VNU Journal of Science, Economics and Business 28, No. 2 (2012) 115-123

Structural decomposition analysis of CO_2 emission variability in Vietnam during the 1986-2008 period

Dr. Nguyen Thi Kim Anh*

Faculty of International Business and Economics, VNU University of Economics and Business, 144 Xuan Thuy, Hanoi, Vietnam

Received 14 September 2011

Abstract. The study employs structural decomposition approach based on Kaya identity and utilizes data from International Energy Agency (IEA, 2010) to analyze the relation between CO_2 emission increase and GDP per capita, energy intensity of GDP, CO_2 energy intensity and population in Vietnam. The research brings about the following outcomes: The rapid GDP increase (y/p) and high CO_2 energy intensity (c/e) are two major factors causing high increase in CO_2 emission even though GDP energy intensity (- e/y) continuously declined and population growth was lower than 1.67% yearly in 1986-2008. The economic structural change and the shift of fuel mix were the main forces driving GDP growth while suppressing CO_2 emissions in Vietnam in 1989. The trend of c/e coefficient is due to the increase in fossil fuel dependency, economic structural change toward industrialization concentrating on manufacturing industries, a large inflow of FDI into manufacturing and construction industries without paying due attention to screening whether the acquired technology is environmentally friendly. Moreover, an increased number of vehicles and urbanization in Vietnam also boosted energy consumption. Consequently CO_2 emission had risen. Therefore, improvement of energy efficiency incorporated with a shift in energy mix to renewable energy, and applying energy-saving and environment friendly technology (EFT) are the most important steps to curb CO_2 emission.

Keywords: Kaya identity, CO_2 intensity, energy intensity.

1. Introduction

Climate change and its impacts on economic and social development have always been hot issues in the world. Studies show that there is a positive relation between greenhouse gas density and global warming. Carbon dioxide (CO_2) is the most significant greenhouse gas, and is responsible for over fifty percent of the impacts. Economic growth accelerated by rapid industrialization has caused a considerable increase in fossil fuel usage, emitting an amount of CO_2 that far exceeds the natural balance. CO_2 emission caused by human activities also upsets nature. As more people are born, human activities such as respiration or fuel burning have boosted the abundance of CO_2 in the atmosphere. Consequently, the globe warms up and the global climate changes. It was mentioned in the Global Environment Outlook 2008 (GEO-4) that Vietnam would be one of the top five economies badly damaged by global climate change.

* Tel.: 84-4-37547506
E-mail: ngkanh@vnu.edu.vn

Located in Southeast Asia, a region with high economic growth but little commitment to the Kyoto protocol, Vietnam has taken some measures to protect the environment. In 1993, the Environment Law was enacted and in 2006, the amended Environment Law came into effect. Since 1986, Vietnam has experienced many reforms, and achieved rapid economic growth at an average annual rate of 7%, which has had a very positive effect on the living standard, and at the same time managed to curb the average population growth to 1.64% annually. So how did the economic growth affect Vietnam's CO_2 emission fluctuation? Which are key factors behind the CO_2 emission growth in Vietnam?

2. Economic growth and climate change impacts in Vietnam

As previously mentioned, Vietnam embarked on many economic reforms that resulted in rather constant and rapid economic growth when integrating into the world economy. The average annual GDP growth rate increased from 5.29% in 1986-1990 to 7.76% and 7.64% in 1991-2000 and 2001-2008 respectively. The average annual GDP/capita growth rate has been as high as 7% annually since 1991 and industry witnessed the highest annual average growth rate of 11.71% and 9.64% respectively for the periods of 1991-2000 and 2001-2008 (Table 1).

Table 1: Average annual growth rate by sector (%)

	1986-1990	1991-2000	2001-2008
Agriculture	2.58	4.49	3.95
Industry	3.20	11.71	9.64
Service	9.03	7.09	7.58
GDP	5.29	7.76	7.64
GDP/capita	2.84	6.11	6.25

Source: Database of IEA, 2010, GDP at PPP constant 2000 USD (calucated by author).

In accordance with a rapid growth, between 1986-2008, the economy was restructured toward industrialization. The share of each sector in the national annual GDP evidently changed: added value in the industry field accounted for 43.2% in 2008 from 28.31% in 1986 while that of agriculture declined to 18.5% in 2008 from 37.26% in 1986 (Figure 1).

Despite the economic and social improvements, Vietnam is suffering from climate change. The average temperature in the North, Center and South tends to rise over time. Over seventy years, the average temperatures in Hanoi, Danang and Tan Son Nhat representing the Northern, Central and Southern regions have all increased, with the increase in Hanoi being higher than the other two. In Hanoi, Danang and Tan Son Nhat (Ho Chi Minh City), the average temperatures have increased from 23.3^0C, 25.4^0C and 27^0C in 1931-1940 up to 24.6^0C (an increase by 1.3^0C), 26.2^0C (an increase by 0.8^0C) and 28^0C (an increase by 1^0C) respectively in 2007.

Not only did temperature change, rainfall also fluctuated. The rainfall in these cities was on a downward trend but not correlated to the temperature. Figure 2 indicates the average rainfall reduction in Hanoi, Danang and Tan Son Nhat (Ho Chi Minh City) during 1941-1950 and 1981-1990. Parallel with the rise in average annual temperature and the fall in rainfall is the increase in drought that has occurred in many provinces.

Furthermore, there have been many changes in the sea level and the frequency of storms and tropical cyclones. In the period 1961-2000, there were fewer storms but more El Nino events, and storms tended to be heavier and last longer. In particular, the average observed sea level in the second half of 20^{th} century at Cua Ong and Hon Dau increased from 2.5 to 3.0 cm/decade because of global warming melting ice (Nguyen Duc Ngu, 2010).

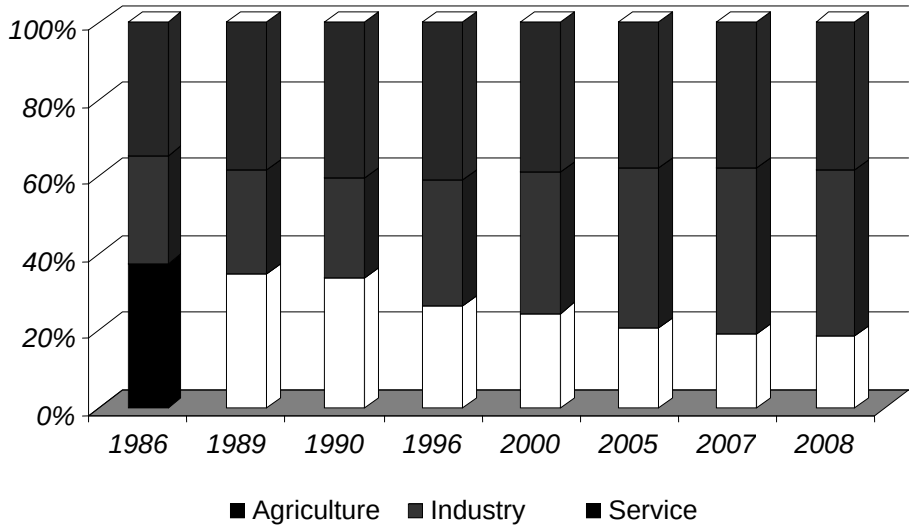

Figure 1: Share in annual GDP by sector (%).
Source: Database of IEA, 2010 (calculated by author).

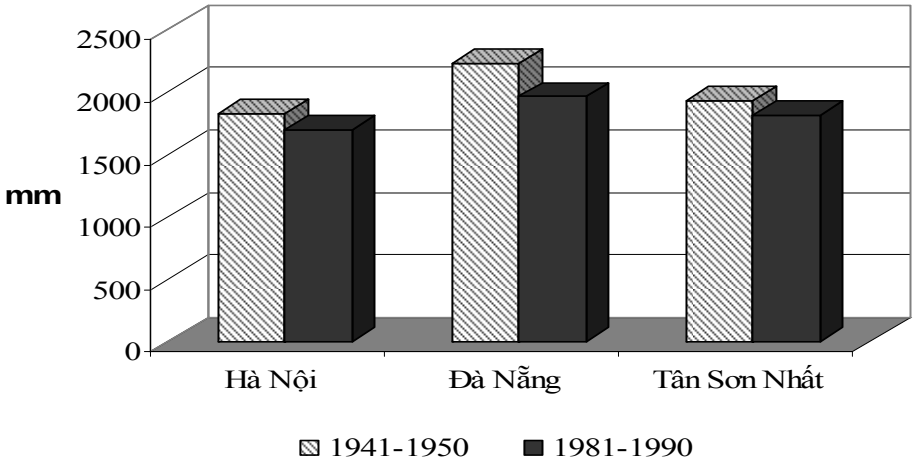

Figure 2: Average annual rainfall in three regions (mm).
Source: Nguyen Duc Ngu, 2010.

3. Relationship between CO_2 emission, economic growth, energy consumption and population

3.1. Introduction of the Kaya identity (1990) as a structural decomposition approach to analyze factors affecting CO_2 emission growth

Structural decomposition approach is an appropriate tool to find out the main factors causing CO_2 emissions. This analytical method concerns two main factor groups: quantitative and qualitative. The quantitative factors include income effect (or per capita GDP growth) and population growth. The qualitative factors consist of economic structural change and shift of fuel mix resulting in the change of CO_2 intensity of fuels (emitted CO_2/energy, change of energy efficiency or change of energy intensity of GDP (energy/GDP).

Kaya's (1990) identity is a decomposition approach. It decomposes the relationship between growth of CO_2 emissions (C), and growth of energy use (E), output (GDP) and population (P). The identity has four elements divided into two groups: (1) the qualitative group includes CO_2 intensity level (CO_2 emissions/Energy = C/E), energy intensity (Energy/GDP = E/Y); and (2) the quantitative group relating to GDP per capita (GDP/Population = Y/P), and population (P).

The identity is defined as follows:

$$CO_2 \equiv \frac{CO_2}{Energy} * \frac{Energy}{Output} * \frac{Output}{Population} * Population$$

$$C \equiv \frac{C}{E} \times \frac{E}{Y} \times \frac{Y}{P} \times P \qquad \text{(Eq. 2.1)}$$

As we take the logarithm, the solution provides the growth rate of CO_2 emissions and relative factors:

$$\lg(C) \equiv \lg(\frac{C}{E}) + \lg(\frac{E}{Y}) + \lg(\frac{Y}{P}) + \lg(P)$$

or it can be rewritten in lowercase as:

$$c \equiv \frac{c}{e} + \frac{e}{y} + \frac{y}{p} + p$$

where c = growth rate in CO_2

c/e = growth rate of carbon intensity of energy supply

e/y = growth rate of energy intensity of GDP

y/p = growth rate of per capita income

p = growth rate of population.

Assumed that population is exogenous, then the level of emissions may be controlled by reducing one of three elements: energy intensity, CO_2 intensity; or the rate of growth of per capita output to cover the population growth - provided the other factors remain unchanged. Nevertheless, in order to keep economic growth sustainable while stabilizing CO_2 density, the preferable measure is to reduce energy intensity and carbon intensity so that the total decline rate of these elements can offset the sum of growth rate of per-capita-GDP and population. Reducing CO_2 intensity means shifting to cleaner energy, and reducing energy intensity means energy conservation or improving energy efficiency. However, the Kaya identity cannot explain in more detail the sources influencing CO_2 emissions such as: which industry emits more, or why CO_2 and energy intensity decline when GDP maintains growth… etc.

3.2. Analyzing factors affecting CO_2 emission growth in Vietnam based on Kaya identity

Breaking the 1986-2008 period into 05 sub-periods: 1986-1990, 1991-1995, 1996-2000, 2001-2005 and 2006-2008, and calculating the average annual growth of CO_2 and its factors of each sub-period and the 1986-2008 period based on the Kaya identity, the results are shown in Table 2.

Table 2: Average annual growth of concerned factors

Factor	1986-1990	1991-1995	1996-2000	2001-2005	2006-2008	1986-2008
c	-0.0239	0.1331	0.0911	0.1339	0.0933	0.0797
c/e	-0.0439	0.0794	0.0619	0.0667	0.0283	0.0356
e/y	-0.0304	-0.0349	-0.0340	-0.0127	-0.0092	-0.0270
y/p	0.0284	0.0671	0.0520	0.0620	0.0601	0.0542
y	0.0529	0.0877	0.0636	0.0766	0.0731	0.0715
e	0.0209	0.0498	0.0274	0.0630	0.0632	0.0426
p	0.0238	0.0193	0.0110	0.0138	0.0123	0.0164

Source: Database of IEA, 2010 (calculated by author).

In 1986-2008, the average annual growth rate of y/p at 5.27% and of c/e at 3.67% were two main elements driving c to grow rapidly by 8.01% per year. In the sub-periods except for 1986-1990, these two factors were also the leading factors determining rapid CO_2 emission growth.

It is noteworthy that in the whole period as well as in each sub-period, e/y bore a negative sign (-) even though it was a little higher recently.

C absolute reduction in 1986-1990 was due to the decline of two qualitative factors (c/e at -4.39%; e/y at -3.04%) which was offset by the positive growth of two quantitative factors (y/p at +2.84%; p at +2.38%). One may question whether this is a sign for sustainable growth and environment protection in Vietnam?

The mitigation of absolute C is reasoned by Andrei (2007) that: (1) oil shock forces affected economies to adopt advanced energy-saving and/or energy-efficient technology, and to restructure economy and shift fuel mix toward reducing dependency on fossil fuel; (2) economic crisis and recession induce the cut down of production, consumption, energy utilization; (3) in some extreme cases, countries such as Sudan, Chad, Swaziland, Fiji, French Polynesia, Papua-New Guinea, which Andrei called "Green growth economies", grow based on natural resource export and domestic production reduction. Poland and Hungary even restructured their economies in response to pricey imported fossil fuel. Only a few developed countries such as Luxemburg, Denmark, Finland, UK, Germany, Bahamas, Puerto Rico and Malta managed to get positive economic growth while enjoying negative c. Nevertheless, Andrei argued that these developed countries have to compromise between high growth rate and CO_2 mitigation, and as a matter of fact, their y/p is lower than the world's average. So which category did Vietnam's 1986-1990 emission reduction fall into?

3.3. Qualitative factors: Economic structure and energy mix

Figure 3 shows the trend of CO_2 emissions and the relevant factors in 1986-2008. All factors were measured in index form with 100 points in 1986. It should be noted that how GDP/P kept growing throughout the examined period while CO_2 fell to the lowest level in 1989 and 1991; it was even less than the 1986 level by 8 and 9 points to 88, 84, 83, 91 and 96 points in 1989-1994 respectively. Apart from the continuous reduction in energy intensity from the base 100 points to 90, 88, 85 and 82 in 1989-1992, the observed decline of CO_2 intensity also explained the sharp fall of CO_2 emissions in these years. According to Polanski et al. (1993), Laiskas (2000) and Zang (2000), E/Y reduction signals energy saving and efficiency, technology improvement or/and economic structural change.

Since 1992, C/E resumed and exceeded 100 points in 1994, becoming the second most significant factor - aside from Y/P - that caused C to increase rapidly since 1998. Though E/Y kept dropping, the decreasing level could not balance the increase of Y/P, C/E and P, and as a result C increased continuously during 1992-2008. Thus GDP growth and C/E are the two most important elements accelerating C emission after 2000, even though E/Y reduced. The ranking of influential factors on Vietnam's CO_2 emission is similar to that of China.

Before 1995, energy intensity of Vietnam ranked second after China, though it kept reducing from 333kg OE/1000 USD GDP in 1986 to 295kg OE/1000 USD GDP in 1990 and 257kg OE/1000 USD GDP in 1995 compared to 426kg OE/1000 USD GDP, 359kg OE/1000 USD GDP, 251kg OE/1000 USD GDP of China in the relevant years (Figure 4). Yet Vietnam has become the country with highest energy intensity since 1995, i.e. in 2005, it was down to 198kg OE/1000 USD GDP but still higher than 142kg OE/1000 USD GDP in China, 138kg OE/1000 USD GDP in Thailand. Most of Vietnam's industries are high energy consumption ones such as: cement, steel and iron, and machinery. This is similar to the case of China when it became the world's largest cement supplier in 2006. Can industrial restructure explain this?

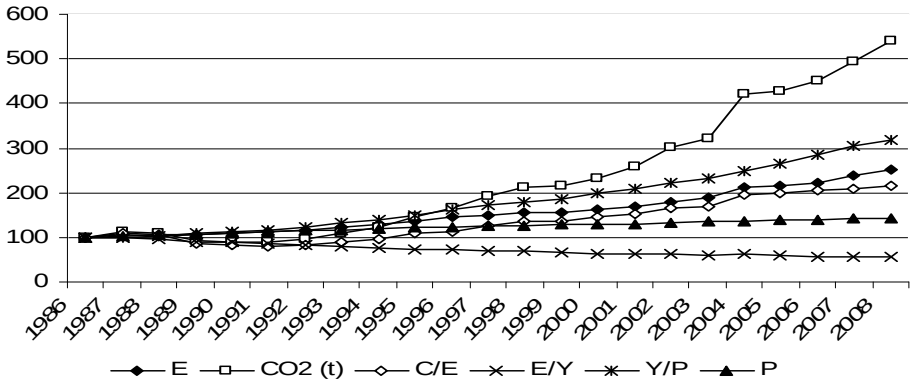

Figure 3: Vietnam's Index of CO_2, E, E/Y, Y/P and P, 1986-2008 (Index in 1986 = 100).
Source: Database of IEA 2010 (calculated by author).

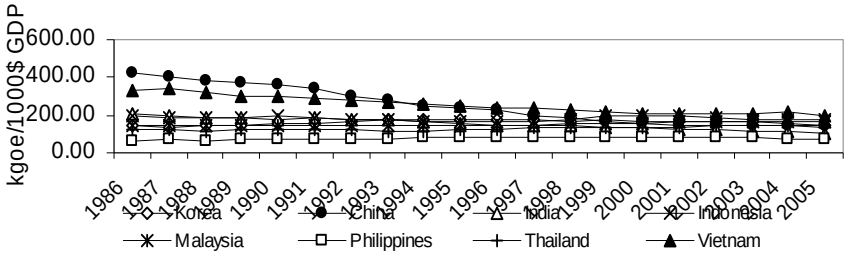

Figure 4: Energy intensity in selected Asian Countries, 1986-2005.

3.3.1. Economic structural change

Economic activities are divided into 3 main sectors: Agriculture, Industry and Service. The annual growth rate of GDP, the value-added of each economic sector, and the CO_2 emissions are shown in Figure 5. The year 1989 was the most notable when it came to structural change, and as mentioned above, also witnessed the sharp decrease of CO_2 emissions by 8 points below the 1986 level. CO_2 emissions in 1989 were just about the average level of 1983-1985. What had happened to economic activities in 1989? Industrial value-added fell by 2.6 percent, while GDP grew at 4.68 percent. The growth of GDP was justified by the growth of both agriculture and services at 7 percent and 7.86 percent respectively. In fact, 1989 marked the acceleration of the 1986 "Doi Moi" policy.

The initiative reforms since 1988 enhanced the growth of Agriculture by over 7 percent from 1989 to 1988. From a rice importer in the mid-1980s, Vietnam turned into one of the world's largest rice exporters in the 1990s.

The Services sector also grew rapidly after the reform in 1989 following the promotion of the private sector by the government and a mass relocation of labor from the state sector to the private sector. The labor mobility of about one million employees to the private sector, particularly to the Services sector, was due to the release of soldiers from the military and layoffs in the state sector after the elimination of budget subsidies to state enterprises. In 1989, the Services sector was 7.86 percent higher than in 1988.

On the contrary, in 1989, the economy for the first time witnessed a negative growth in the

Industry sector at 2.3 percent less than the previous year. As a matter of fact, although the economic reforms were courageous, the economy had to confront a number of obstacles such as capital shortages, high inflation, devaluation of the Vietnam currency and debt burden. Such financial difficulties led to the cut-off of some main industrial projects, which added to the negative growth of industry already worsened by the stagnation of the State sector, which owned the major part of industrial production. These factors resulted in the decline of industrial output and energy use.

Hence, the growth of low energy intensity Agriculture and Services sectors accounted for 4.7 percent growth of GDP. The decline in Industrial value-added by 2.3 percent resulted in a 15.28 percent drop in commercial energy consumption, which in turn led to the reduction in CO_2 emissions by 15.24 percent in 1989 compared with 1988, 7 points lower than the 1986 level.

From 1992, due to the adjustments of Law on Foreign Direct Investment in Vietnam, normalization of relation with the United States and the deeper integration into the world economy, the economy continued on an industrialization trend and the FDI inflows increased steadily, all three sectors grew, and this contributed to the GDP movement. Since then, industry constantly enjoyed the highest growth rate (at an average rate of 15% yearly) compared to agriculture and service. This would have resulted in increases of energy consumption as well as of CO_2 emissions unless other measures were employed to improve energy efficiency. This is similar to the situation in China where there has been a structural shift from agriculture to industrial manufacturing.

The jump in CO_2 emissions since 1992 and the variation in c coefficient at 0.1339 in 2001-2005 and 0.0933 in 2006-2008 are sufficiently complicated compared to 1989 and cannot be concluded to result only by economic structural change. The reasons may be embodied in the changes of energy intensity in industrial sub-groups like construction and transportation, and fuel mix.

3.3.2. Shift of fuel mix

Being a relatively small producer and consumer of energy, Vietnam is blessed with an abundance of primary energy resources consisting of coal, oil, gas and hydro-power. In 1971-1998, the commercial energy use increased at an average rate of 2.1 percent annually compared with 8.8 percent in Korea, 7.7 percent in Malaysia, and 6.2 percent in Thailand; and since "Doi Moi" in 1986, the growth rate has been 3.5 percent in Vietnam while it was 9.2 percent, 8.7 percent, 8.1 percent in Korea, Malaysia and Thailand respectively. In 1998, though Vietnam's per capita commercial energy production was not so low compared to other Asian countries, its per capita commercial energy use was just 53 percent of China's, 73 percent of Indonesia's, 22 percent of Malaysia's, and 11 percent of Japan's. In Vietnam, electricity is generated from four resources: coal, oil, gas and hydro-power.. In the North, coal was the most important input for thermo-power plants before 1988. All the plants were built a long time before the national liberalization and were rather obsolete. Between the late 1980s and the early 1990s, some thermo-electricity plants - such as Hoa Binh - were operated under-capacity or shut down, and some other hydro-power plants were put into operation, making the hydro-electricity share increase to 70% of total national electricity generation. Thus, apart from the increase in renewable electricity (hydro-power) in 1989 as concluded by Vu Xuan Quang (2003), the reduction of thermo-power generation (under-capacity operation and closing of some thermo-power plants) also gives reason for the CO_2 emission reduction in 1989-1992.

Since 1995, some gas-and-oil power plants were built with the ODA fund, some coal-power plants were encouraged to use surplus coal, and the national grid was upgraded, contributing to the

development of Vietnam Electricity Industry. As a result, the CO_2 emission of the electricity industry, even though it went down in 1989-1996, has resumed since 1998.

In 2000-2008, the consumption of hydro-, coal- and gas- electricity tended to grow rapidly, causing CO_2 emission to increase in this sub-period.

The CO_2 emission per capita in Vietnam was still much lower than the average rate for the world. In the 1980s and 1990s, Vietnam's CO_2 emission per capita was about one-tenth of the average rate for the world, however, since 2000 Vietnam's CO_2 emission experienced a rocket growth rate, reaching one-third of the world's, which remained rather constant (Bui Van Ga, et.al., 2009). If this rapid growth of fossil fuel usage for daily life consumption and production is maintained, unquestionably Vietnam's CO_2 emission per head will soon exceed the world average level.

4. Conclusion

The structural decomposition analysis based on Kaya identity above revealed that Vietnam's CO_2 emission growth has been driven significantly by two factors: rapid GDP growth (y/p) and high CO_2 intensity of energy (c/e) which cannot be offset by continuously reducing energy intensity of GDP (-e/y) and the depressing of the population growth to an average rate of 1.67% yearly in 1986-2008.

Secondly, structural change was, indeed, the main force driving GDP growth while suppressing CO_2 emissions in Vietnam in 1989. The steady growth of agriculture and service sectors followed various economic reforms in the late 1980s. In parallel, the shift of fuel mix in terms of the larger supply of hydro-power and cutting down of thermo-power in the late 1980s to mid-1990s was another factor forcing CO_2 emission down in 1989-1992.

Thirdly, the trend of c/e coefficient is due to the increase in fossil fuel dependency and the economic structural change toward industrialization concentrating on manufacturing industries. In addition, the process of integration has attracted a large inflow of FDI into manufacturing and construction industries without paying due attention to screening whether the acquired technology is environmentally friendly. What is more, an increase in the number of vehicles and the urbanization in Vietnam also boosted energy consumption. It is forecast that the electricity industry has to grow at 20% annually in order to satisfy the requirements of social-economic development in the years ahead.

Though Vietnam has not yet committed to CO_2 mitigation under the Kyoto Protocol, and its current CO_2 emission per capita is still lower than that of the world, it is concerned that CO_2 emission per capita has sharply increased in the last 10 years, which quickly narrows the gap between the two figures. Vietnam's main energy resources are fossil fuels such as natural gas, oil and coal all of which embody high CO_2 intensity. Improvement of energy efficiency incorporated with a shift in energy mix to renewable energy, and applying EFT are the most important steps to deal with curbing CO_2 emission. At present, energy saving is the initial step contributing to that task. Together, all these measures will help to maintain a sustainable development of Vietnam's economy and society.

References

[1] Vietnam's the 21th Centry Agenda: Sustainable Development in Vietnam.

[2] Nguyen Duc Ngu (2010), Climate Change and Sustainable Development in Vietnam, *Report of The Third International Confernece on Vietnam Studies*, pp. 579-596.

[3] Nguyen Hai Hoanh (2007), "Environment and Economic Growth", http://www.tiasang.com.vn/Default.aspx?tabid=67&News=1872&CategorylD=8.

[4] Nguyen Ngoc Tran (2008), "Adaptation to Climate Change and Sea Level Rise in Cuu Long River Delta and Central Coast - Some tasks should be carried out", http://www.tiasang.com.vn/Default.aspx?tabid=67&CategorylD=8&News=225.

[5] Bui Van Ga et.al (2009), "Possibility to mitigate CO_2 emission by Biogas power generation in Vietnam, *Science and Technology Journal*, Da Nang University, Vol.1 (30).

[6] Andrei Illarionov (Editor) (2/2005), *Reasonability of Protocol and Kyoto-type Targets, Climate Change Policy and Ecoomic Growth: A Way Forward to Ensure Both,* Margo Thorning (International Council of Capital Formation) and Andrei Illarionov (Institute of Economics Analysis), pp. 1-30.

[7] Han, X. and Chatteriee, L. (1997), "Impacts of growth and structural change on CO_2 emissions of developing countries", *World Development*, Vol. 25 (3), pp. 395-407.

[8] Liaskas, K., et.al. (2000), "Decomposition of industrial CO_2 Emission: The case of European Union", *Energy Economics.* 22. pp.383-394.

[9] Polenske, R. K. and Lin, X. (1993), "Conserving energy to reduce carbon dioxide emission in China", *Structural Change and Economic Dynamics*, Vol.4, no.2, pp. 249-265.

[10] Vu Xuan Quang (2003), "Forecasting Carbon dioxide emissions in Vietnam", *Global Warming and the Asian Pacific* (Ed. Ching-Cheng Chang, Robert O. Mendelsoln, pp. 13- 34, Edward Algar Publishing House.

[11] Wier, M. (1998), "Sources of changes in emissions from energy: A structural decomposition analysis", *Economic Systems Research*, Vol. 10, pp. 99-112.

[12] Zhang, Zhongxiang (2000), "Decoupling China's carbon emissions increase from economic growth: An economic analysis and policy implications", *World Development* (H. W. Wilson - SSA), Vol. 28 (4), pp. 739-752.

[13] Chunbo Ma and David Ian Stern (2007), "China's Carbon Emissions 1971-2003", *Rensselaer Working Papers in Economics*, Rensselaer Polytechnic Institute, Department of Economics.

Phân tích theo cơ cấu biến động phát thải CO_2 trong quá trình tăng trưởng kinh tế ở Việt Nam giai đoạn 1986-2008

TS. Nguyễn Thị Kim Anh

Khoa Kinh tế và Kinh doanh Quốc tế, Trường Đại học Kinh tế, Đại học Quốc gia Hà Nội, 144 Xuân Thủy, Hà Nội, Việt Nam

Tóm tắt. Nghiên cứu áp dụng cách tiếp cận phân tách theo cơ cấu dựa trên đẳng thức Kaya và sử dụng số liệu của Cơ quan Năng lượng Quốc tế (IEA) năm 2010 để phân tích quan hệ giữa gia tăng biến động phát thải CO_2 và tốc độ gia tăng GDP/người, cường độ năng lượng của GDP, CO_2 và dân số ở Việt Nam. Nghiên cứu đã đạt được những kết quả sau: Trong giai đoạn 1986-2008, tốc độ gia tăng nhanh chóng của GDP/người (y/p) và cường độ năng lượng CO_2 (c/e) là hai nhân tố chủ yếu làm tăng mạnh phát thải CO_2 mặc dù cường độ năng lượng của GDP (-e/y) liên tục giảm và tốc độ tăng dân số trung bình đã thấp hơn 1,67%/năm. Chuyển dịch cơ cấu ngành kinh tế và cơ cấu năng lượng là động lực chính làm giảm phát thải CO_2 trong khi vẫn duy trì tăng GDP vào năm 1989. Xu hướng gia tăng cường độ năng lượng CO_2 (c/e) là do gia tăng phụ thuộc vào nhiên liệu hóa thạch và chuyển dịch cơ cấu theo hướng công nghiệp hóa tập trung vào ngành công nghiệp chế tạo, thu hút lượng lớn FDI vào công nghiệp chế tạo và xây dựng mà chưa có sự quan tâm thích đáng tới việc thẩm định công nghệ của các dự án FDI có thân thiện với môi trường không. Thêm nữa, việc đô thị hóa và mô tô hóa (gia tăng một lượng lớn xe máy) ở Việt Nam cũng làm tăng tiêu thụ năng lượng. Kết quả là gia tăng phát thải CO_2. Do vậy, nâng cao hiệu quả sử dụng năng lượng kết hợp với chuyển dịch cơ cấu năng lượng sang các loại năng lượng tái tạo, tăng cường áp dụng công nghệ tiết kiệm năng lượng và thân thiện với môi trường là những bước đi quan trọng nhất để giảm phát thải CO_2.