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"Diagram of Circular Flow Between Economic and Natural Systems" — Measuring Sustainability of an Economy

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Abstract: To estimate values of gross domestic products (GDP), economists developed the circular flow of income in macroeconomics. GDP measurement based on this diagram is only used to evaluate the rate of economic growth for each country, which does not consider environmental aspects of sustainable development, including natural resources and the environment. This paper, the author built "Diagram of circular flow natural system" and combined with "Diagram of circular flow economic system". The combination of these two diagrams generates an innovative circular flow between natural and economic systems. It is called "Diagram of circular flow economic and natural systems". Different parts of this diagram represent an integral system containing multiple indicators measured in monetary values. All the economic and environmental indicators built by the diagram can be estimated by the national accounting system. This diagram can be used to measure sustainability, examine economic development trends, and estimate economic values for the environment.

Key words: circular flow of economic and natural systems; characteristics; applications
JEL codes: M110, M1

1. Introduction

During the process of writing the Ph.D. thesis titled "Financial mechanisms for sustainable development of the coal extraction industry in Quang Ninh province, Vietnam" with the overall purpose is to study this content, the thesis aims to base on the theory and analysis of the situation of state budget management from coal mining activities in Quang Ninh province to propose orientations and solutions to complete the management process. The proposed solutions will help ensure the sustainable development objectives of the coal industry in the province in the future; main research objectives are to accomplish the above goal, the thesis research process aims to implement the following tasks: Firstly, the study will provide a literature overview of research issues related to the following topics: public finance, public assets, sustainable development of economic sectors and coal mineral industry, the status of state budget, and state budget management procedures. Through the analysis of domestic and foreign documents, the thesis will produce a synthesis of what research questions have been answered and identifies the research gaps that this study will try to fill in. Second, the study will determine the theoretical framework for research on state budget management from coal mining activities towards sustainable development. In particular, this thesis will be focusing on clarifying: concepts, objectives, principles, evaluation criteria, content, and factors affecting this management. Thirdly, the dissertation will synthesize and analyze the sustainable

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development processes that some other countries and some other localities in Vietnam have experienced to draw lessons for Quang Ninh province in managing the state budget from coal mining activities. Fourth, this study will analyze the status of coal mining activities towards sustainable development in Quang Ninh province. Fifthly, from the theoretical issues that have been clarified, the thesis will analyze the situation of state budget management from coal mining activities in Quang Ninh province towards sustainable development. Thereby, the thesis will evaluate to highlight the shortcomings, limitations and causes of shortcomings and limitations in the state budget management from coal mining activities in the province. Sixthly, on the basis of the conclusions from practical analysis, the thesis will propose orientations and solutions with scientific and practical bases to improve the management of state budget from coal mining activities in Quang Ninh province towards sustainable development.

The author of the thesis came up with an innovative circular flow connecting the economic system with the natural system based on their interconnected relationship, finally a "Diagram of circular flow between economic and natural systems" is created. This diagram will be useful in analysis and measurement which are necessary to scientific research in sustainable development.

2. Background

Development is a natural trend of each community and each country, but for a long time, people have only followed the trend of pure economic development. This trend has caused many social and environmental consequences. Recognizing this, over the past 30 years, instead of pure economic development, countries turned to sustainable development (SD) trend which is defined as: "Sustainable development is a harmonious combination between economic development (economic pillar), social development (social pillar) and environmental protection (environmental pillar). The concept of sustainability is described in Figure 1 as follows:

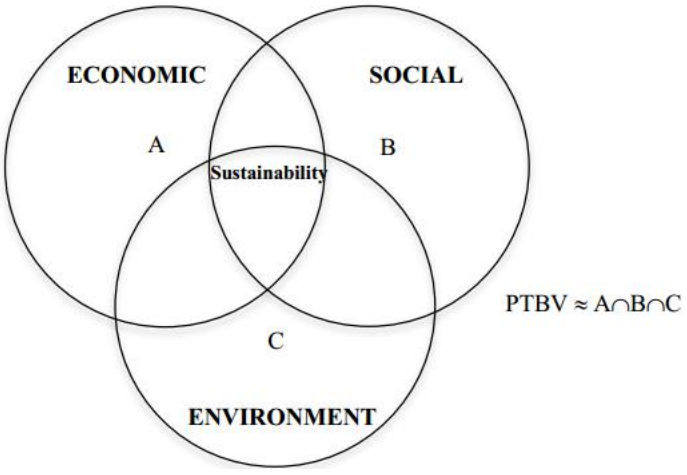

Figure 1 The Relationship between Socio-economic Development and the Environment

To assess the level of sustainable development of each country, the United Nations Conference on Sustainable Development (UNCSD) in 2001, proposed 58 indicators for all 3 pillars, in which there were 20 indicators of economic pillars (e.g., GDP per capital), 19 indicators of economic pillars (e.g., the proportion of the poor/the proportion of population below national poverty line), 19 indicators of environmental pillars (e.g., greenhouse gas emissions). The advantages of the above indicator system is that it helps to fully assess pillars

related to sustainable development. However, its disadvantage is that it cannot assess the degree of association among the pillars which is shown in the definition of sustainable development definition. For example, it is difficult to determine the relationship (combination) between economic and environmental pillars. Some important questions related to these 2 pillars are still not answered such as:

- What is the propotion of the natural resource contribution to GDP? (Vietnam's GDP in recent years has averaged 250 billion USD. There are two parts in GDP: one is the result of enterprises' production and business activities, the other is from the exploitation of natural resources. The question is: "what is the propotion of the natural resource contribution to the above mentioned 250 billion USD?" This question has not been answered.)
- With GDP generated in the economic pillar, how much (does it cost)/has been spent at the environmental pillar?

There are many things needed to be done to solve the above problem, including the development of a "Diagram of circular flow between economic and natural systems" that the author has made, and it will be presented in this article.

3. Construction Process of "Diagram of Circular Flow Between Economic and Natural Systems"

This process included 3 steps: Developing circular flow diagram of macroeconomic, developing circular flow diagram of natural system, combining circular flow diagram of macroeconomic and circular flow diagram of natural system.

3.1 Step 1: Developing Circular Flow Diagram of Macroeconomic

Figure 2 has been developed by macroeconomic researchers (Vietnam Ministry of Education and Training, 2007) and is being used to calculate the GDP of countries.

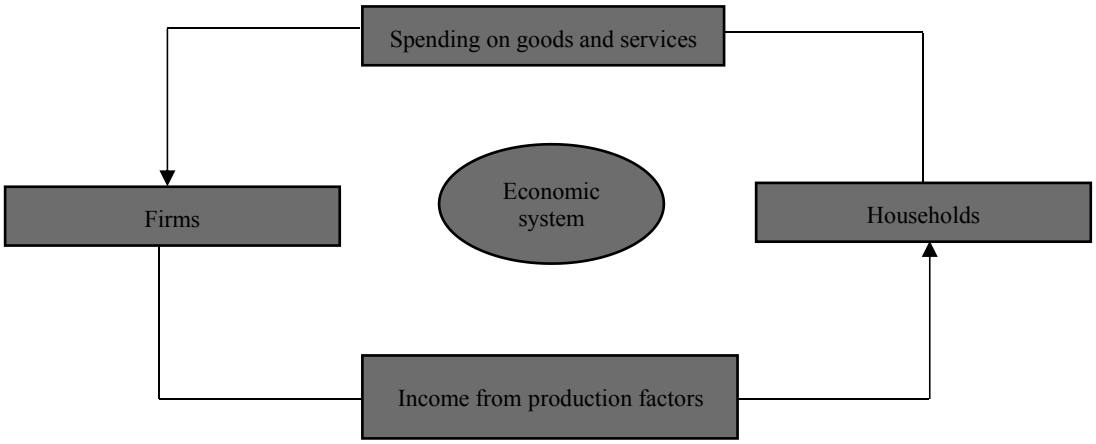

Figure 2 Basic Circular Flow Diagram of Macroeconomic

3.2 Step 2: Developing a Circular Flow Diagram of Natural System

The natural system includes natural resources and the environment. The natural system plays a certain role in the economic development of each country. This factor is very important to countries with abundant resources. A good example is the Gulf countries, where oil reserves account for 64.5% of global oil reserves. The population in

these countries only accounts for 0.4% of the world's population, but their income makes up 10% of total world income (Lai Kim Bang, 2005). In this step, the author develops the basic circular flow diagram of the natural system (Figure 3).

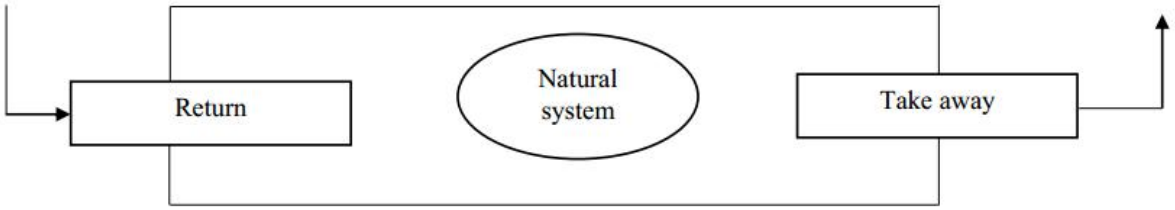

Figure 3 Basic Circular Flow of the Natural System

In Figure 3, the "take away" and "return" flows are calculated in terms of value. The "take away" part of this system will be put into the economic system, the "return" part will be drawn from the economic system.

3.3 Step 3: Combining Circular Flow Diagram of Macroeconomic and Circular Flow Diagram of Natural System

In this step, it is necessary to detailize the two basic diagrams mentioned above, and combine them, then we have the Figure of circular flow between economic and natural systems. Let have a look at Figure 4:

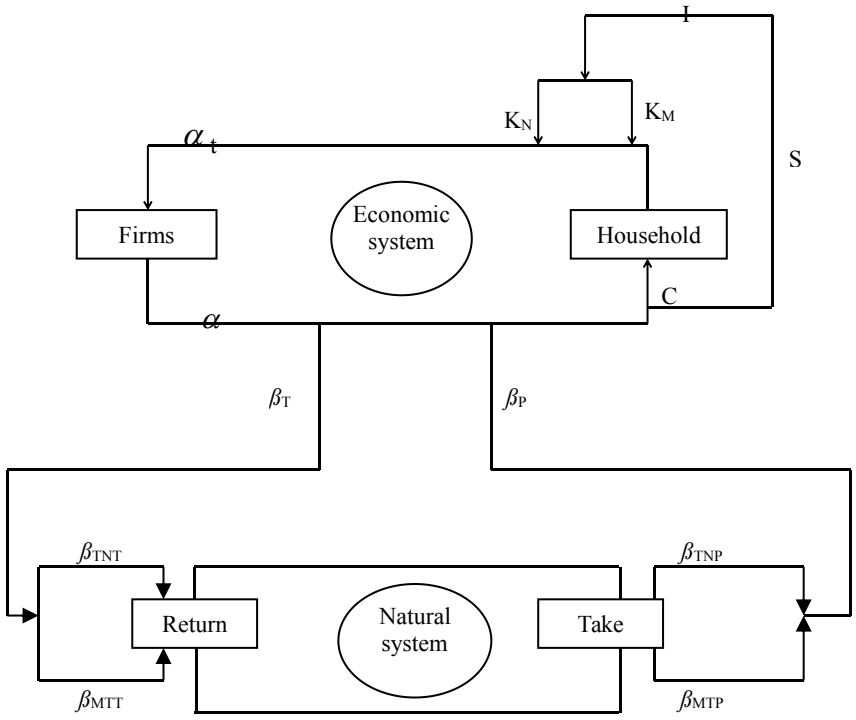

Figure 4 Diagram of Circular Flow Between Economic and Natural Systems

Where:

K_N: Natural capital (value/year)

K_M: Man-made capital (value/year)

S: Savings (value/year)

C: Consumption (value/year)

α_t: Upper flow of the economic system (value/year)

α_d: Lower flow of the economic system(value/year)

β_P: Right-hand side flow of the natural system (value/year)

β_T: Left-hand side flow of the natural system (value/year)

β_{TNP}: Economic values of extracting natural resources (value/year) (for example: economic values of extracting forest, mineral, and ocean resources, etc)

β_{MTP}: Economic values taken away by the natural system (value/year)

β_{TNT}: Economic values returned by the natural system (value/year) (Economic values of reforestation, conservation and preservation of biodiversity, etc)

β_{MTT}: Economic values returned to the natural system (value/year) (values of protecting forests).

According to α_d (upper flow), income for households originates from the sale of factors of production and values of natural ecosystems (β_P).

According to α_t (lower flow): income for sellers or firms is generated from the expenditure of households, which consists of consumption and savings ($S = K_M + K_N$).

In Diagram 2.3, another important thing is the environmental price (β_{MTT} and β_{MTP}). In fact, the environment is a commodity, but it is a "public goods". Normally the price of the environment or Shadow Price can be calculated by the value of intention, however, in this diagram the environment price is calculated by environmental restoration cost because the environment was destroyed by enterprises' production process, in other words, β_{MTT} is equal to β_{MTP}.

After step 3, the combination of the two diagrams has been done.

4. Characteristics of the Circular Flow Diagram

a) This circular flow combines the diagram of circular flow macroeconomics (Vietnam Ministry of Education and Training, 2007), which is used in macroeconomics to measure GDP and estimate economic growth, and the natural cycles of ecosystems to measure sustainability of an economy.

b) Our circular flow succeeds in simplifying the interlaced transactions of multiple economic agents and the perplexing relationship between the economic system and the natural system. The diagram of our suggested circular flow not only ensures scientific foundations in analysis but also engenders acceptably equitable reports.

c) Our contribution to the existing literature in relation to natural resources and the environmnet is the seperation of these two areas. Two distinct flows of natural resources (β_{TN}) and of the environment (β_{MT}) are respectively associated with natural resource economics and environmental economics, which makes the analysis and measurement of each flow different.

d) Regarding the above argument, the part containing β_{MTT} and β_{MTP} of our circular flow diagram has a unique symmetric characteristics in terms of cost and benefit analysis. The symmetry of this circular flow can be illustrated by the following statement: "Missing a benefit is an opportunity cost and vice versa". The symmetric characteristics is considered as an effective tool to the evaluation of environmental effects.

e) Our diagram can be used in theoretical analysis and measurement system for national accounts (In order to determine the value of β_T, β_P needs to be included into our country's system of national accounting with the support of environmental accounting, a field recording the values of natural resources and their fluctuations over time).

5. Applications of Our Circular Flow Diagram Between Economic and Natural Systems

5.1 Measurement of Sustainability

The upper flow (α_t) of our diagram can be used to determine the components of GDP. Following is the standard formula to calculate GDP:

$$GDP = C + I + G + NX$$

Where:

C: Consumption

I: Investment ($I = K_M + K_N$)

G: Government Spending

NX: Net export (Imports – Exports).

As GDP is well known for only quantifying economic growth, sustainability measures must renovate the framework of GDP under the presence of the natural system. A study conducted by Lai Kim Bang (2005) proposed the idea of Green GDP (GGDP) [2]. GGDP is estimated for each industry of an economy, and the total GGDP is calculated as followed:

$$GGDP = \sum_{i=1}^{n} GGDP_i$$

Where:

i: i^{th} economic industry

n: number of industries of an economy

The measurement of $GGDP_i$ for each industry is, however, still sophisticated. With the cicurlar flow we suggest, calculating GGDP becomes much easier:

$$GGDP = GDP - \beta_T$$

Henceforce, GGDP can be a standard scale of sustainability measures, if GGDP per capita is provided along with GDP per capita as part of UNCSD's sustainability indicators, which will capture a holistic image of sustainable development in each country.

5.2 Analysis of Different Trends for Economic Development

Because of distinctive economic conditions, many countries have been establishing and following different paths of economic development. Our circular flow can be used to quantify and delineate those contemporary trends. Following are three prominent trends for economic development:

- The first trend is when $\beta_P >> \beta_T$:

This trend often known as growth at all costs exists in some developing countries like Somalia, Ethiopia, and Uganda. The motive behind this economic development trend is based on excessive extraction of natural resources, resulting in depletion of natural resources, environmental damage, and desertification.

- The second trend is when $\beta_P = \beta_T = 0$:

Reversing the first trend, policymakers in European countries induce an ecological approach towards economic development that barely creates damage for nature; take for example "conservationism" or "zero or negative growth".

- The third trend is when $\beta_{MTT} = \beta_{MTP}$ và $\beta_P > \beta_T$:

This is the sustainable trend for economic development.

5.3 Environmental Valuation

Because the environment is categorized as public goods, which differs from private goods that have a given market price, the economic value for the environment is determined as shadow price. Regarding the evaluation of environmental effects, giving the environment a monetary value is an intricate process, which often utilizes different environmental valuation methodologies such as willingness to pay and might yield approximate outcomes. Nevertheless, when paying attention to the symmetry of the part containing β_{MTT} and β_{MTP} of our circular flow diagram, we can conclude that the economic value of the environment can be estimatedly equal to β_{MTT}. In any specific project, the value of the environment is the total cost of restoring damaged ecosystems to the standard levels of environmental quality. Thanks to our circular flow diagram, the complication of environmental valuation is resolved and becomes easier to quantify.

6. Conclusion

In the field of sustainable development research, this is the first time the "Diagram of circular flow between economic and natural systems" has been developed with many practical applications. In order to have further research after the "Diagram of circular flow between economic and natural systems", the author proposes some following criteria to the National Accounting System:

- Annual environmental protection cost.
- Annual natural resource restoration cost.
- The contribution of natural resources to annual GDP.

The study of these indicators is the responsibility of the "national environmental accounting", which has been established in developed countries since the 1990s. However, it is still quite new in Vietnam.

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