^* and $\phi^1{}_{ij} = \Omega_{ij} / W_j$

Ω_{ij} : expenditure *essential* of sector i for abating the residual j;

W_j : total residual j, including residuals from both production and non-production activities; The part of W is amount pollutant that need to abate the residuals

a) In the case j =1→ m_1: Ω_{ij} : expenditure for abating the pollutant j in sector i; W_j : total amount of pollutant j.

b) In the case j=m_1+1; Ω_{ij} : output of exploitation sectors; W_j : total mineral reserves;

c) In the case j= m_1+2: Ω_{ij} : expenditure of sector i for using land (renewing/recovering used land's quality, payments for renting land); W_j : total area of used land;

d) In the case j=m_1+3; Ω_{ij} : expenditure for recovering the cultural relics damaged by productive activities of sector i. W_j : total of cultural relics damaged;

e) In the case j=m_1+4; Ω_{ij} : expenditure of sector i for the people suffering from professional diseases; W_j : total number of people afflicted with professional diseases;

f) In the case j=m_1+5; Ω_{ij} : expenditure for re-training employees in sector i (the expenditure for usual/normal training is reflected in the intermediate transaction block of I-O model, but most of economic entities have to pay extra expenses for retraining their employees to remain production capacity, and these amounts of expenses often vary over years); W_j : total number of employees.

g) In the case j=m$_1$+6; Ω_{ij} : expenditure of sector i for a unit capital (bank interest repayments); W_j : total value of capital.

From the above definitions and relations, the system, in some extend, can be considered as the most parsimonious in terms of the way it extends the familiar input - output formulation. Thus, we can put forward the general equation as:

$$\begin{pmatrix} X \\ W \end{pmatrix} - \begin{pmatrix} A\Phi_1 \\ V * V_1 * \end{pmatrix} \begin{pmatrix} X \\ W \end{pmatrix} = \begin{pmatrix} Y_1 \\ \Phi^2 + g \end{pmatrix} \tag{7}$$

$$\begin{pmatrix} (I - A) & -\phi^1 \\ -V^* & (I - V1*) \end{pmatrix} . \begin{pmatrix} X \\ W \end{pmatrix} = \begin{pmatrix} Y \\ \phi^2 + gY \end{pmatrix} \tag{8}$$

Where: ϕ^2 is the mx1 vector impact from other resources and

g is the (mxn) direct pollution coefficient matrix of final uses, which shows the amount of residuals (in physical units) generated per unit of product (monetary units) consumed by households.

From equation (7), we have:

$$(I - A).X - \phi^1.W = Y_1 \tag{9}$$

$$W = V^*.X + \phi^2 + g.Y + V_1*.W \tag{10}$$

where: $V^*.X$ is the total impact of production on residuals;

ϕ^2 is the total amount of residuals from other sources;

gY is the total amount of residuals generated from household consumption.

V_1*.W is the amount of residual generated from abating activities.

4. Real GDP:

From equation (8), we can further express following terms:

$$Y = X - AX - \Omega$$

$$Y = X - AX - \phi^1.(V^*.X + \phi^2 + g.Y + V1*.W) \tag{11}$$

Equation (11) becomes the measure of real GDP when we consider all production impacts that are not usually reflected in calculating the value of basic GDP. It is equal to net supply of production (i.e. GDP based on the production approach), minus the total cost of production for abating residuals (including: expenditure for abating pollution, output of exploitation sector, expenditure for using land, expenditure for putting in order cultural relics damaged, expenditure for people suffering from professional diseases, expenditure for re-training employees and expenditure for capital loan from the rest of the world), and minus the total expenditure for abating residuals from other sources and from household consumption.

Substituting for GDP, we put forward the idea of “Real Gross Domestic Product (RGDP)” as:

$$RGDP = GDP - \Omega \qquad (12)$$

With: $\Omega = \sum \Omega_i$

$$\Omega_i = \sum \Omega_{ij}$$

From equation (12), RGDP can be interpreted as the real development of the economy.

5. The inverse of the expanded IO-based coefficient matrix is thus defined as:

$$C = \begin{pmatrix} (I-A) & -\phi_1 \\ -V^* & (I-V1^*) \end{pmatrix}^{-1} \qquad (13)$$

Matrix C is thus used to substitutes for conventional matrix $(I-A)^{-1}$.

6. The implication of feedback effects:

Besides providing the measure of the real GDP, the scale of feedback effects also implies that each economy should set up ***residual-abatement funds***, including fund for abatement of environmental pollutants, fund for recovering land’s quality or for finding new cultivation lands, fund for finding new natural resources, fund for recovering cultural relics, fund for curing professional diseases, fund for re-training activities, reserve fund for foreign borrowing, etc.

The analysis of model linkage framework multipliers.

From the balance viewpoint of equation (8), the final term (Y) can be expressed as following differential equation.

$$\Delta X = (I\text{-}A)^{-1}\Phi_1.\Delta Y. \qquad (15)$$

The multiplicative term $(I\text{-}A)^{-1}\Phi_1$ in equation (9) (now denoted as P1), is the matrix multiplier for endogenous production propagation impacted by abating activities. In another words, it is the matrix multiplier due to change in volume of pollution.

From sub-matrix multipliers, the external matrix multipliers for the relation between Economic and Pollution can be derived as follows:

$$\theta_1 = (I - (I\text{-}A)^{-1}.\ \Phi_1.(I\text{-}V_1^*)^{-}1.V^*)^{-1}$$

$$\theta_2 = (I - (I\text{-}V_1^*)^{-1}.V^* .(I\text{-}A)^{-1}.\ \Phi_1)^{-1}$$

θ_1 is external matrix multiplier of production caused by pollution and other factors.

θ_2 is external matrix multiplier of pollution and other caused by Economic activities.

The equation (7) can be further elaborated with reference to Schur (Schur,1917; Sonis and Hewings, 1993) as follows:

$$E_1 = (I\text{-}A\text{-}\Phi_1.(I\text{-}V_1^*)^{-1}.V^*)^{-1}$$

The enlarged Leontief inverse E_1 contains elements, which are larger than those of the standard Leontief inverse $(I\text{-}A)^{-1}$ due to the fact that they include extra output required to meet feedback (abating activities induced output effects).

Using an explicit hierarchical order among the blocks with this matrix decomposition technique, Sonis and Hewings (1993) identified the following multiplicative structure of Leontief inverse and Miyazawa partition:

$$C = \begin{pmatrix} \theta_1 I \\ I\theta_2 \end{pmatrix} \begin{pmatrix} IP_1 \\ V * I \end{pmatrix} \begin{pmatrix} (I-A)^{-1} 0 \\ 0(I - V_1 *)^{-1} \end{pmatrix}$$

And: $E1 = \theta_1.(I-A)^{-1}$

In the case where only capital and labor are the impact variables, θ_1 and θ_2 could be straightforwardly understood.

III. Conclusion

This paper is attempt for trying to develop a theory framework in order to be looking for suitability of a country.

The authors would like to thank Mr. Francisco T. Secritario at the Phillipine and Dr. Le Thanh Nam at Osaka University, Japan for commenting on the manuscript.

References

Adriaanse, Albert, Stefan Bringezu, Allan Hammond, Yuichi Moriguchi, Eric Rodenburg, Donald Rogich, and Helmut Schütz. 1997. Resource Flows: The Material Basis of Industrial Economies. Washington, DC: World Resources Institute.

Anielski, Mark, and Jonathan Rowe. 1999. The Genuine Progress Indicator: 1998 Update. San Francisco: Redefining Progress.

Bolt, Katherine, Mampite Matete, and Michael Clemens. September 2002. "Manual for Calculating Adjusted Net Savings." Environment Department, World Bank. On the web at http://lnweb18.worldbank.org/ESSD/envext.nsf/44ByDocName/AdjustedNetSavingsAManual200262KPDF/$FILE/Savingsmanual2002.pdf

Bui Trinh, Francisco T. Secretario, Kim Kwang mun, Nguyen Thuy Duong, Nguyen Thi Huong et. al. 2000. *Estimating residuals impacts of Hochiminh City and Rest of Vietnam based on interregional I/O model*. Report to NISSAN Science Foundation.

CEC (Commission of the European Communities–Eurostat), International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, World Bank. 1993. *System of National Accounts 1993*. Brussels/Luxembourg, New York, Paris, Washington DC: CEC, IMF, OECD, UN, World Bank.

BUI TRINH, K.KIM, F.SECRETARIO, "Economic Environmental Impact Analysis Based on a Bi-region Interregional I-O Model for Vietnam" presented at 15th IO conference of IIOA at Beijing, 2005.

Daly, Herman, and John Cobb, Jr. 1994. For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future. Boston: Beacon Press.

Eurostat. 1994. *SERIEE: European System for the Collection of Economic Information on the Environment 1994 Version*. Luxembourg: Office for Official Publications of the European Communities.

General Statistics Office, Government of Vietnam. 1998-2003 Statistical Yearbook. (Hanoi: Statistical Publishing House).

G.J.D. Hewings, M. Sonis, M.Madden, Kimura Understanding and Interpreting Economic Structure)Advances in Spatial Science) , Springer – Verlag Berlin Heidelberg New York, 1999.

Hamilton, Kirk, and Michael Clemens. 1999. Genuine Savings Rates in Developing Countries. *World Bank Economic Review* 13(2): 333–56.

Hecht, Joy. Forthcoming 2004. *National Environmental Accounts: Bridging the Gap Between Ecology and Economy.* Washington, DC: Resources for the Future.

UN *Hand book of Input-Output table Compilation and Analysi*, New York,1999.No.27.

Isard, W *Methods of Regional analysis*, Cambridge, MIT Press, 1960.

Miller R.E. Interregional feedback in input – output models: some experimental results" Western Economic Journal, 1969.

IUCN 2003. *2003 IUCN Red List of Threatened Species.* <www.redlist.org>. Downloaded on 08 November.

The System of National Accounts, 1993, UN

United Nations, European Commission, IMF, Organisation for economic co-operation and Development World Bank *Integrated Environmental and Economic Accounting* 2003 (SEEA 2003) (http://unstats.un.org/unsd/envaccounting/seea2003.pdf).

Wassily Leontief, *Input – output economics*, Second edition, New York, Oxford University Press, 1986.

Appendix:

Input-output framework expanded for pollutions

		Sector	**Pollutions**	**final demand**			**Pollutions**		**Output**
		1.....n	**1.....m**	**Consumption**	**Capital Formation**	**net,export**			
Sectors	1 . . . n	A.X	$\Phi_1.W$	Y_1^1	Y_1^2	Y_1^3		Y_1	X
Pollutions	1 . . . m	$V_1^*.X$	$V_2^*.W$	$g_1Y_1^1\Phi_2$	$g_2Y_1^2$	$g_3Y_1^3$	Φ_2	$g + \Phi_2$	W
Value added	1 2 3 4	VA_1	VA_2						

$Y_1^1 + Y_1^2 + Y_1^3 = Y_1$ is vector of Final demand

$g_1Y_1^1 + g_2 Y_1^2 + g_3 Y_1^3 = g$ is vector of residuals generated by Final demand